AC 2009-526: A PRACTICAL GLOBAL DESIGN COMPETITION

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A PRACTICAL GLOBAL DESIGN COMPETITION

Abstract

The Accreditation Board for Engineering and Technology (ABET) has made clear the need for engineering graduates to function on global, multi-disciplinary teams. Industry has also made it clear that global, integrated product and process teams are the current and emerging normal manner of business. To satisfy industry’s need and ABET requirements, Wichita State University has initiated the Spirit Global Design Challenge. Often, these two requirements (teaming and global) are considered independently. One of the key components of the Spirit Global Design Challenge is to integrate multi-disciplinary teaming in a global environment. Eight students from two institutions (four from each institution) on each side of the Atlantic participated in the challenge in the Fall of 2008. Each student, faculty and industry person involved completed a survey concerning their global perceptions. The survey was completed prior to the experience and after completion of the experience. Producing global engineering graduates is a strategic goal of our college which has launched a strategic initiative, the ‘Engineer of 2020,’ in order to prepare graduates for effective engagement in the engineering profession in the year 2020. Both global and multidisciplinary criteria are now part of a program required for all engineering students beginning with the Fall 2007 class. This program will make the educational experience more meaningful to the student and the student more desirable to local, national and international industries. This paper describes the motivation for the Spirit Global Design Challenge, its linkage to ABET outcomes, defines global learning and how it integrates into the Engineer of 2020 program, and provides pilot implementation lessons learned and the initial assessment of students’ global perceptions (pre and post global design experience). The paper then concludes with plans for the next implementation.

I. Introduction and Motivation

Industry has made clear the need to graduate engineers with more than just technical skills. A key component for today’s graduate is the ability to thrive in a globally collaborative workplace. Engineers must work with global colleagues in both face-to-face and computer mediated environments. Efforts to assess virtual team projects have been performed. This paper describes the Spirit AeroSystems Global Design Challenge (SGDC) which is an effort to integrate design and global communication. The effort is motivated by Wichita State University’s goal to broaden engineering graduates, and by Industry’s demand for well rounded graduates, as well as the Accreditation Board for Engineering and Technology (ABET) criteria for accrediting engineering programs.

The GDC is a collaboration among Spirit AeroSystems and two university partners. In 2008, the university partners were Wichita State University (WSU) and the University of Manchester (UM). Spirit AeroSystems is the largest tier 1 supplier in the aerospace industry, providing aero structures and systems. Spirit has worldwide facilities in Wichita, KS; Tulsa, Oklahoma; McAlester, Oklahoma; Prestwick, Scotland; Samlesbury, UK; and joint ventures in Moscow, Russia; Malaysia; and China. The 2008 Challenge involved students and faculty from the two universities and practicing engineers from two Spirit AeroSystems sites. The participants were
divided into two teams with the task of designing a segment of aircraft fuselage. The project provided an experience for students to work with global colleagues and to experience this collaboration in both face-to-face and computer mediated environments. This paper describes the initial results from the pilot implementation in Fall 2008, lessons learned from the pilot, and plans for the next generation of the project in 2009.

II. Literature on Global Learning and Definition

Many have presented the need for engineers to be more aware of global issues, cultural concerns, and even global constraints in design. In fact, Shuman, et al.² state that future engineering graduates need “to become highly innovative global ‘problem solvers.’” Downey, et al.³ present the required competencies for an engineer to be “globally competent.” Global learning may even impact the lifelong learning of graduates. As students become more aware of differences in clusters, even in engineering design, they realize their need to learn throughout their lives.⁴ The definition of global learning is considered by some to be less important than the implementation. According to Hedberg⁵, there is a degree of consensus regarding the definition of global learning, but the problem is in regard to “how to attain these ambitious goals.”

For the purpose of the SDGC, global learning is defined as the combination of global reach, achieved with modern communication technology, and global perspectives arising from interaction between students living in different countries, to educate the global citizen. Features of global learning include:

- An authentic and substantive goal, such as producing a design for a client or solving an engineering problem
- Working in a multi-disciplinary team with people living in other countries or with a client from another country
- A focus on requiring the students to learn more about culture through improving their intercultural communication competence
- Opportunities for professional presentation of the global learning experience

Integration of global learning into an engineering course involves changes to the learning strategy, taking it from a didactic/pedagogical approach to a heutogogical approach that involves autonomous learning. Typically, students will need to learn in a team towards some substantive and authentic goal. In the process, they must be able to communicate effectively. That, in turn, requires them to understand the perspectives of each other and themselves, improving their intercultural communication competence.

III. Engineer of 2020

The College of Engineering (CoE) at Wichita State University (WSU) has launched a strategic initiative, Engineer of 2020, in order to prepare graduates for effective engagement in the engineering profession in the year 2020. This initiative is, in part, motivated by two reports from the National Academy of Engineering, of the National Academies, entitled “The Engineer of 2020”⁶ and its follow-on report, “Educating the Engineer of 2020”⁷. These reports, written by two groups of distinguished educators and practicing engineers from diverse backgrounds, were developed in response to a concern that engineering students of today may not be appropriately
educated to meet the demands that will be placed on the engineer of the future, without
refocusing and reshaping the undergraduate engineering learning experience. In the first report,
the group provided guiding principles that will shape engineering activities in 2020. The report
also states that in order to successfully educate engineers who can effectively contribute in this
changing landscape, engineering educators will have to produce graduates who possess more
than just the technical knowledge and skills traditionally taught to engineering students.

A number of noted engineering education leaders have responded and commented on these
reports. Butcher claims the reports call for “ingenious leaders — ingenious engineers” and calls
these engineers, “well-rounded Renaissance Engineer”[s]8. Turns, Atman, et al.,9 use these
reports as an input to what an engineer needs to know. Dym, et al. present how engineering
education is being challenged to require students to consider additional design constraints
required as part of “new fundamentals”10. In response to this challenge, the CoE at Wichita State
University intends to establish its leadership in reshaping the undergraduate experience to
prepare the engineer of 2020, and at the same time make the educational experience more
meaningful to the student and the student more desirable to local and national industries. As
such, the CoE proposes that to fulfill the requirements for an Engineering BS degree at Wichita
State University, each student will complete the program course requirements including at least
three of the following six activities:

1. Undergraduate Research
2. Cooperative Education or Internship
3. Global Learning or Study Abroad
4. Service Learning
5. Leadership
6. Multidisciplinary Education

Three of the above are required to provide flexibility for the student to tailor the program to their
individual needs. The three requirements can be integrated into current curriculum choices and
not create an undue burden for students. One of the three requirements the student chooses could
be the Global Learning or Study Abroad criterion. To complete this requirement, the student
must complete one or more of the following:

1. Successfully participate in a global learning project within an existing class; this will
typically involve internet-based communications with students, teachers, and colleagues
in at least one other country. Global learning projects should include at least one
participant from outside the English-as-a-first-language world (e.g., Russia, Japan, China)
to be eligible.

2. Successfully complete a study abroad component; this involves participating in a credit-
bearing, university-approved study abroad activity in a foreign country. (Note: Students
possessing an F-1 VISA qualify for this criterion and must submit a form to the Director
of Engineering Education.)

3. Submit a previous global learning or study abroad experience; in this case, the student
must prepare a two-page report outlining:
• Summary of previous experience, including dates and locations
• Description of the student experience (typically a reflective paper, though not restricted to this)
• Contact information of faculty/sponsors involved in the global learning experience

The effort described in this paper directly applies to the “Global Learning” criterion of the Engineer of 2020 program. More details on the complete Engineer of 2020 program at Wichita State University can be found in\textsuperscript{11}.

IV. Linkage to ABET outcomes

The second motivation for the effort described in this paper is the new Engineering Criteria 2000 (EC2000) of ABET which states that graduates must attain the following criteria (those that apply directly to this effort are shown with **):

a) an ability to apply knowledge of mathematics, science, and engineering
b) **an ability to design and conduct experiments, as well as to analyze and interpret data
c) **an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) **an ability to function on multi-disciplinary teams
e) **an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) **an ability to communicate effectively
h) **the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in, life-long learning
j) a knowledge of contemporary issues
k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Many of the ABET outcomes are met by several activities (a single activity does not fulfill the requirements). The Global Design Challenge is to improve the skills and knowledge of our graduates and is part of a comprehensive effort to improve our graduates.

V. Pilot

This section of the paper describes the pilot for the Global Design Challenge in Fall 2008 and the lessons learned. The pilot implementation of the program is shown in Table 1 for the two cohorts (teams). The pilot implementation included students and faculty from Wichita State University and the University of Manchester. In order to ensure a successful pilot, two students from each university were on each cohort. One faculty from each university was a part of a single cohort as was a design engineer from Spirit AeroSystems. The pilot had four students from each university and each university funded the students and faculty. All cohorts (teams) were given the same design challenge and competed for the best design.
The design project was identified as a fuselage design effort which included providing trade study summaries and detail down select for non-lattice structural configurations to meet prequantified loads, pressures, and weight challenges.

Table 1: Pilot Implementation

<table>
<thead>
<tr>
<th>Team 1</th>
<th>Team 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• WSU Student 1</td>
<td>• WSU Student 3</td>
</tr>
<tr>
<td>• WSU Student 2</td>
<td>• WSU Student 4</td>
</tr>
<tr>
<td>• UM Student 1</td>
<td>• UM Student 3</td>
</tr>
<tr>
<td>• UM Student 2</td>
<td>• UM Student 4</td>
</tr>
<tr>
<td>• WSU Faculty</td>
<td>• UM Faculty</td>
</tr>
<tr>
<td>• Spirit - Wichita</td>
<td>• Spirit - Prestwick</td>
</tr>
</tbody>
</table>

Student and faculty selection process:

Students from Wichita State University were recruited by advertising the GDC in classes and with poster displays. Students were selected after submitting their resumes and a cover letter (students were given a rubric which assessed each student). The rubric allowed the evaluators to narrow the list of candidates. Spirit AeroSystems and Wichita State University faculty interviewed each of the candidates and selected the students to participate. The University of Manchester students were selected by faculty at the institution. The selection of the WSU and UM faculty was done in partnership by the institutions and by Spirit AeroSystems.

Timeline:

WSU students were selected in May 2008 and UM students were selected in August. Students met via a teleconference call in early September and the UM students then traveled to Wichita where they stayed for approximately two weeks. During the time in Wichita, each student team worked independently, but all students engaged in many social activities together. The students went to Spirit AeroSystems in Wichita for intellectual property training and were given a tour of the facilities. Just before the UM students left Wichita, the students presented to Spirit personnel demonstrating their progress. Each group was not permitted to see the other team’s presentation. The student groups met virtually using various collaboration tools for the next three weeks. Then, the WSU students visited Manchester for a week (including tours of UM facilities and Spirit UK facilities). At Spirit Prestwick students again presented their progress. Students continued meeting in computer mediated environments and submitted their written reports. The project duration was about 4 months.

Most of the lessons learned from pilot implementation related to project logistics. The most obvious issue is matching the semester length. Matching the design challenge timeline to the university schedule is difficult with two universities. The next implementation will have three universities, which will make matching the challenge timeline to all three universities challenging. Another issue is the length of stay when students visit another institution. The one week stays used in the pilot may not be sufficient. Students need time to acclimate to a new time
zone and to a new culture. If students have not acclimated to the time zone and the culture to at least a small degree then the issues with presenting technical concepts to different cultures will not be as noticeable to the students. The final issue concerns the interval between the face-to-face visits (the previous three weeks between visits was too short). The next implementation will ensure that there is a longer period between the visits.

VI. Assessment Methods

There are two types of outcomes that will be examined from this project: project results (design) and student learning. Overall student learning will be assessed in two areas: 1) student attitudes and perceptions about the impact of global issues on design and on design teams and 2) the quality of the resultant design. The first outcome will be assessed with a pre and post test attitude survey and the second outcome will be assessed by industry. A key benefit to this type of effort is in student experience with evaluation both by industry and faculty. Spirit AeroSystems had several people involved in this pilot effort and they determined the “winners” of the competition. Spirit AeroSystems provided feedback using industrial criteria for each group that will be invaluable both for the student and the academic institutions. Another benefit is that industry was more exposed to academic evaluations of these kinds of efforts. The remainder of the paper will focus on analysis of the pre and post survey results of the pilot study.

Participants:

Two design teams involved in an international project for the Fall 2008 semester were asked to participate in a survey regarding attitudes and perceptions about the impact of global issues on design and on design teams. Each team had a faculty sponsor, 4 students, and an industry person. All members in the design team completed a pre-survey at the beginning of the project and a post-survey at the completion of the project.

There were 9 participants (6 students, 2 industry, and 1 faculty) who took the pre and post surveys. The faculty participant was a male from Taipei, Taiwan with Mandarin as his native language and English as a second language. The faculty participant had a Ph.D., belonged to the age group of 45 to 54 years old, and had 15 years of experience teaching.

Materials:

A survey was created to measure participant attitudes and perceptions about the impact of global issues on design and design teams. Downey, Lucena, Moskal, Parkhurst, Bigley, Hays, Jesiek, Kelly, Miller, Ruff, Lehr, & Nichols-Belo\textsuperscript{12} provide a typology of methods for accomplishing global competency (international enrollments, international projects, international work placements, international field trips, and integrated class experiences). Hunter, White, and Godbey\textsuperscript{13} conducted a survey to help define global competency. Both resources were used to develop the Global Competency Attitude Survey for Engineering Students used in this study.

Procedure:

Participants received a link to the online survey twice in the Fall 2008 semester. The survey started with an informed consent then asked some demographic questions. The rest of the survey
consisted of attitudinal questions. The survey took an average of 6.53 minutes (SD = 5.47) for participants to complete.

Results:

Paired samples t-tests were conducted in SPSS for the pre and post surveys’ attitudinal questions for the student participants (due to the insufficient sample size of industry and faculty participants, no statistical analysis was conducted for these sub-groups). The student participants had significantly different responses (t(5) = 2.24, p = 0.03) for the attitudinal question “I understand the demands of cross-cultural communication.” Responses to several other questions showed a marginal change. For example, students rated themselves as more able to “recognize that there are always different ways to solve a problem” (p=.08) and to “communicate in more than one language because I am savvy about the cultural and language demands” (p=.09) at the end of the project. Interestingly, students also rated themselves less able to “communicate engineering ideas to non-engineers” at the end of the project.

Pre and post scores were also compared for the entire group of participants. Participants had a higher agreement with the statements “I understand the concept of globalization” and “I understand the demands of cross-cultural communication” in the post-survey ((t(8) = -3.15, p = 0.05; t(8) = 2.53, p = 0.04). Interestingly, the statement “I can communicate engineering ideas to non-engineers”, showed a decrease (p=.08). As the students presented their project to several groups that included non-engineers, students became more aware of the difficulty in presenting technical material to non-technical people. Table 2 shows the means, SDs, t values, and significance (2-tailed) for the attitudinal statements for student only as there were a low number of responses for the industry and faculty groups.

Table 2. Student Responses to Pre and Post Survey.

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre Survey Mean (Std. Dev)</th>
<th>Post Survey Mean (Std. Dev.)</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating for English Writing Abilities</td>
<td>4.50 (.55)</td>
<td>4.67 (.52)</td>
<td>-.54</td>
<td>5</td>
<td>.63</td>
</tr>
<tr>
<td>Rating for English Speaking Abilities</td>
<td>4.67 (.52)</td>
<td>4.40 (.55)</td>
<td>1</td>
<td>5</td>
<td>.36</td>
</tr>
<tr>
<td>I feel able to participate in eng projects in a foreign country</td>
<td>4.33 (.82)</td>
<td>4.33 (.52)</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>I am open to new experiences</td>
<td>4.67 (.52)</td>
<td>4.83 (.41)</td>
<td>-1</td>
<td>5</td>
<td>.36</td>
</tr>
<tr>
<td>I know when I’m suffering from culture shock</td>
<td>3.83 (.75)</td>
<td>4.33 (.82)</td>
<td>-1.46</td>
<td>5</td>
<td>.20</td>
</tr>
<tr>
<td>I can communicate effectively with people from different cultures</td>
<td>4.33 (.52)</td>
<td>4.17 (.41)</td>
<td>.54</td>
<td>5</td>
<td>.61</td>
</tr>
<tr>
<td>I can communicate engineering ideas to non-engineers</td>
<td>4.67 (.52)</td>
<td>4.17 (.41)</td>
<td>2.24</td>
<td>5</td>
<td>.08</td>
</tr>
<tr>
<td>I can cope with different cultures and attitudes</td>
<td>4.17 (.41)</td>
<td>4.50 (.55)</td>
<td>-1</td>
<td>5</td>
<td>.36</td>
</tr>
<tr>
<td>I understand the concept of globalization</td>
<td>4.17 (.41)</td>
<td>4.83 (.41)</td>
<td>-2</td>
<td>5</td>
<td>.10</td>
</tr>
<tr>
<td>I can collaborate with a diverse design team</td>
<td>4.33 (.52)</td>
<td>4.50 (.55)</td>
<td>-1.42</td>
<td>5</td>
<td>.70</td>
</tr>
<tr>
<td>I understand the demands of cross-cultural communication</td>
<td>4.17 (.41)</td>
<td>4.83 (.41)</td>
<td>-3.16</td>
<td>5</td>
<td>.03</td>
</tr>
<tr>
<td>I can recognize that there are always different ways to solve a problem</td>
<td>4.17 (1.17)</td>
<td>4.67 (.82)</td>
<td>-2.25</td>
<td>5</td>
<td>.08</td>
</tr>
<tr>
<td>I can relate to people who are from a different culture</td>
<td>3.83 (.41)</td>
<td>3.67 (1.03)</td>
<td>.54</td>
<td>5</td>
<td>.61</td>
</tr>
</tbody>
</table>
I know how to communicate engineering ideas to other engineers regardless of their country of origin  
4.17 (.41) 4.33 (.52) -.54 5 .61
I am familiar with business settings in other parts of the world  
2.67 (1.03) 3.50 (1.05) -1.75 5 .14
I know when other people are suffering from culture shock  
3.50 (.55) 3.83 (.75) -1 5 .36
I am able to communicate in more than one language because I am savvy about the cultural and language demands  
2.50(1.23) 3.33 (1.63) -2.08 5 .09

VII. Future Implementation

This section describes the plans for the next implementation. These plans are based on the experience during the pilot and the lessons learned. The section begins with details for how the cohorts will be divided for 2009.

The next implementation of the program is shown in Table 3 for the three cohorts (teams) and includes students and faculty from Wichita State University, University of Manchester and University Sains Malaysia. Two students from each university are on a single cohort, and each university will supply six students total. One faculty from each university and one design engineer from Spirit AeroSystems will also be included in each cohort.

<table>
<thead>
<tr>
<th>Team 1</th>
<th>Team 2</th>
<th>Team 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSU Faculty Focal</td>
<td>UoM Faculty Focal</td>
<td>Malaysia Faculty Focal</td>
</tr>
<tr>
<td>WSU Student 1</td>
<td>Malaysia Student 1</td>
<td>UoM Student 1</td>
</tr>
<tr>
<td>WSU Student 2</td>
<td>Malaysia Student 2</td>
<td>UoM Student 2</td>
</tr>
<tr>
<td>UoM Student 3</td>
<td>WSU Student 3</td>
<td>Malaysia Student 3</td>
</tr>
<tr>
<td>UoM Student 4</td>
<td>WSU Student 4</td>
<td>Malaysia Student 4</td>
</tr>
<tr>
<td>Malaysia Student 5</td>
<td>UoM Student 5</td>
<td>WSU Student 5</td>
</tr>
<tr>
<td>Malaysia Student 6</td>
<td>UoM Student 6</td>
<td>WSU Student 6</td>
</tr>
<tr>
<td>Spirit Europe Sponsor</td>
<td>Spirit Malaysia Sponsor</td>
<td>Spirit Wichita Sponsor</td>
</tr>
</tbody>
</table>

It is likely that students in the subsequent cohorts may need more intercultural training prior to participation since these future cohorts will be working with students from countries that may be more culturally diverse than those working primarily in the UK and USA. Other changes will be implemented from the “lessons learned” from the pilot implementation. The success of the pilot will be reviewed upon completion. Based on the pilot, necessary modifications will be identified.

Students are typically provided credit towards their degree (either class or final project) and a stipend for participation in the challenge. Students and faculty are expected to meet with their team (virtually, when not on the same campus) at least once a week during the challenge – this includes record keeping of the meetings. Industry provides an appropriate design challenge and provides each team with a mentor to consult about challenge details.
VIII. Conclusion

The student experience in the College of Engineering at Wichita State University is becoming a holistic approach that addresses all aspects of student education, with an emphasis on well-rounded students and graduates. Industry needs, accreditation requirements and The National Academy of Engineering reports, “The Engineer of 2020” and “Educating the Engineer of 2020” have made it imperative to implement programs like the Spirit Global Design Challenge. This paper presented an overview of the current plans for implementation of this program at WSU.

The type of effort presented in this paper has significant benefits to both industry and academia. Students developed more innovative design skills. The bandwidth for creativity and innovation is increased, instilling design in a more diverse environment. Students are exposed to multidisciplinary teamwork and learn how to be effective while working “globally.” Industry benefits by helping to develop, and subsequently recruit, better engineers. Spirit Aerosystems will improve its recognition as a Global Integrator. In addition, Spirit Aerosystems will gain access to new and different ideas by tapping into a youthful student resource pool. There is also the potential of cost savings by resolving “engineering challenges” that may be solved with the influx of new and diverse talent. Both industry and academia benefit by developing key relationships on a global scale. As more engineers are needed with global collaborative skills, efforts like the SGDC can develop engineers to face the needs of today’s (and tomorrow’s) industry.

The students in the pilot showed a significant increase in their understanding of cross-cultural communication and globalization. The next implementation will provide an additional opportunity for students to participate in a global design team.

References

