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TEACHING MULTINATIONAL, MULTIDISCIPLINARY SUSTAINABLE PRODUCT DEVELOPMENT

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ABSTRACT

This paper describes a multinational program aimed at teaching processes and methods for sustainable product development using multidisciplinary project-based teams. The foundation course teaches processes for designing sustainable products and services, metrics and evaluation methods through a combination of lectures, project work, and examination of actual business cases. It is to be followed by courses on green manufacturing and pre-commercialization planning. The program features bi-national collaboration between the U.S. and Mexico, motivated by our shared vision for the development of sustainable solutions in a global context.

The exploratory foundation course of the program, *Design for Sustainability*, was taught in Fall 2007 at the University of California at Berkeley with students and faculty members from 14 disciplines and three institutions: University of California at Berkeley (UCB), the California College of the Arts (CCA) in San Francisco, and the National University of Mexico (UNAM) in Mexico City. This paper describes the course content, project experiences, faculty evaluation and student lessons learned from the foundation course as well as a proposed three-phase strategy for future program development.

INTRODUCTION

There is increasing demand for professionals who are equipped to solve today's pressing sustainability problems. These professionals will need "flat world" skills – multidisciplinary teamwork, rapid prototyping, creativity, business, entrepreneurship and human-centered design ([1], [2], [3], [3]) – and the ability to apply those skills to propose and implement solutions that address the deterioration of our ecosystems and depletion of resources. They must learn to both contribute to the transformation of current organizations and to create new ones based on a sustainability vision.

The authors of this paper are developing a program that aims to educate such professionals in the context of a global economy, specifically by taking advantage of the opportunity to establish a bi-national collaboration between the U.S. and Mexico. Such a collaboration is made both feasible and reasonable by the proximity of the two countries, their shared problems and resources, the proximal time zone (less than a 2-hour time difference versus 8+ hours with Europe and 14+ with Asia and Australia) and the existence of various collaborative agreements and cultural and educational initiatives between them (e.g., NAFTA, the U.S.-Mexico

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Foundation for Science). Further, there are complementarities between the U.S. and Mexico that have not been fully exploited: U.S. companies, for example, have access to high level technological resources, practices and infrastructure and are located in an economy with significant buying capacity; Mexican organizations, on the other hand, offer reliable and cost-competitive technical capabilities for engineering design and manufacturing [6], and the Mexican government is pushing towards further developing science and technology capabilities in the country.

The Sustainable Product Development program will be multinational and multidisciplinary, and designed to provide the participants with criteria, knowledge, tools and experiences in developing sustainable products and services, along with the required processes for exploiting or implementing those products or services through successful business models. The design of the program derives from an exploratory foundation course, *Design for Sustainability*, taught in Fall 2007 at the University of California at Berkeley (UCB). This course was adapted from a project-based, customer-focused new product development class that had been taught at Berkeley for over ten years to better reflect the sustainability imperatives of today's markets ([7], [8]). Students from 14 disciplines – including mechanical engineering, businesses and industrial design – participated in the course from three institutions: the College of Engineering (COE) and Haas School of Business (Haas) at UC Berkeley, the California College of the Arts (CCA) located in San Francisco, and the National University of Mexico (UNAM) located in Mexico City.

The course provided students with an up-to-date and extensive review of the challenges, philosophies, methods and techniques for achieving sustainability, woven into an integrated product development process that used projects to explore their application. The projects proposed sustainable solutions, including products, services and business models. The lessons learned during this first implementation of the class by the authors, included: a deeper understanding of sustainability concepts methods and techniques as they are practiced today; relevance of the topic to the students, and their interest in and commitment to it; how and where sustainability considerations can be built into the product design process; practical issues associated with keeping shared vision for and commitment to a class project among student participants from different institutions; and which characteristics of the projects and team composition best promote successful bi-national collaboration.

The learning from the *Design for Sustainability* course was used to design the three-part program presented in this paper. The program comprises three sequential multidisciplinary and multinational project-based courses covering (1) product development, (2) design refinement and prototyping and (3) incubation-deployment. All three courses are to be project-based, with the last run as a directed-study Masters level project course.

The following section of this paper describes the *Design for Sustainability* course, stressing its bi-national component. Then the lessons learned and opportunities for improvement are presented based on the experience gained by the authors and on the feedback of students and course judges. Next, the proposed program is introduced and its main parts presented. The paper closes with final remarks on the program and future activities for finishing its design and implementation.

THE DESIGN FOR SUSTAINABILITY COURSE

The focus of the *Design for Sustainability* course was on innovation processes for sustainable products, from product definition to sustainable manufacturing and business models. It was an operationally-focused course, as it aimed to develop the interdisciplinary skills required for successful design and development of sustainable products or services [7]. The course built on our study of prior courses in "design thinking" ([4], [5]), project-based learning ([8]-[13]) and sustainability ([14]-[15]), as well as multinational course design ([16], [17], [18]). The course achieved a multidisciplinary dimension through participation of students from different UC Berkeley departments, as well as from the Industrial Design program at the California College of the Arts. Besides this, students from two of UNAM's schools joined the course to take advantage of the opportunity to initiate the bi-national collaboration. Students were geographically located in Berkeley, San Francisco and Mexico City. The distribution of participants by discipline and location is provided in Table 1.

The 'course' was actually conducted through three courses run in parallel at each of the three institutions. Shared lab times were scheduled at major milestone dates to facilitate collaboration and communication. The course based at UC Berkeley was co-taught by two "lead" instructors – one from the Department of Mechanical Engineering and the other from the Haas School of Business. Although the majority of Berkeley students came from business or mechanical engineering, a third came from a wide range of other disciplines as shown in Table 1. The third "lead" instructor was from CCA, and taught a parallel course in CCA's Industrial Design program. Two faculty members from UNAM were also involved in the class, one resident at UC Berkeley and the other present with the students in the parallel course at UNAM in Mexico.

The three lead instructors designed and co-taught the semester-long course in Fall 2007. The UNAM instructors helped their students to follow the classes and keep pace with their Berkeley and CCA classmates. This was challenging as the UNAM students had different class times and other project commitments at the beginning of the course. UCB students spent three hours in the classroom/lab per week and the CCA students spent six classroom/lab hours per week, while the nine UNAM students initially spent only one hour per week. In a mid-course correction, the UNAM course was expanded to two

hours per week and the timing of these hours was adjusted to fall just after the UC Berkeley class. The lecture times at UC Berkeley and CCA overlapped, so it was possible for students to meet for project presentations or when there was a laboratory session. A few lectures were conducted jointly at UC Berkeley and the rapid prototyping lecture and tour was conducted jointly at CCA. Four laboratory/ studio sessions were scheduled during the semester to allow the teams to meet together and benefit from instructor feedback as a team. UNAM students joined these sessions by telephone or internet.

The course was an elective course for both UC Berkeley and CCA students. At UNAM, the course was defined as a seminar to fulfill terminal requirements, but without academic credit value. To enroll in the seminar, interested UNAM students were asked for their academic records and English proficiency level. The possession of a U.S. visa was also considered, although not strictly required. In the end, nine UNAM students were selected from 30 applicants.

All students participated virtually in the projects using a web-based course management tool for data storage and mail communication. Telecommunications and internet services were used for synchronous team meetings. The UNAM students and the geographically separated UC Berkeley and CCA students made the most use of these tools. In addition, the UNAM and CCA students were mentored by local instructors. The CCA students participated virtually at times and physically as well in presentations, particular classes and laboratories. Six of the UNAM students were able to join their teams during the last week of the semester to finish their project deliverables and participate in a final presentation and tradeshow.

UNAM's faculty representative at UC Berkeley acted as a liaison for the participants in Mexico carrying out several academic and logistics functions: supporting the understanding of the lectures, describing what was happening at Berkeley, advising bi-national teams about cultural and communication issues, serving as a link between the UNAM participants and the others, maintaining a UNAM presence in the class, and assisting in the organization of meetings and the visit of the Mexican participants to Berkeley. Based on early course feedback from the students, the liaison participated in seminar sessions at UNAM via internet calls after every lecture held at UC Berkeley to discuss the material covered in class and talk about general issues related to the team projects. These meetings were supported by material posted in the course web tool, and by pictures and short videos taken by the liaison in class. These latter resources proved very useful in giving the UNAM team a better understanding of the UC Berkeley class dynamics, faculty and students.

Guest speakers (e.g., Michael Barry [19], Brenda Laurel [20], and L. Hunter Lovins [21]), experts on particular topics included in the course, presented some of the lectures. They gave complementary and knowledgeable views on the sustainability issues covered. Some of them were design coaches and technical advisors for the class projects as well.

The course content was structured around a new product development process [13] that included opportunity identification, concept generation, concept/project evaluation, development and launch, embedded throughout with a focus on the social, environmental and financial aspects of sustainability.

The first part of the course covered basic definitions of sustainability and introduced three sustainable theme areas: (1) sustainable living (food and global health), (2) sustainable buildings (building features, processes; products associated with work or living spaces), and (3) sustainable transportation (modes of transportation and new systems). In addition to a product development textbook, the case reader for the class included Harvard Business School cases, chapters from *Natural Capitalism* [21] and *Cradle-to-Cradle* [23], and a number of other relevant readings. Several life cycle analysis tools [24] and carbon calculators were used in the class as well.

Table 1. Students that participated in the Design for Sustainability course by institution and discipline.

Institution		Disciplines	No. Students	Totals
UCB	College of Engineering	Architecture	2	40
		Bioengineering	3	
		Civil and Environmental Engineering	4	
		Electrical Engineering and Computer Science	1	
		Mechanical Engineering	16	
	Industrial Engineering	1		
	School of Information	Information Management and Systems	2	
School of Business	Businesses	12		
CCA		Graphic Design	2	15
		Industrial Design	12	
		Interior Design	1	
UNAM	School of Industrial Design	Industrial Design	2	9
	School of Engineering	Mechanical Engineering	4	
		Mechatronics Engineering	3	
				64

The process of selecting projects and forming teams was initiated by allowing each student to present a project proposal based on opportunities and needs identified during the first few weeks of the semester, and in part driven by the study of the sustainable theme areas. After hearing the proposals, the students submitted their top five project preferences. Using this data, the lead instructors created and staffed 11 projects, balancing student preferences with the goal of creating multidisciplinary teams. With one exception, each team had at least one business, one engineering and one design student. The

number of students per team varied between four and seven; six of the teams had six students.

None of UNAM's proposed projects were selected, but the Mexican students were still placed in their first or second choices. It was considered advisable for the UNAM students to be paired up on a smaller number of projects rather than spread individually across more projects so as to make the collaboration manageable. Thus, just four of the 11 teams had UNAM students (Table 2), and 7 teams did not participate in a bi-national arrangement. Whilst Mexican students were selected based on their proficiency in English, no language requirement was placed on the U.S. students.

The teams were supported by "design coaches" from the San Francisco Bay Area's professional design community who coached them throughout the product development process. Teams were asked to meet with their coaches at least three times and to communicate regularly with them throughout the semester. Coaches were given access to all of the materials posted on the team websites, and some made use of this access. Additional workshops on some of the techniques and tools covered by the course were offered by the teaching assistant.

During the course, the students maintained constant communication using e-mail and "chat", along with physical meetings when possible. All teams, including those without Mexican students, found it difficult to meet due to time availability and other class schedules. The teams with UNAM students tried a number of different approaches to bring in all participants for synchronous meetings including audio and video calls employing internet during their meetings. All of the interactions within teams with Mexican students were in English.

The course management system (bSpace) offered web communication and shared documents tools that many of the student teams found valuable. The document sharing and mail features, including threaded archives, provided an easy way to communicate among the instructors, the class and each team. Although the majority of the teams used the web tool and its mail feature extensively to share files and communicate, public chatting software was preferred over the comparable feature of the web tool, and some teams used public internet alternatives for sharing large files (presentations, images, videos, etc.).

At the end of the course, the project results were presented and 'proof-of-concept prototypes' were exhibited in a tradeshow (Figure 2) where they were evaluated by judges on the process followed and the results presented. Students were also asked to evaluate their classmates' projects, providing them both feedback and a chance to act in the role of evaluator. In addition, students were asked to assess the contribution of each of their team members, and to give comments for improving the course. The feedback corresponding to the teams with UNAM students is summarized in Table 2.

There was no evidence in the judges' evaluations of the impact of UNAM participation on the team's performance – in either direction. The judges' positive evaluations were more

related to projects with clear, simple and focussed objectives, than to a bi-national composition of the teams.

The UNAM student evaluations identified important benefits above and beyond those that all of the class shared: they were exposed to a new pedagogical model, learned about multidisciplinary collaborative work with their teammates and learned about U.S. culture. Some UC Berkeley and CCA students who participated in the bi-national teams mentioned that the bi-national collaboration "*allowed us to leverage combined resources and learn about each other's culture and acquire a global vision on sustainability*".

Based on student comments and feedback, it appears that the project objectives, the disciplines represented in each country and the number of students from each country directly influenced the value of bi-national teams (Table 2). The most successful bi-national teams were able to develop a clear mission statement and move forward with a shared view of the goals and the work to be accomplished. The projects with poorly defined missions were not able to keep the shared vision intact across cultural and geographical distances. The level of English of all the Mexican participants allowed constant and fluid communication with their colleagues, and thus was not a factor in the development of shared vision. (See [25] for a more complete analysis of the factors that go into the process of creating a shared vision on a team.)

Although there was no direct evidence of the pedagogical impact of the Mexican collaboration on the students that did not participate in bi-national teams, many expressed their interest in and support for the work done. Clearly the collaboration must have stimulated an awareness of the global dimension of sustainability in the class.

LESSONS LEARNED

The outcomes of the course indicated both successes and challenges. An evaluation of the students' projects and assignments showed that they learned the basic concepts of sustainability, and the design process and techniques covered by the course. Some of the projects reached promising results that could be further developed in new products. The participation of students from different institutions and from Mexico gave the class a multidisciplinary and global perspective on the projects. This participation also helped the faculty members identify opportunities for improvement and the challenges of bi-national education and collaborative project realization. The lessons learned from the exploratory *Design for Sustainability* course follow in two categories – design for sustainability issues and bi-national teamwork issues.

Table 2. Course projects with UNAM students

<i>Project name</i>	<i>Project mission</i>	<i>UNAM Students</i>	<i>CCA Students</i>	<i>UC Berkeley Students</i>	<i>Comments</i>
Grey Water connect	Protect global water supply by helping consumers to (1) be aware of their water use and (2) take steps to conserve and recycle water in their homes.	2	1	3	The mission statement started out narrowly defined, but grew to be more general, clear and simple. There were specific contributions to the project from the UNAM students, however, the leadership of the project depended on the UC Berkeley students. The specialty of UNAM students did not particularly contribute to the selected concept solution, but their background work in identifying different legal policies in Mexico opened up new avenues for concept development. The UNAM students were typically assigned particular tasks and were at UC Berkeley the last week of the course (Figure 1).
The Merelan Alliance	If we can increase the supply of clean water to people in areas of acute water need, then we can increase life years and productivity per capita, resulting in improved public health and economic conditions	4	0	3	The mission statement started out very narrow, focusing on a particular form of desalination. The number of UNAM students on the team was larger than on others, and their disciplinary specialties were beneficial to the project. More importantly, local UNAM expertise in this area helped the team to expand its scope and approach, allowing the students to develop a case study based in Mexico. The team defined tasks to be carried out by the team members. UNAM students participated in technical decisions and were at Berkeley the last week of the course (Figure 1). One member of the UC Berkeley team has some facility in Spanish. This team continues to develop their product and recently competed for an award on innovative technologies and placed as a semi-finalist.
Community Assessment of Renewable Energy and Sustainability (CARES)	CARES believes that giving consumers, communities, governments and corporations access to the latest data, models and solutions will accelerate adoption of sustainable solutions, thus enabling communities to reduce their environmental footprints	2	1	4	The mission statement started out broad and ended that way. The disciplines of the UNAM students were not particularly relevant to the project. They did not assume a leadership role and neither did they visit Berkeley. One UC Berkeley student flew to Mexico to meet with the UNAM students in person. The team hoped that the CARES project would develop a case study with a Mexican community, but it was never realized. Although the project did not gel in the end, the team submitted a proposal for continued funding, which they received, and team members still communicate.
Green Modular Furniture	To create a sustainable furnishing alternative for 'metro hippies' that is affordable, functional, and aesthetic.	1	1	4	The mission statement was more particular than those of the other projects. There was a relationship between the concept solution and the specialty of the UNAM student. The student was assigned particular activities by the others and did not visit Berkeley.



Figure 1. Final class with UC Berkeley, CCA and UNAM participants

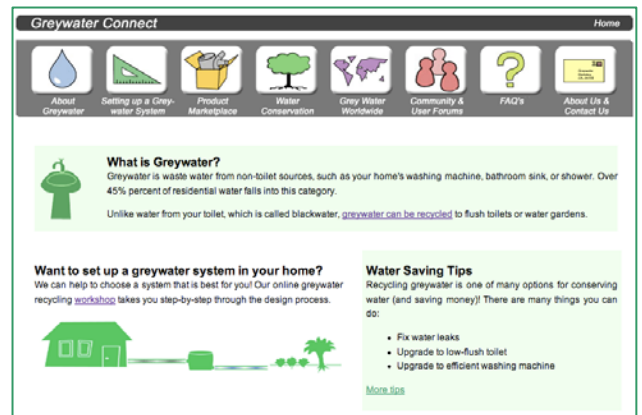
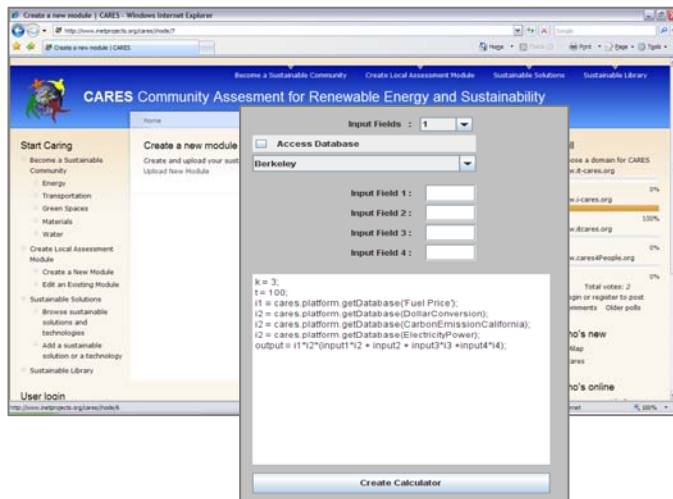
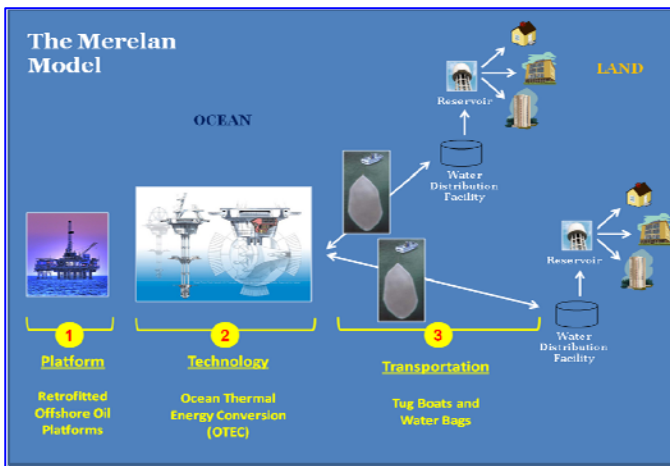


Figure 2. Final bi-national teams projects' results. Upper left, The Merelan Alliance; Upper right, Green Modular Furniture; Lower left, Community Assessment of Renewable Energy and Sustainability (CARES); Lower right, Grey Water Connect

Design for sustainability issues:

- The instructors did not find a textbook that adequately addressed both multidisciplinary new product development and sustainability. As we compared the *Design for Sustainability* course outcomes to those achieved in our regular *New Product Development* class, we came to believe that sustainability is an important component of any good product design and thus it may not be advisable to set up an independent class on sustainable product design.
- Both instructors and students found it surprising and disappointing that customer needs research did not identify sustainability as a top need. Specifications related to sustainability were generally defined by the teams and not by customers. This may change in the future as more information on sustainability is made available and accessible for more products and services.

Bi-national collaboration and team work issues:

- Bi-national collaboration gives a multinational and multidisciplinary perspective to the course and, in particular, to the projects.
- A proficient level of all team members in a shared language facilitates personal interactions amongst them and makes it easy to contribute to the project outcomes.
- For the students to develop a shared vision and shared responsibilities, it is paramount that all of the participants in the course are aware of the time and commitment required to follow the lessons, complete the readings and course assignments, and participate significantly in the project. As an indicator, all of the students should dedicate a similar amount of time. For international students, this time may need to consider overcoming the difficulties of taking the course in a second language.
- The nature of the problem addressed by the team affects the collaboration. Appealing projects that take advantage of the resources and needs of both countries or exploit a market opportunity in both countries synergize the bi-national collaboration.
- The complementarity of the disciplines of the team members located in different countries motivates collaboration, but also promotes a relationship based on task division over real partnership.
- Cultural issues became relevant to the collaboration as well: the way that living in Mexico City and living in Berkeley affects the normal life of the students (traditions, social customs, religion, access to technology, etc.), general knowledge well known by the students of one country that could be totally unknown by the others (e.g., the Toyota *Prius* was referred frequently in the course, but in Mexico this car had not been introduced so it did not mean anything to those students, whilst *Clio* from Renault

is a very popular car in Mexico, but is not on the market in the U.S.).

- The use of the web tool proved valuable. It was the kernel for sharing the class and project materials and communications. Some of the features of the tool could be improved and others better exploited. In particular, many students complained about the time required to load big files in the system. The wiki feature of the tool was only used by instructors for posting announcements and relevant information and not by the students at all (although teams in past classes have found it useful).
- The visit of the Mexican students to Berkeley was very productive. To actually meet physically created a closer relationship that assisted collaboration. The students that visited were motivated and co-developed the prototype demo with the UC Berkeley students.
- The budget for bi-national courses must include funds for communication (telephone calls, web cams, etc.) and travel as well as for the direct costs associated with the proof-of-concept prototypes.
- The small difference between Berkeley and Mexico City's time zones facilitated the communication and the relatively short distance between the cities made the visit of the Mexican students affordable.

THREE - SEMESTER SUSTAINABLE PRODUCT DEVELOPMENT PROGRAM

Program introduction

This section introduces a three-semester academic program that builds on the lessons learned from the exploratory *Design for Sustainability* class. The program aims to turn more of the *Design for Sustainability* class projects into entrepreneurial ventures, allowing opportunities to further assess the projects' potential social and economic success and enabling a virtuous circle that feeds back fresh ideas and experience for the teams and faculty participating in the program.

The UC program will leverage its new Engineering and Business for Sustainability (EBS) Certificate Program. The vehicle at UNAM will be a required sequence in its Mechanical Engineering Masters Degree Program.

Program Objectives

Regardless of the location, the goal is to offer graduate students the opportunity to engage in learning about innovation processes for sustainable products, including product definition, sustainable manufacturing and entrepreneurial venture implementation. The students are to develop the interdisciplinary and multinational skills required for successful design and development of sustainable products and services and then scale them through socially-responsible entrepreneurial ventures.

Motivation

Based on an evaluation of the *Design for Sustainability* course, and on those of the longer-running *New Product Development* course [8], it is clear that a multi-course approach is essential to integrate design and manufacturing, and to provide students with the opportunity to actually develop their ideas and launch them. The main reasons to follow this approach include:

- It was clear from this first experience that cultural and economic forces exert different pressures on students from different countries. In the UC Berkeley-UNAM case this issue can become an advantage rather than a shortcoming. UNAM's students faced high unemployment rates in recent years making entrepreneurial ventures that target the design of innovative and sustainable products very appealing to them. Establishing a sustainable business is therefore an alternative for many UNAM students as they depart their last semester. On the other hand, UC Berkeley team members are often interested in further pursuing *New Product Development* (or *Design for Sustainability*) class projects after the course has finished but many times have prior career goals and commitments before entering the course. As a logical consequence, at the end of the course, many projects are left with only one leader trying to push the business forward [8]. We are excited about the opportunity of having Mexican-American multidisciplinary teams further develop the most promising concepts and increase the odds of successful entrepreneurial start-ups.
- Our evaluation shows that the lack of time and money to further develop and refine promising products is an obstacle to encouraging team members to further develop their class projects. The three semester program will provide the required time to develop the expertise needed for the teams to apply for pre-commercial funding (e.g., grants from the National Collegiate Inventors and Innovators Alliance, Industrial Design Society of America, UC-Mexus and funding from CONACYT-Mexico's Science and Technology Council) and enter business plan competitions.
- Having more class projects turned into entrepreneurial ventures would provide a good opportunity to expand the authentic learning experience of our students in connecting to real-world conditions. It will enable a good feedback system to keep faculty and students up to date with the evolution of sustainable business ventures.

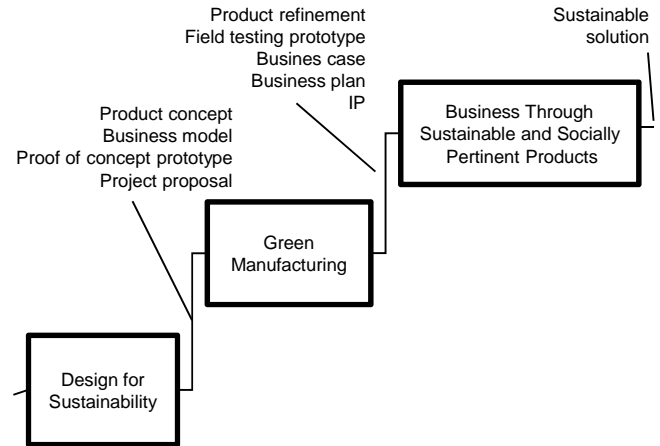


Figure 3. Program courses

Description of the Program

The program is composed of three courses, as shown in Figure 3:

1. Design for Sustainability (DFS)
2. Green Manufacturing (GM)
3. Business through Sustainable and Socially Pertinent Products (BSSP)

The program incorporates the following characteristics:

- Synergy between UC Berkeley's Certificate on Engineering and Business for Sustainability and UNAM's Mechanical Engineering Masters Degree.
- Exposure of students to the full product-design-to-implementation process (i.e., user needs, brainstorming, prototyping, manufacturing, business planning, business management, marketing, company finances, entrepreneurship, capitalization). Although only the most promising design concepts will be developed through the sequence, the aim is to engage as many engineering students as possible in all three courses of the program.
- Foster collaborative and multi-disciplinary work through multicultural and multinational project teams. Disciplines: engineering, industrial design, business, management, computing.
- Employ project-based learning in all three courses of the program.
- Emphasize the design and development of sustainable products with positive social impact.

The first course in the sequence will be the revised *Design for Sustainability* course discussed earlier. The other two courses of the proposed program are briefly described below.

2nd Course: Green Manufacturing (GM)

Students participate in the *Green Manufacturing* course [26] in the second part of the program. The focus of the course is on developing skills for designing sustainable products for environmentally-sound and volume manufacturing. The class provides the tools and techniques that will allow teams to design and implement manufacturing practices demanded by today's competitive global marketplace. This course is currently being taught at UC Berkeley and approximately half of the students are drawn from those taking the previous product development course.

Although it is desirable that the students work on the same projects as they did in the first course, we recognize this will not always be the case. Students could be in the class who have not taken the first course of the program, or students who took the first course may choose to work on other projects.

By the end of this course students will be able to:

- Explain what comprises sustainable manufacturing practices,
- Apply techniques and tools for product and manufacturing process design and development using sustainability thinking
- Test solutions in detail and carry out field tests.

Students in the UNAM course will also be expected to produce a solid business plan for a sound and marketable product or service. They will also be asked to identify sources of grants and funding to continue their projects. UC Berkeley students will be encouraged to submit a business plan for their project as part of the business plan and "big ideas" competitions run by their *Management of Technology* program [26].

3rd Course/ Directed Study: Business through Sustainable and Socially Pertinent Products (BSSP)

This component will be taught as a separate course at UNAM, but as an independent study for a Masters Project at UC Berkeley. All students are expected to acquire knowledge for the implementation and "entrepreneurial incubation" of sustainable products and solutions. Some teams will carry out this phase with the projects that they have been working on during the program, but this will not be a requirement. Nevertheless, it is expected that those projects will have a better probability of succeeding in establishing a company to exploit their product.

The BSSP course at UNAM addresses the following subjects:

- Techniques to lead a "socially conscious" business.
- Business and management skills and organizational structures for innovative entrepreneurial ventures.
- Tools and techniques for marketing new products and services.

- Finance and accounting for technology based businesses.
- Tools and techniques to aid in the successful operation and maintenance of businesses.
- Understanding the importance of life-long learning in companies able to respond quickly to unpredicted market and society needs.

The students with the most promising projects will be the focus of this part of the program. The UC Berkeley students will be drawn from those who have participated in the first two courses, or equivalent ones offered in the *Engineering and Business for Sustainability* [26] or *Management of Technology* certificate programs [26] that cross business and engineering. The other activities of the last phase will only concern the teams that really are committed to formalizing an organization and turning their projects into a business, and will be centered around protecting the intellectual property of their products, refining the corresponding business cases, getting the required funding, etc. The goal is to provide a mechanism and infrastructure to incubate the best projects into new companies.

FINAL REMARKS

This paper describes the authors' motivation for promoting bi-national collaboration between the U.S. and Mexico. The exploratory course *Design for Sustainability* was described, along with lessons learned. The course is the foundation for a three-semester product development program focused on sustainability, green manufacturing and tools for bringing sustainable solutions to market. The ambitious program aspires to foster new business cases for implementing sustainable solutions and incubate new companies that exploit sustainable products and services.

The proposed program intends to graduate students that will be better able to understand new product development processes as well as useful tools and techniques that support sustainable product development practices. Multidisciplinary and bi-national teamwork is expected to increase the number of design concepts that are turned into entrepreneurial ventures. UC-Berkeley and UNAM-Mexico City's students can join to create and establish successful enterprises. A higher number of design projects addressing social issues are also expected to increase. Current political, social and economic forces in Mexico can become a strong catalyst for teams pursuing socially-conscious projects. The authors and faculty members of the institutions involved in this program are now working in its detail and implementation.

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