
AC 2012-3469: PREPARING ENGINEERS FOR GLOBAL CAREERS: CULTURALLY DIVERSE DESIGN COMPETITIONS AND FORUMS FOR FIRST-YEAR ENGINEERING STUDENTS

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Preparing Global Engineers: Culturally Diverse Design Competition and Forum for First-Year Engineering Students

Abstract

An international design competition was conceived between two culturally distinct engineering institutions to study teams competing in the unique process of engineering design. These successful competitions have taken place since the fall semester of 2007 on the campuses of two engineering universities (alternating as hosts): one Western and one Middle Eastern. The Petroleum Institute (PI) of Abu Dhabi, UAE, and The Colorado School of Mines (CSM), USA, have held these competitions as part of a collaborative research initiative titled “Preparing Global Engineers: Developing Engineering Design Education Across Cultures.” The competitions were expanded in 2009 to include international forums for students and faculty to share optimal views of engineering design methodologies.

While the theory, objectives, and practices of the respective cornerstone engineering design programs are similar, the respective cultures are vastly different. Data gathered from the observance of culturally diverse competing teams is studied with the objective of developing curriculum and pedagogy that will prepare our student teams for global engineering practice. In addition, the experiential value of international travel and intercultural exchange inherent in this project is significant.

Introduction

Both the STEPS Program (PI) and the EPICS Program (CSM) introduce team-based engineering design problem solving to students in their first and second years. While the theory, objectives, and practices of the programs are similar, the respective cultures are vastly different. Recognizing the need for students to understand the global nature of modern engineering and have an awareness of customary practices in diverse cultures, a collaboration was initiated in 2007 with the following objectives:

- Prepare students for global engineering
- Develop opportunities for faculty and student international exchanges
- Develop curriculum and pedagogy for engineering design education across contrasting cultures
- Increase faculty and undergraduate research and publication in interdisciplinary and cross-cultural engineering design education

This project, “Preparing Global Engineers: Developing Engineering Design Education Across Cultures,” was not only intended to promote faculty research in the development of engineering design education across cultures, but to encourage undergraduate research through solving real engineering problems and observing the processes therein.

The first four years of the collaboration between the two design programs have been marked by highly successful activities that brought these very different cultures together to compete in engineering projects and to share views of optimal engineering design methodologies. The collaboration hosts two major activities: International Design Competitions and International Design Forums. The following narrative describes the rationale for the activities. Figure 1 introduces the Western/Middle Eastern contrast as PI and CSM students mingle during a competition break.



Figure 1. *Culture Shock: PI Students Bundle Up at CSM in January 2010*

Preparing Global Engineers

With more companies expanding into new areas of the world, the need for engineers who are capable of working in more than one culture has increased. G.N Saunders-Smiths and E. de Graaff have recognized the need to teach global competency to a future workforce. “Long gone are the days when employee searches were geographically limited. Increasing numbers of employers now seek the best qualified candidate by conducting a global search, regardless of distance, and in some cases, language¹.” Like Carnegie Mellon, more and more engineering universities are stressing the value of “students graduating as global citizens, equipped with the skills to innovate, communicate, and lead teams comprised of people from all over the world. Great innovators understand cultural differences and local market needs...Traveling abroad is an excellent way to enrich the academic experience and learn to work with people from different cultures².”

The purpose of the International Design Competition is to prepare our students for global engineering practice by introducing them to cultural differences that inform their profession and other intercultural relationships. Since many of our Middle Eastern students have never traveled out of the UAE, and a number of the American students have never traveled internationally, the notion of some day working with international teams of engineers in foreign lands is both intriguing and a source of anxiety.

R. C. Jones and B. S. Oberst have identified the need for reform in engineering education in the Arab world and all parts of the world, “as universities prepare graduates to enter the profession of engineering which has been transformed by massive technological developments and by globalization of all aspects of concern to engineers. Engineering educators in the Arab states region face particular challenges in addition to those facing similar educators in other parts of the world (including) tailoring programs to fill the needs of countries that are undergoing rapid modernization³.”

G.L. Downey and J. Lucena have identified cultural differences in how engineers define and solve problems differently. “While it is now appropriate to assume that each person is a member of one culture whose boundaries coincide with those of a country, it is still critically important for students to gain educational and work experiences with people who were raised and trained in other countries and to understand dominant images and patterns of engineering work in those countries” Their research has developed into a course at CSM⁴.

The competitions and forums described in this paper expose our students at an early stage in their academic careers to the concept of cultural differences influencing both engineering practices and their futures in international settings. D.L. Pells points out that while travel was not only professionally valuable, he also had a better knowledge of geography and history, and an increased awareness of global issues⁵.

I. Encouraging Intercultural Communication

Not only is it important for our students to know how engineers solve problems differently in different cultures, as Downey⁴ has pointed out, but they need to have exposure to and an appreciation for other factors, such as values, manners, customs, and languages that may influence successful overall communication in the global arena.

This project has been particularly beneficial in extending the geographic boundaries of students in the UAE. Their lives deeply and daily influenced by Islamic religion and law, and with extended families as their primary subculture, the National students' lives have thus far been highly provincial. International travel between the two universities and participation in activities that mix the students have yielded broadened perspectives on both sides. In recent years, the influx of expatriate students from the Middle Eastern region to the UAE campus has created internal cultural challenges on both sides. Since their future careers as engineers will undoubtedly place them in international settings, this project enables our students to function optimally, not only as engineers but as internationally savvy and tolerant people.

The competitions and forums have not only exposed our students to cultural differences in solving engineering problems but other cultural and geographic differences as well. Middle Eastern students had to adjust to the winter cold weather in the US in January. Sightseeing activities included excursions in Denver and the mountains where the students had their pictures taken in Wild West costumes and experienced snow for the first time. On the other hand, while in one hundred degree weather in Abu Dhabi, US students went on a desert safari where they went 4-wheeling in the sand dunes and sampled the local cuisine. Figure 2, below, shows a CSM student invited to judge a camel competition in Abu Dhabi. In all cases, the students good-naturedly adapted to the weather and geographic and culinary restrictions.



Figure 2: CSM Students Judge Camels in Abu Dhabi

II. International Design Competition

Today there are many collegiate engineering design competitions in almost all fields of engineering, such as the American Society of Civil Engineers “Concrete Canoe” competition and the American Society of Mechanical Engineer’s “Safety Engineering” design contest. The US Department of Energy’s National Renewable Energy Lab sponsors a “Solar Decathlon.” Most of the competitions are sponsored by engineering societies (the largest competitions are held by the Society of Automotive Engineers), some by government agencies (such as NASA) and some by industry (such as Ford Motor Company’s “Future Truck Competition”). Few are solely organized through universities, such as Illinois Institute of Technology’s “International Bridge Building Contest.” The emphasis of most of these competitions is a real-world challenge of designing and building an original device or product through the practical application of engineering principles students learn in the classroom⁶. In this way the paper subject Competition is similar.

The International Design Competition is not yet a large scale competition, but it sets itself apart from the mainstream competitions in its bi-cultural sponsoring universities, its thematic root of “Preparing Global Engineers,” and its emphasis on undergraduate research analysis.

Four international design competitions have been held to date (See Table 1). The projects are chosen for their contemporary global applications and in consideration of the “14 Challenges for the Future” proposed by the National Academy of Engineers⁷. The list was compiled by a panel of accomplished engineers and scientists who identified four major areas: sustainability, health, reducing vulnerability, and the joy of living. All of the competition projects have had global applications and altruistic intent, as evidenced in Table 1.

First-year design teams from PI and CSM to prepare their project solutions over the course of the semester. The unique process of engineering design requires our students on both campuses to identify efficient models and methodologies in the areas of teamwork, communications skills, open-ended problem solving, marketing, and project management. Students’ awareness that this is a competition creates motivation and determination.



Figure 3. Dr. Robert Knecht Views a Solar Seawater Desalination Presentation

Deliverables include a preliminary poster presentation with prototype, followed by a formal presentation of the final report by the finalist teams. Criteria for evaluation include

innovation, creativity, communications, marketing, graphical skills, and professionalism. At the end of the semester, the final competition between the top two teams is held in the UAE or US. Activities are devised to promote the event, get the teams further acquainted, and to revel in the spirit of the occasion. Invited guests include faculty, students, and representatives from local industry and agencies.

Table 1: Projects and Clients

<i>Date</i>	<i>Host</i>	<i>Project</i>	<i>Client/Sponsor</i>
December 2007	UAE	Solar Seawater Desalination Devices	The Peace Corps
June 2008	US	Solar Furnace for Toxic Waste Destruction	Abu Dhabi National Oil Company
January 2110	US	Environmentally Sustainable Village	US Program
December 2011	UAE	Harvesting Energy from Playground Equipment/Household Level Biogas System for Power Generation	UAE Program International Development Enterprises

Through the competition activities students and faculty are able to investigate and identify differences in cultural approaches to all the major design themes: teamwork, communication, project management, graphical and technical abilities with the goal of synthesizing them into culturally adaptable engineering design models. Both sides have benefited by the observance of different approaches to a given problem. For instance, the Middle Eastern students have been consistently ahead in oral presentation scores, perhaps because of an oral cultural orientation, while their writing skills are naturally impeded by English as a second language. While the design-and-build nature of some of the projects was daunting to the Middle Eastern students (perhaps because of a lack of familiarity with tools and construction techniques), their graphical presentations have been outstanding.



Figure 4. The Toxic Trackers Team Accepts Award for the Solar Furnace for Toxic Waste Destruction Project

IV. International Student/Faculty Design Forum

A by-product of the International Design Competition – The International Design Forum – was generated in 2009 as a result of the discovery that when the competition was over, everyone had a lot to say about the process and experience they shared. Team members talked about observable differences in the poster presentations of the competing teams. Marketing, graphics, creativity, and focus were examined. Informal feedback discussions gave rise to interactive workshops on topics such as teamwork, graphics and oral skills, and intercultural differences that influenced decision-making. The students chose topics such as “How do you deal with a team slacker?” and “What factors influenced the quality of the winning team’s product?” Faculty also became involved and ultimately developed their own topics for discussion groups such as team building techniques, encouraging women in design courses, leadership across cultures, and integrating problem solving skills throughout curriculum.

The table below shows overall themes explored during the forums. The students also applauded the undergraduate research aspect of the forums. As far as we know, this is the only program that calls on undergraduates to not only participate in design competitions, but also evaluate these activities and, based on outcomes, construct forums and workshops for international participation. The students were eager to be the leaders in provocative discussions but they were also instinctively sensitive to their international counterpart’s cultural differences.

Table 2: Forum Themes

Date	Forum Theme
April 2009 (PI):	“Team Building, Learning Styles, and Communication Styles”
January 2010 (CSM):	“Cultural Influences on Engineering Design”
December 2011 (PI):	“Marketing Your Team Image and Product”

V. Conclusion and Invitation

Globalization has brought with it an awareness that nations no longer exist in vacuums; business and industry have expanded across cultures. Changes in political structures and communication technology have made for increasing global interaction and interdependence. In 2001 President Clinton wrote a memorandum to the heads of executive departments and agencies regarding the United State’s policy on international education: “To continue to compete successfully in the global economy and to maintain our role as world leader the United States needs to ensure that its citizens develop a broad understanding of the world, proficiency in other languages, and knowledge of other cultures...⁸”

The Middle Eastern/US collaboration continues to provide our students with opportunities for a globally informed education through it competitions and forums. The activities described above have fostered a rich and productive intercultural dialogue while giving students valuable training in a global engineering project. While creating solutions to global problems requiring their technical engineering skills, the students discovered that soft skills such as

communication and teamwork were integral to their success, regardless of culture. Faculty and students enjoyed greater understanding of the differences and sameness of their respective cultures, not just in the areas of engineering design, but in overall international relations. All of the students supported the environmental and humane goals of the competitions and forums. The students felt they learned a great deal from one another about stereotypes that affect perceptions and thus productivity on teams dealing with global projects. Travel was integral to the exchange, and the students carried back to their respective universities the good will and new perspectives they had acquired.

The competition committee invites other international collegiate entities to join us in these activities. The next International Design Competition and Forum will be held in January, 2013, on the CSM campus. Please let us know your interest by emailing Dr. Suzanne Scott (sscott@pi.ac.ae).

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