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Education without Borders: Development of an Interdisciplinary Project Based Educational Program

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Abstract

An interdisciplinary project-based educational program has been developed as a joint effort between IIT Chicago and the Monterrey Tec in Mexico. With a unique and innovative emphasis on inter-professionalism. This program concentrates on shaping students' erudition, preparing them for a dynamic and competitive global environment. Distinctive amongst higher education, this program was designed as an extension of currently existing interprofessional and senior project courses at IIT and Monterrey Tec, respectively. Multidisciplinary teams of senior undergraduate and graduate level students participate in this program. Working on real world problems, students will learn how to make scholarly decisions via integrating science and technology through application of project management, leadership, economics, safety, ethics and sustainability. A team of professionals consisting of university faculty with diverse expertise, representatives of sponsoring organizations and participating industry (ies) will guide the program. The team will also monitor students' progress through a rigid schedule to make sure highly sought workplace experiences and professional skills such as problem solving, planning, economic analysis and business planning, are exercised through the course of the study. Effective planning and well-timed E-communication will be the key for program success. Students are directed to develop and emerge from this experience as mature professionals, knowledgeable about emerging worldwide problems.

Keywords: IIT, Engineering Education Without Borders, Monterrey Tec.

Introduction

During the last two decades higher education directed its focus toward programs and curriculum developments that has promise for enhancing employability of their graduates. Coincidently, increasing number of universities have pursued development of courses and curriculum modifications that can enhance both graduate and undergraduate levels entrepreneurship. The focus of such curriculums has been to encourage and facilitate development of entrepreneurial skills and competencies among students. Accordingly, students are encouraged and directed at the same time to either consider business start-ups, as a self-employment career, or pursue jobs through which they could develop and implement their ideas as entrepreneurial employees with an organization.

Entrepreneurship is concerned with the development of a range of skills and capabilities including: planning, co-coordinating and organizing; using initiative and working independently; effective time management and risk management skills; good communication skills; adaptability and flexibility; taking responsibility and decision-making; being resourceful; and the ability to innovate and exercise vision. All of which has been considered in addition to innovation/invention in the proposed program in this paper.

Education Without the Boarder (E-WB):

The main objective of this exercise was to develop an Interdisciplinary Project Based Educational Program Between Illinois Institute of technology and Tecnológico de Monterrey (ITESM). Accordingly, a course with focus on Engineering Education Without the Boarder (E-WB) was created by merging two innovative undergraduate programs at the Illinois Institute of Technology (IIT) in Chicago, and Tecnológico de Monterrey (ITESM) IN Monterrey, Mexico.

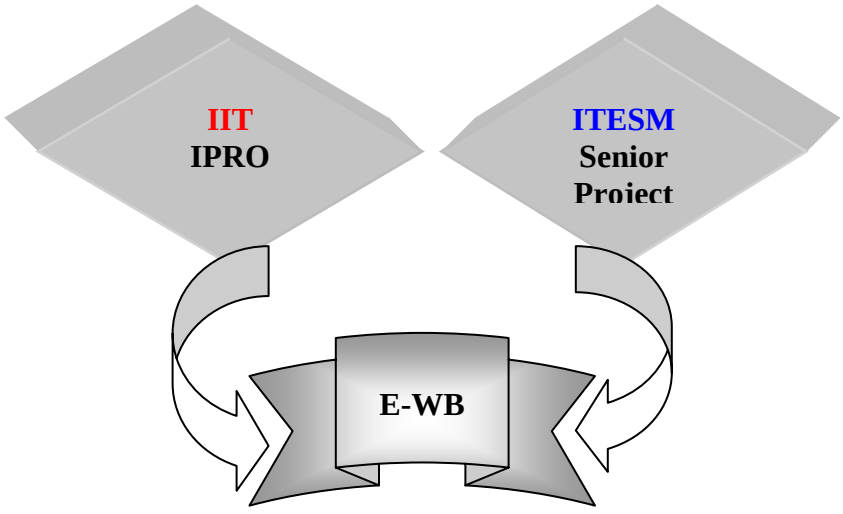

Figure 1. Formation of EEWB

Figure 1. presents strategy and major educational elements of E-WB program. A brief introduction to the IIT IPRO and ITESM Senior Project programs is provided.

IIT Interprofessional project team Course (IPRO)

The breadth and diversity of IPRO project team experiences started in 1995 is truly remarkable. The special character of each IPRO project begins with the vision of the either faculty, or professionals in sponsoring organizations. The focus of the program is to stir student's imagination, force them to think outside of the box, be innovative, creative and learn how this experience can bolster their career development.

With over 500 projects completed through July 2005, the learning experiences and outcomes of the projects cover a spectrum of achievement and a variety of intersections with research, design, process improvement, international service and entrepreneurship themes. IPRO inspires learning by removing traditional boundaries of "class room" teaching. It promotes teamwork, problem-solving, innovation, action, and entrepreneurship.

The main focus of this signature undergraduate course is to prepare students for the realities of today's global, competitive environment. Students develop and emerge from the experience with maturity, confidence, and valuable professional skills that are highly sought after in the workplace.

IPRO Team Course is a two-semester requirement for all students. Unique in higher education, the IPRO program is shaped by the interactions of student teams, faculty advisers and sponsoring organizations.

Senior project for chemical engineering programs at Monterrey Tec.

As in most Chemical Engineering programs, students at the Tecnologico de Monterrey are required to take a capstone course where technical knowledge is integrated in a final year project. In our case, this project is suggested and supervised by a real client, typically from local industry. The course then simulates a consultancy firm, where students, organized in groups of three to five members, are given one project; the course coordinator acts as a senior consultant or firm director. Faculty from different backgrounds depending on the projects are "hired" as technical experts that are available to guide students in their projects and evaluate their progress; experts are not assigned to a single team or project, but rather represent another set of resources that the students may use. After the first contact between the client and the course coordinator where the objectives and methodology of the course are explained, interactions between the clients and the firm are made entirely by the students. In this context, the teams of students must propose and justify project objectives, methodologies and solutions to academics and industrial clients independently.

A team of professionals consisting of university faculty with diverse expertise, representatives of sponsoring organizations and participating industry (ies) guide the EEWB course. While focusing on non-technical topics such as presentation skills, team building and facilitating, and technical report writing, faculty focuses on enhancing skills such as oral communication, interpersonal, teamwork, analytical, and leadership skills.

Pedagogical of the E-WB Program

The primary goals of E-WB program was to (a) enforce strong entrepreneurial visions with global perspective into engineering education at both universities (IIT and ITESM), and (b) define essential, and vital factors for successful development of a new curriculum model for engineering education, with strong emphases on entrepreneurship and inclusion of social, cultural, and economic factors in design.

The first step toward meeting program (E-WB) goals and objectives was to identify a suitable topic around which course activities could evolve. Due to innovative nature of this course, topic had to have

global significance with potentials to enhance students problem solving, team work, team communication, project management, engineering analysis, and business plan development skills.

The faculty formed four student teams which represented Design and Composition study and Business plan Development. Teams were given one project to work on. Project selected for this program by program lead faculty, Dr. Nasrin Khalili of IIT was "Development of a Water Purification System for Developing Countries". In order to address the team project, each student team needed to utilize and integrate the technical tools and concepts they had learned in their previous classes. Following operation models of interdisciplinary teams in industry, students who had background information sufficient to the project were selected as team leaders and were assigned to work closely with other team members.

Effective planning and well-timed E-communication was the key for program success. Students were directed to develop and emerge from this experience as mature professionals, knowledgeable about emerging worldwide problems.

Faculty Advisory Board

Due to interdisciplinary, intercultural, and long-distance E-based learning structure of the program, it was vital to take extreme measures to ensure quality and a highly effective learning environment for students at both IIIT and ITESM. Accordingly, a faculty advisory board was formed to direct course progress by inviting faculties from Tecnológico de Monterrey and IIT with expertise related to the project topic (i.e. faculty from finance, chemical engineering, business, entrepreneurship, and environmental engineering departments).

While prepared for difficulties associated with changing from traditional class room based courses, faculty members worked closely together and with students involved to create a productive learning environment for students at both universities.

The course objective was also to promote and teach an applied and hands-on approach to problem solving and entrepreneurship while focusing on global perspectives of the project. Accordingly faculty advisors pushed for implementation of (1) Ability and Skill development (idea generation, knowledge development, planning skills, team work, team creation, communication and management skills, etc.), and (2) Project planning and Operation (idea generation techniques, invention and innovation in design, design practicality, business plan development, bench marking etc.) Experimental design, laboratory exercises and team exercises were enforced in order to provide experience in applying science and engineering aspects of the project while course focused on both core team work, and leadership. Working on real world problems, students were directed to learn how to make scholarly decisions via integrating science and technology through application of project management, leadership, economics, safety, ethics and sustainability. Figure 2 demonstrates work format at both universities involved.

Student's progress was monitored closely through a rigid schedule to make sure highly sought workplace experiences and professional skills such as problem solving, planning, economic analysis and business planning, are exercised through the course of the study.
Schedule consisted of weekly, mid-semester and final written and oral reports, as well as weekly class discussions. Communication between students and faculty at both universities was made possible by using web-server generated at IIT IPRO department and video-conference calls.

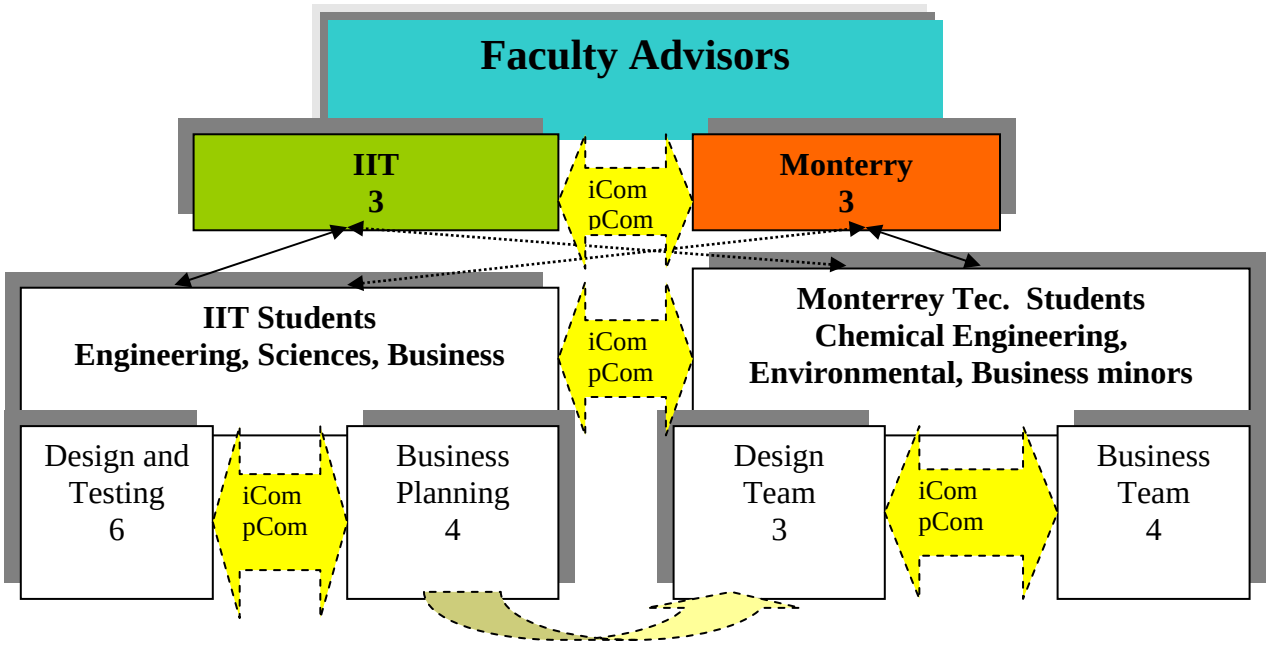

Figure 2. Team and Advisory Board Configuration of EWB (iCom, pCom represent internet based and personal communications)

The E-WB was designed to empower students graduating with a portfolio of valuable professional experiences complementing their academic degrees. This portfolio includes competencies in:

- Invention, Innovation and Creativity
- Understanding globalization and importance of incorporating social, cultural, environmental, and economic factors in very early stages of design and innovation,
- Focusing on project sustainability,
- Incorporating Social, cultural, Multidisciplinary teamwork and project management
- Leadership and decision-making
- Effective communication and problem-solving
- Managing client/customer relations
- Balancing quality, economics, safety, ethics and sustainability
- Identifying technology commercialization opportunities and strategies
- Provide students an educational experience that has a unique and unrivaled emphasis on interprofessional team projects focusing on global social and cultural factors. Students emerging from their experiences in this course learn how to make early and substantive contributions in their chosen professions and ways to overcome cultural and social barriers.

Scholastics

E-WB program focused on **Teamwork** directing students to work on self-directed multidisciplinary teams of 3-5 students. Project teams were mentored by faculty with shared professional interest, **Problem-solving** encouraging students to effectively apply their multidisciplinary knowledge and best practices to tackle challenging engineering, science and technology problems they were discovering during the course evolvement. And **Innovation and Action by** serving as an incubator for inspiration and experiencing real world problems. Empowered and energized, teams were pushed to not only explore innovative solutions to a stated problem but also try to provide a mechanism to find solutions. Teams had to work hard to push the boundaries of innovations and experience, and experience challenges involved with taking a process or product from Ideas to Production.

The teaching strategy focused on not only motivation, ability and skill development, useful use of resources, and strategy development but also on planning and operation. The key elements of planning was to define industry and market; develop strategies for product positioning, marketing, distribution, sales, operations, management and development; and to prepare a business/financial plan for the product of concern. Effective written and verbal presentation skills were emphasized throughout the course.

The course used classroom lectures, case study discussions, and provided reading material and background information when possible. Students were the main responsible party for conducting literature search and providing sufficient background information related to the topics under investigation. Business planning was approached by the use of classroom lectures, discussions of assigned readings, and the stepwise preparation and presentation of potential business plans by student teams at both IIT and Monterrey (please see figure 2). The plans were periodically posted on course web-site and reviewed by students, faculty advisors and invited external experts from industry as well as guest entrepreneurs. As presented in assessment section, the biggest challenge observed at IIT was motivating, on the personal capacity, students who had difficulty associating with the unique structure of the course. With few exceptions, junior or senior standing was required of undergraduates. The curriculum was designed for students whose primary interest is in technology, as opposed to business management.

Students

Multidisciplinary teams of senior undergraduate and graduate level students participate in this program. Working on real world problems, students will learn how to make scholarly decisions via integrating science and technology through application of project management, leadership, economics, safety, ethics and sustainability. IIT students were selected from multiple disciplines; engineering, sciences, architecture, and business. ITESM students however, were from chemical engineering department monitoring in business and environmental studies. Total number of students involved at IIT and ITESM were 12 (7 undergraduates and 5 graduate students) and 7, respectively.

Faculty

A team of professionals consisting of university faculty with diverse expertise, representatives of sponsoring organizations and participating industry (ies) will guide the program. The team will also monitor students' progress through a rigid schedule to make sure highly sought workplace experiences and professional skills such as problem solving, planning, economic analysis and business planning, are exercised through the course of the study. IIT team of faculty consisted of an associate professor of environmental management (faculty lead), a professor of finance, a professor of entrepreneurship studies, industry consultants, and IIT director of interprofessional projects. Three professors of chemical engineering and business studies from Monterrey Tec. collaborated with IIT faculty team in design and implementation of the program.

Communication.

Faculty from both universities were actively engaged with course design, student selection, providing background information on-line, and advising from the beginning of the semester. Accordingly, while working independently, students were encouraged to make a good use of their resources which included faculty advisors. Communications between students and faculty was made possible via email and IIT web site "iGroup". This site was instrumental to the project since it enabled students and faculty from both universities to effectively communicate with each other throughout the semester. This site allowed group to send emails, post documents, and exchange information crucial to project success.

Based on the need of the project, students invited consultants and other faculty advisers from both universities to participate in classroom discussions, video conferencing, conference calls, and/or on-line discussions. This option provided opportunity for students to learn from professional expertise and real life experience of external resources.

Course Activity Pattern

Decisions about the direction of the project were made by students and faculty advisors during the weekly meetings in an enjoyable, energetic and interactive team environment. The first step was problem identification, followed by identifying a deadline for students to submit a proposal highlighting their activities throughout the semester. Since project topic was selected by IIT, Dr. Khalili lead faculty advisor visited Monterrey Tec. during the first week of classes, met with students and explained course structure in detail. During this meeting students learned about the project, the " iGroup" web- site, and the course format, and expected delivery.

Example work proposal provided by students at Monterrey Tech included *Objectives, Research Methodology, Design and execution, performance evaluation, presentation and analysis of the results, a Tentative Project Schedule, and Resources.* Project activities and reports divided in two sections: technical part, and financial and business part. The two teams worked simultaneously and complementary on project tasks and preparation of the reports. Monterrey students worked closely with the technical team of IIT providing socioeconomic data needed for design, configuration and business planning information. Professors at IIT and Monterrey Tec. worked closely in monitoring team activities at both universities.

Project Outcome and Results

Students teams at IIT and Monterrey Tec (ITESM). were able to successfully complete course assignments providing design configuration, performance evaluation and development of business plans for the assigned project. While both student groups worked closely together, they were free to make any modifications they choose to the design and business plans for implementation of the project. Accordingly, collaboration resulted in two very similar design configurations and business planning's for the project.

It is important to note that collaboration with Monterrey Tec. students was one of the most significant factors impacting project success. IIT students needed the social wisdom and clear understanding of cultural factors in order to design an effective and socially acceptable water purification system (design and business plan) for Mexico.

Students at IIT and Monterrey, considered three main tasks for implementing the project: (1) Educate the community on the risks and consequences of drinking contaminated water in the communities where there isn't potable water, and introduce the clay-based filter designed by students, (2) Train the potters on the detailed requisites of water purification filter and educate them about benefits it offers, and (3) Provide specific and detailed instructions to the people that are going to use the filter. A pilot study focusing on these tasks is in development. The tentative schedule for implementation of the pilot study is summer and fall 2006.

Course Assessment and Evaluation Methods

Student Assessment

Informal student evaluation was carried out throughout the semester in order to monitor and assess students work while collecting sufficient information for maximizing course effectiveness. Accordingly, IIT students were asked to post weekly reports on line in addition to presenting their activities, questions, and lessons learned during the class meetings which were conducted twice a week. The level of students' contribution to this evaluation varied from poor to significant.

In addition, two formal assessment forms, "Self Assessment" and "Peer Evaluation", were used toward the end of the semester to identify Team Effectiveness, Student Ratings of Achievement, and Course Effectiveness. In these surveys students were asked to rate members of their team. A scoring system was used to provide definitions for each level of the scale provided in the peer review forms. Results indicated that while all students participated in "Self Assessment" survey, most students were uncomfortable with submitting the Peer Evaluation forms. Cumulatively results gave some indication of the relative skill attainment for students involved.

In another survey we examined students' knowledge of project performance and accomplishments. The simple test based on 'The Informal note on knowledge' was passed to the members of the IIT team. The goal was to evaluate the team's perception on where the project stands. Results have shown some level of consistency. A significant co-relation has been identified between the team member's *activity level* and the confidence on *the progress* of the project. Generally dormant members seemed to display too much confidence in the project's progress.

Results also indicated that team members have a consistent view of the where the project stands.
The test scores was not sufficient to directly measure if the consistent view is a result of good communication between members, or from vision which students have from project progress level. Further more results were not sufficient to provide a clue in to the impediments to progress. The conclusion best drawn from this can be that majority of the team members have knowledge of where the project stands and where it needs to go. Table 1. presents example statements made by students participating in these surveys.

Table 1. Student Assessment Results

Was project working on a Global problem? Was this experience essential to succeed in work place?	What did you gain from this course?	Comments
Our IPRO is working on a real world problem and I feel that I am definitely learning skills that are needed to succeed in the work place. I am learning more about working in a team to achieve a specific goal, discussion of topics, accepting opinions, teamwork and helping resolve member differences and these are the values and skills I will take as real world experience to my first job	I gained a really firm idea of project management from this IPRO based on the way the goals were setup, the IPRO was divided into two main team and then smaller teams to allow for more specialization, specific members were assigned specific individual tasks to do. I also learned more about teamwork from this IPRO from the way we worked and put all our ideas and results together from the specific task to arrive at a suitable outcome. In the future I hope project teams I join will have fewer members as I feel it was sometimes hard to keep up with so many people at the same time.	This was a great experience**.** A lot of the credibility of the business plan has been made possible through the union with Monterrey University, so I think it is essential that a link be maintained between the two universities. The students from there have also been hard working and dedicated, and can easily communicate with their peers in that project.

Faculty Assessment

Following figure demonstrates lead faculty evaluation/assessment of IIT students. Assessment was made based on the level of participation and effectiveness.

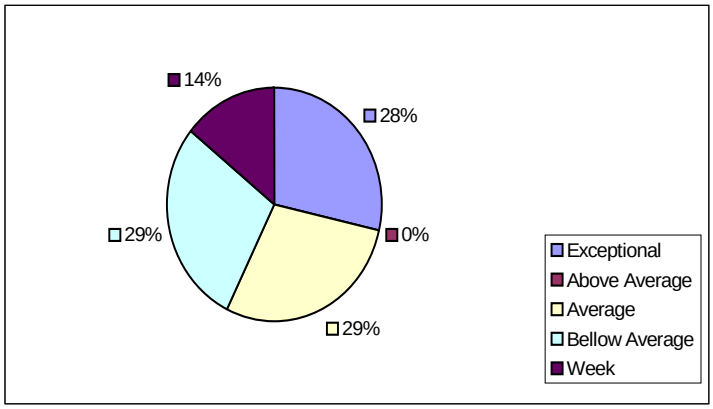

Figure 3. Lead faculty evaluation of students' performance

As shown in Figure 3, the level of student participation and contribution to the project goals, objectives, and achievements varied significantly among participating students. Personal goals, academic standing, background, capacity for independent work, ability to function in team environment, and capability to think "out side of the box" had a pronounced impact on their performance. Students majoring in architecture have shown a much higher ability to innovate and create daring design, while engineering

and science major students had problems with taking the risks and pursuing options toward innovation and creation of new and unfamiliar process or products.

Summary and Conclusions

Overall, the faculty team enjoyed the process of integrating education, not only across the curriculum, but also across boarders. Effective planning and well-timed E-communication was the key for program success. Students were directed to develop and emerge from this experience as professionals who are knowledgeable about emerging worldwide problems.

The cooperative teaching environment was found to be both stimulating and challenging. The surveys and assessments were invaluable in guiding faculty in development of the project and leading its direction further. Financial resources could be a limiting factor; therefore, they have to be addressed via universities or through educational grants.

Improvements could include better scheduling and mix of technical and managerial topics within the project. A well designed student selection process must be developed and enforced in order to make sure participating students have sufficient motivation, self discipline and background (i.e. prerequisite courses in design, project management or leadership) for these courses. At IIT we are in the process of developing a customized application and an interview process to select students for future E-WB program and courses.

Due to demanding nature of the E-WB program, incentives should be identified for participating faculty. Finally, there is definitely a need for formative and summative quarterly assessments in order to perform corrections and constructive suggestions on a timely fashion for course improvement. We have realized that many details would become apparent only after the conclusion of activities assigned during the course, or at minimum, after a series of classroom sessions.

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