

Establishing an Immersive Cross-Cultural Experiential Learning and Design Collaboration for Engineering Students and Faculty

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Abstract

Engineering graduates must not only develop technical skills for success within their career but they must also develop global competence to interact effectively in today's increasingly interconnected world. Beginning in 2008, a group of universities from different parts of the world partnered together with a goal of better preparing global engineering graduates. This resulted in a culturally immersive international product development and design experience that takes place each summer. Students primarily from universities within the USA travel to the National University of Singapore for an intensive two and one-half week design interaction in late May and Early June. Professors from participating universities that include the National University of Singapore (NUS), Penn State University (PSU), Brigham Young University (BYU), and Brigham Young University-Idaho (BYU-I) co-teach the program.

Students attend interactive classroom sessions, visit companies within Singapore to learn about product development and design, and work on a collaborative group project that includes a final presentation and typically a proof-of-concept prototype. Student teams are intentionally diverse, with representation from the different universities and cultures. In this way, students experience diversity of thought both technically and culturally that enriches the development of design concepts and the learning experience. In addition, students and faculty experience the cultural diversity of the host location while also learning from each other.

This collaboration has led to additional opportunities for students and faculty to collaborate including senior capstone design partnerships, research collaboration, and faculty exchange. This paper provides insights into collaborative international team-based student design experiences and faculty interaction among multiple universities including the flexibility and adaptation of this approach in other curricular areas or different host locations.

Introduction

There is a growing body of work that emphasizes the importance for engineering and technology students to develop global competence to meet the demands of a modern technical workplace. Global competence includes the skills necessary to work successfully in today's international and inter-connected environment^{1,2,3,4}. In response to this demand, many universities have implemented programs to help develop global competencies within their students. These programs include: study abroad, student exchange, faculty exchange, mentored travel, international projects/service learning, international research, international internship or co-op and others⁵.

While these more traditional program approaches can help achieve selected competencies, we have experimented with new models for programs that might be more efficient or better address particular competencies. In this paper we explore the creation and execution of a multi-university program that uses an immersive, cross-cultural experiential learning approach built around a collaborative design project.

The School of Engineering Design, Technology and Professional Programs (SEDTAPP) at Penn State University (PSU) and the Department of Mechanical Engineering (ME) of the National University of Singapore (NUS) explored and partnered together to develop a summer program on “Engineering Design” for students from the PSU and NUS. The intent of this program was to provide student participants (most typically in their sophomore year) a culturally immersive international product development and design experience.

The program was initiated in late May of 2008. Engineering students from PSU attended NUS for an intensive two and one-half week international design program. Professors from both PSU and NUS were involved in this program. Beginning in 2009, Brigham Young University (BYU) mechanical engineering and design students and professors became actively involved in the program. Other universities including Carnegie Mellon University and the University of Illinois at Urbana-Champaign have been involved in subsequent years, though participation by students from these universities was not regular and did not involve their professors.

This international engineering design program provides a platform for an intensive cross-cultural design and international team-based collaboration for all involved. The diversity of student participants is much broader than just the locations involved as students at participating universities come from many other parts of the world.

Program Overview

To meet the goals of this international experience the program was designed to bring students together from universities within the USA and Singapore together for an intensive two and one-half week design interaction held in Singapore in late May and Early June.

Students form their own multi-cultural teams with a goal of having equal representation from each partner university. Each team typically includes 6 students who work together on a product design and development project. Students have an opportunity to interact regularly within a team environment with others from diverse cultures and backgrounds. This provides a more immersive cultural experience that also extends into the evenings and weekends, as it is common for students to spend free time together with their team.

As part of the experience, students have the opportunity to visit global and local companies within Singapore to learn more about the product development process, manufacturing, and develop an increased understanding of the global economy, laws and regulatory practices pertaining to each company.

Students attend interactive classroom sessions taught by Professors from PSU, NUS, BYU, and Brigham Young University-Idaho (BYU-I). The program covers topics relating to the basic product development process within a global context. A list of lecture topics and the schedule utilized from the most recent program conducted in 2013 is shown in Table 1.

Two approaches have been utilized for project selection over the years. In previous years, student teams were formed at the beginning of the program and each team proposed a product to be developed. More recently student teams have all been assigned a problem to address within the

Table 1 - Lecture Topics and Schedule from 2013

Design Phase	Date	Time	Topics	Key Instructor	
Problem ID and Bkgd Research	16-May	9am - 9.30am	Introduction	NUS	
	16-May	9.30am - 10.30am	Global Design -Cultural Aspects	NUS	
	16-May	10.30am -11am	Welcome Tea		
	16-May	11am -12noon	Teaming	BYU	
	17-May	9am - 10am	Identifying Customer Needs	BYU	
	17-May	10am - 11am	"Design Thinking"	NUS	
	17-May	11am - 3pm	observational studies		
	17-May	3pm - 4.30pm	Summary of observational studies	NUS	
	Weekend				
	20-May	9am - 10am	Product Specifications	NUS	
	20-May	10am - 11am	Intellectual Property	BYU	
	20-May	2pm - 5pm	Problem Statement Review with Faculty		
Concept Generation	21-May	9am - 11am	Conceptual Design and Creativity	PSU	
	21-May	11am -12noon	Utility Theory / survey data	PSU	
	21-May	3pm - 5pm	Visit to Xentiq	NUS	
	22-May	9am - 10am	HF & Ergonomics / DfHV	PSU	
	22-May	10am - 11.30am	Prototyping and Design for Manufacturability	NUS	
	22-May	11.30am - 12.30am	Compliant Mechanisms	BYU	
	22-May	3pm - 5pm	Visit to Makino	NUS	
	23-May	9am - 10.30am	Economic analysis and project justification	BYU-I	
	23-May	10.30am -12noon	Concept selection	PSU	
	23-May		Concept Review with Faculty		
Concept Selection	Long Weekend				
	27-May	9am - 10.30am	Team New Zealand prototyping and decision case	BYU-I	
	27-May	10.30am -11.30am	Design for Reliability	NUS	
	27-May	2pm - 5pm	Review of Final Concept with Faculty		
Concept Realization	28-May	9am - 10.30am	Product Cycle Development	NUS	
	28-May	10.30am -12noon	Case about ethics and product liability	BYU-I	
	29-May	9am - 10am	Standards	PSU	
	29-May	10am - 11am	Mass Customization	PSU	
	30-May		Project Work Day		
	31-May	10am -5pm	Final Presentations		

constraints of the year’s “theme” (e.g., water conservation, public transportation, etc.). In 2013, student teams were tasked with coming up with a more effective method to keep hawker centers (an open-air cooked food complex that started in the 1950s to make street-food vending more sanitary in Singapore)⁶ clean. Workers at Singaporean hawker centers struggle to clean up tables quickly after customers to maintain expected sanitation levels. Student teams focused on more efficient and effective cleaning methods and products that would minimize the amount of soap

and material required since hawker center workers provide their own cleaning supplies. Student teams worked closely with workers to identify desired changes. They developed concepts, sketches, and then made and tested prototypes employing combinations of squeegees, brushes and sponges. Students are guided in the development of the product at various stages through interactive sessions where they receive feedback and comments from professors and other students.

Each student team provides a comprehensive presentation and technical report at the conclusion of the program. The final presentation is expected to be a confirmation of their learning outcomes from the interactive sessions and further refinement and affirmation of their understanding of the key concepts. Every member in the group takes part in the final presentation, highlighting their contribution. Components of grading consist of the performance by each group, individual performance as assessed by each student's presentation, and also peer feedback submitted by group members.

After the final presentation, there is also a wrap-up session when students have the opportunity to give their feedback on the course and difficulties encountered in understanding the concept or in the manner the course is conducted.

Course Outcomes

The intent of this paper is not to provide detail on course outcomes and assessment as that is planned for future work. However, it is important to note that all three universities involved in the program have developed a list of common outcomes and objectives for students related to developing global competence in a design context that include the following:

1. Learn the fundamentals of a structured engineering design process
2. Learn to appreciate working on a design project with students from different cultures
3. Begin to understand how product design is done by successful global product development companies
4. Gain a vision of global opportunities available for well-prepared product design/development engineers
5. Begin to understand the integrated nature of business, engineering, law, and other disciplines in a global economy

Outcomes 1, 3, 4, and 5 contribute to developing the students' design abilities and experience, while outcomes 2, 3, 4, and 5 specifically address design as a global, multi-cultural activity. These outcomes are assessed in three ways. First, each student group prepares and delivers an oral presentation describing their design process and demonstrating the resulting product. Second, each group writes a technical report detailing their design and the process used to develop it. Third, each student in the class completes a questionnaire about the course, its activities, and their experiences, including peer collaboration and contributions. The first two assessments look closely at students' design experience, while the third gives feedback on the students' experiences in multi-cultural design teams. As indicated, future work is planned to assess the effectiveness of the program in achieving desired outcomes.

Benefits of Collaboration

This program provides a flexible model to incorporate additional faculty and universities. Since the course is team taught, it is relatively easy to invite a new professor to participate where they can teach modules based upon their expertise pertinent to the course material. As long as a university is interested and committed to the program there is potential to scale the program pending support from all universities involved.

Students and faculty are also able to closely collaborate with industry. Industry has participated in this collaboration in two key ways: hosting tours during the summer program and sponsoring projects. The site visits to companies in Singapore are a highlight of the program. Students are able to observe best practices in design, testing, and manufacturing that provides context for their design efforts and exposes them to additional company/industry design perspectives.

Industry partners also gain exposure to students and faculty through the sponsored projects and tours that enable them to reflect on and articulate their own practice. Although the quality of project outcomes has varied (as it always does with student projects) the industrial sponsors are pleased with the results. In addition to receiving project deliverables including prototypes and concept descriptions, industry partners have the opportunity to work closely with international student teams on projects of mutual interest. We have been fortunate in that many of the project sponsors have offices in both the USA and Singapore.

Benefits for Students

In addition to the outcomes listed above, the program provides a number of more culturally oriented benefits to students. This type of multi-national, multi-cultural activity has proven to be an ideal environment for teaching and learning about product development in and for global markets. The US students, in particular, benefit from the multi-cultural experience. Although the Singaporeans are accustomed to the “melting pot”, working closely with students from the US has also benefitted them. The different cultural attitudes, in particular towards risk-taking, are the most commonly observed difference. *For example, when conducting their design activities, the students from the US are often more willing to generate and consider non-traditional design concepts.*

Students are able to participate and learn in a team-based immersive cross-cultural international design experience. Each student benefits from working with people who think and act differently than they do^{7,8,9}. Exposure to another culture helps students to develop respect and appreciation for other processes and systems, economic, historical, political, and other views that differ from their own. Students become more open to accepting new ideas and opinions and are more comfortable to seek out new experiences and associations. *For example, students in this program reported that exposure to the diversity of thought and culture increased the range of innovative design concepts and deepened their learning.*

Engineering organizations benefit from having employees with a diverse range of skills and experiences. Cross-cultural adaptability, respect for cultural differences and intercultural communications skills and sensitivity are important for engineers to be successful within a global

environment^{10,11}. This diversity is especially a competitive advantage in product development organizations where creativity and the ability to handle ambiguity are necessary elements in innovation. As companies become more global the requirement for employees who possess global competence also greatly increases¹².

International study abroad experiences, especially with an engineering emphasis are providing large benefits to students to increase their global competence. A significant, but difficult to measure advantage for students participating in the program is personal development. *For many students self-confidence and maturity increase. They have a positive experience in facing and overcoming ambiguity that builds confidence in their ability to have future success when faced with similar situations.* The Institute for the International Education of Students (IES)¹³ conducted a large survey of students from decades of study abroad programs. While the programs were not engineering related or product development related, the results of the survey validate the anecdotal results we have observed in this program. The survey found that greater than 95% of participating students experienced increased self-confidence and maturity. More than 80% of respondents indicated positive effects resulted from their exposure to the diversity associated with another culture. At least 63% indicated that the international study abroad program influenced their career interests and path.

Academic commitment can increase as a result of the international experience. As students are exposed to new learning activities they acquire new skills that influence and better prepare them for their chosen career path. These international programs also have the potential to ignite interest in new or alternative career paths as well. We believe that this program is having the desired outcomes and is providing significant benefits to students to help prepare them to take advantage of and be successful in the global economy.

Benefits for Participating Universities

While learning experiences rooted in travel-based collaborations can be important, there are capacity and financial factors that prevent the opportunity from being available to all students. As a result, all three institution partners actively pursue opportunities to engage students in a less resource-intensive manner. One benefit of the collaboration is the expansion to these non-travel experiences. For example, activities in the summer program have extended to course collaborations during the academic year. Senior-level (i.e., “capstone”) design teams from the three principal universities have collaborated on projects during the academic year. These joint-projects face all the challenges of typical capstone projects with the additional logistical and cultural issues of international collaboration. They are an excellent opportunity for our students.

The institutions have also benefitted from first-hand experience with new programs. For example, the experiences at NUS with the development of their design-based curriculum have informed related efforts at Penn State University. Similarly, Penn State University has more than a decade of experience with a college-wide freshman engineering design course. *Best practices in program development at one institution are readily transferred to the others.* There are also ancillary benefits due to public perception of the association with the other institutions.

Benefits for Faculty

Similar to the benefits described for students, faculty and their associates develop increased awareness and capability in communicating across other cultures and learning from others who think and act differently than they do. The mutual interest in teaching has led to a sharing of teaching strategies. *Due to the intensive, but short schedule, each professor is able to attend all class sessions and observe and learn from one another.*

The compressed program schedule also makes it a good laboratory to try new things and receive immediate feedback. As a result both the summer program and the courses that the faculty teach have evolved and improved. The faculty have also benefited as we host one another on visits, including a sabbatical. This results in deeper research collaborations, including the co-advising of students. It also provides an opportunity to learn about other curricular developments, facility improvements, etc.

Obstacles to Collaboration

Fortunately, the institutions currently involved in the program are all on semester-based schedules that begin and end at approximately the same time. This reduces the logistical issues both in providing the summer program and in coordinating additional collaborations. Universities considering a similar program would benefit in identifying partner universities with schedules similar to their own, otherwise the logistics involved in coordinating details between partner universities may be too difficult and could jeopardize the success of accomplishing student outcomes.

Major considerations affecting the workable and sustainable offering of such a multi-university partnership program include a common schedule suitable for professors and students from all participating universities, recognition of the program for credit consideration, fee structure and/or exchange agreement, and setting up of an administration procedure with dedicated support by the hosting university to facilitate registration, accommodation and facilities booking, hospitality, and teaching activities. For example, while there is interest from European and Chinese universities, there is difficulty finding a common schedule with the U.S. universities for their students to participate in the program.

Similar to the challenges faced in industry, communicating across geographical and time separations can be difficult. While there is only a 2-hour time difference between PSU and BYU, the time difference between those institutions and NUS ranges from 12-15 hours, depending on the time of year. For the non-travel collaborations, that means that meetings happen early in the morning and late at night. While this enables a 24-hour design cycle, it can be difficult to coordinate among the participating universities.

As is often the case, the costs associated with international travel can be problematic—and they continue to increase annually. All universities involved work to keep the program costs down but as costs continue to increase it may affect the number of students who are able to participate. As a result, the continued development of non-travel programs is important to this multi-university collaboration. The relationships developed during the summer program help to facilitate that.

Finally, like all relationships, providing a program like this takes time. Faculty need time to maintain the relationships, recruit and manage student participants, prepare materials, and continue to innovate and improve the course content.

Conclusion and Plans for Future Work

Student feedback and course evaluations indicate the positive results the program has in providing a multi-cultural international immersive team-based design experience. The summer design program has fostered additional collaboration across the three partner institutions including: faculty exchange, teaching method development, senior capstone design, international research exploration, and exploration of additional international collaborations. This model can easily be adapted to other course content and could be offered anywhere in the world as long as there are two universities interested in international collaboration. BYU and PSU continue to explore additional collaboration opportunities with other universities in hopes of replicating the success found in the NUS summer design program.

Future work will include an assessment of the effectiveness of the program in meeting course outcomes including gathering pre-experience and post-experience competency data from students.

Bibliography

- ¹ Warnick, G. M., Global competence: Determination of its importance for engineers working in a global environment. PhD diss., Department of Educational Administration, University of Nebraska – Lincoln, 2010. Accessed 1/3/2014 from <http://digitalcommons.unl.edu/cehsedaddiss/35/>.
- ² Lohmann, J. R., Rollins, H. A., & Hoey, J. J. (2006). Defining, developing and assessing global competence in engineers. *European Journal of Engineering Education*, 31 (1), 119-131.
- ³ Hunter, B., White, G.P., Godbey, G., What does it mean to be globally competent? *Journal of Studies in International Education*, Vol. 10, No. 3, 267-285 (2006)
- ⁴ Parkinson, A. (2009). The rationale for developing global competence. *Online Journal for Global Engineering Education* 4: 1-15.
- ⁵ Parkinson, A.P. Engineering Study Abroad Programs: Formats, Challenges, Best Practice, *Proceedings of the ASEE 114th Annual Conference and Exposition*, Honolulu, Hawaii, June 24-27, 2007.
- ⁶ Wikipedia. *Hawker center*. Accessed 1/2/2014 from http://en.wikipedia.org/wiki/Hawker_center
- ⁷ Allan, M., & Chisholm, C. U. (2008). The development of competencies for engineers within a global context. *EE2008* (pp. 1-12). Loughborough: Higher Education Academy Subject Centre and the UK Centre for Materials Education.
- ⁸ Doerry, E., Doerry, K., & Bero, B. (2003). The global engineering college: Exploring a new model for engineering education in a global economy. *Proceedings of the 2003 ASEE Annual Conference & Exposition*. Session 1279. Nashville, TN: ASEE.
- ⁹ Mariasingam, M., Smith, T., & Courter, S. (2008). Internationalization of engineering education. *Proceedings of the ASEE Annual Conference & Exposition*. AC 2008-1144. Pittsburg, PA: ASEE.
- ¹⁰ Flynn, G. (1995). Expatriate success is no longer just a question of job skills. *Personnel Journal*, 84(6), 29.
- ¹¹ Graf, A. (2004). Expatriate selection: An empirical study identifying significant skill profiles. *Thunderbird International Business Review*, 46, 667-685.
- ¹² Kohrs, K. (n.d.) Program in global engineering [Brochure]. Ann Arbor, MI: University of Michigan College of Engineering.
- ¹³ Dwyer, M.M., & Peters, C.K. The benefits of study abroad. Accessed 1/3/2014 from IES Abroad News <http://www.iesabroad.org/study-abroad/news/benefits-study-abroad>