Evaluation of the Engineers Without Borders Challenge at Western Australia Universities

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Abstract: *Since 2007, Engineers Without Borders, Australia (EWBA) has coordinated a national first year engineering design challenge for students attending Australian universities. The EWB Challenge offers students the opportunity to work in a team on a real world problem aiming to improve conditions in a disadvantaged community. Since its inception, the EWB Challenge has had over 18,000 students at 31 universities participate. However, little program level evaluation has been conducted to assess the impact of the competition on student learning or the overall student experience. In 2010, a mixed methods program evaluation was initiated at the three universities in Western Australia actively participating in the Challenge during semester one. This evaluation contained two elements: semi-structured focus groups and a common survey. This paper focuses on the evaluation plan, including methods, preliminary results and plans for ongoing and expanded evaluation of the Challenge.*

Introduction

In 2007, Engineers Without Borders, Australia (EWBA) began conducting a first-year engineering design challenge at 24 universities around Australia. Since then, more than 18,000 students have participated in the EWB Challenge at 31 universities. However, little systematic evaluation has been conducted to understand how much students are learning from the Challenge. This paper will present an initial evaluation of the Challenge at Western Australian Universities during the first semester of 2010. The evaluation was a mixed methods investigation containing two components. The first component was a survey that was distributed to nearly all of the first semester participants in Western Australia. The second component was voluntary semi-structured focus groups conducted at each university. The combination of these two components allowed for the researchers to triangulate the students' perceptions of the Challenge. The researchers plan to use this initial evaluation to develop a continuous monitoring and evaluation system for the Challenge.

To define the learning objectives for the Challenge for the purposes of the evaluation, the initial conference paper proposing a national design competition was consulted. Bullen, Webb and Brodie (2007) identified ten attributes as the benefits of a national first year design competition. These national design attributes were used as the student learning objectives for the evaluation of the EWB Challenge program. The objectives can be found in Table 1. Addressing accreditation criteria was not directly evaluated in this study and will not be discussed further due to the rest of attributes paralleling the accreditation criteria for both the Engineers Australia (Nafalski, McDermott, & Göl, 2001, pp. T4A-23) and ABET, the engineering accreditation board in the US, (Prados, Peterson, & Lattuca, 2005). Both list communication skills, working in multidisciplinary teams, knowledge of the engineering design process and knowledge of the globalization as graduate attributes. "The use of diverse assessment criteria" was combined with "forming the foundation of design streams" to create one design characteristic for this study to measure the students' understanding of the overall design

process. Retaining students and program integration were combined into one category of retention under the assumption that students who are well integrated are more likely to remain in engineering.

Table 1: Learning Objectives used in the Evaluation

Attributes: Students will	*Referenced as*	*Origin*
Understand the role of engineers in society	Society	Bullen et al.
Understand of team roles and teamwork	Team	Bullen et al.
Understand the globalization of engineering	Global	Bullen et al.
Use of diverse assessment criteria	Design	Bullen et al.
Address accreditation criteria		Bullen et al.
Illustrate the multidisciplinary nature of engineering	Multidisciplinary	Bullen et al.
Form the foundation of design streams	Design	Bullen et al.
Provide a professional base to retain students	Retention	Bullen et al.
Be integrated into the program	Retention	Bullen et al.
Approach mentors for pastoral care	Pastoral Care or PC	Bullen et al.
Be able to navigate the EWBA Website	Website	For addedevaluation
Enjoy working on the EWB Challenge	Challenge	For added evaluation

Methods

Three universities around Western Australia were identified for this study, based on their location, size, the timing of their course, and the implementation of the Challenge into a credited course. The uniform implementation of the Challenge by these universities was important to establish the generalizability of the results.

An exploratory mixed methods approach was chosen for this study. As this was an initial investigation into the program, mixed methods offered a way to triangulate the impact of the Challenge and to help guide the direction of future investigations. Exploratory mixed methods allow for an initial quantitative assessment, followed by a qualitative assessment to confirm and support the initial claim (Creswell & Plano Clark, 2007). In this study, an initial survey was used to gain responses from a majority of the Western Australian students working on the EWB Challenge in the first semester of 2010. In the same time frame, focus groups were conducted to help confirm the survey results and gain deeper understanding of student views on the Challenge. The results of the surveys and focus groups were analysed to discover elements of the program that were notably different from other program elements.

The techniques used for this evaluation measured the student's perceptions of what they were learning and the major elements of the Challenge. In future work, more direct measures of student learning will be included in the evaluation to ensure that the learning objectives that students self-report learning are truly being met.

Quantitative Methods

One researcher visited each university and distributed the survey. The survey contained 39 5-point Likert scale items and five open-response items. Paper and pencil format was chosen to encourage high response rates, as most students completed the survey during class time. Just over 550 students are enrolled in the EWB Challenge in WA, and 383 responses were obtained, indicating a 73% response rate. This response rate is high enough to ensure limited responders bias (Shannon, 1948) and therefore, no further actions were taken to correct for the bias. Once the surveys were completed, one researcher manually entered the data into a computer. Another researcher verified that there were no discrepancies between the written responses and those entered into the computer.

The survey was developed with questions addressing each learning objective of the Challenge. The items were grouped around these different attributes, and the means of these groups were statistically analysed for significant differences. The attributes identified as significantly higher or significantly

lower than the other components were identified as either strengths or weaknesses of the overall Challenge program. To begin, The Welch's test was used to analyse if the objectives had equal means to each other. This test assumes that the sample is independent and randomly selected. This assumption is considered to be met since students completed the questionnaire by themselves, with limited interaction with fellow students, allowing for an independent sample. Each student had an equal chance of being selected to complete the survey allowing a random sample to be assumed. Welch's test does not work well with skewed data, so a normal distribution must be assumed. Since the sample size was over 35, the central limit theorem ensures a normal distribution (Lix, Keselman, & Keselman, 1996). Welch's test was chosen over the usual F-test ANOVA due to unequal variances between the different attributes. The statistical software JMP (by SAS) was used to complete statistical analysis. Tukey's test for comparing means was used to individually compare the attribute means to each other to identify which means were statistically different. Tukey's test assumes that the sample sizes are equal (they varied slightly for this survey); however, a conservative estimate can still be offered with unequal sample sizes using Tukey's test (Hayter, 1984).

Qualitative Methods

Following the class period where the surveys were distributed, focus groups were conducted at each university. All students were strongly encouraged to attend, but participation was low due to additional time commitments beyond class time. The focus groups aimed to investigate student views of the program in more depth than is possible from a survey. A total of eight focus groups were conducted with a varying number of students at each university based on the timing of the lectures and availability of the students. There were between 1 and 6 students in attendance at each group. The focus groups were centred around four questions: What is the best part of participating in the Challenge? What is the most challenging part of working on the Challenge? How did the Challenge being based in Australia impact your motivation on the project? and What changes would you make to the Challenge if you were able? The sessions lasted approximately twenty minutes. The focus groups were recorded and transcribed by one researcher, then checked for accuracy by another. Thematic analysis was used to analyse the data from the focus groups (Boyatzis, 1998), in which themes emerge from the data rather than a predetermined list. The transcriptions were read once for major themes, and then reread to locate specific segments that supported the individual themes. NVIVO8 software was used to organize the coding process. During triangulation, these themes were related back to the learning outcomes evaluated in the survey to discuss strengths and weaknesses of the EWB Challenge.

Preliminary Results

The Welch's Test was used to compare the means of the attributes. The resulting F-value was 73.2 and the p-value was less than 0.0001, which is much less than alpha (0.05) indicating that there was a significant difference between one or more of the means. To discover which means were statistically different, a Tukey comparison was used. Table 2 shows the results of the Tukey analysis. A significant difference between results is indicated by the 'A' or 'B' in the table with 'A' meaning it was significantly high and 'B' indicating significantly low. 'AB' indicates the norm. From this analysis, the strengths of the Challenge are the Global, Multidisciplinary, and Team learning objectives. The EWB Challenge website is a weakness of the program. The rest of the attributes were neither strengths nor weaknesses.

The results of the thematic analysis were divided into program strengths and program weaknesses shown in Table 3. Program strengths were themes most commonly identified as benefits or positive aspects of the program by the students. Program weaknesses were areas most commonly seen as challenges the students faced, negative aspects of the program, or aspects the students thought should be changed to improve the program.

The results indicate that students enjoyed working on a real-life problem where they felt their solutions would make a difference. For example, one student said, "My favourite part was, probably, getting an actual project that you could work on. Something that was real. Something that wasn't thought up and you could actually apply your knowledge." Another student said, "We know that it's actually going to be applicable somewhere. So it's actually going to help." This was usually tied to the

idea of being able to help people. One student said, "what my research and what I was doing could actually, eventuate into affecting and improving somebody's quality of life." Other students said things like, "it really inspires you to do something for other people" and "we could really make a difference with someone else that was really important to me." Students also enjoyed working through the design process and feeling like an engineer, saying "even though we're students, [we're] acting like an engineer would in real life so we get the experience we need in the future and that was really rewarding for me." Multiple other benefits were identified in a smaller number of focus groups such as being creative with their solutions, working with other classmates, and doing something atypical for a classroom assignment.

Table 2: Results of Tukey Mean Comparison Test with alpha = 0.05

Attribute	*Grouping*
Global	A
Multidisciplinary	A
Team	A
Design	AB
Society	AB
Retention	AB
Pastoral Care	AB
Challenge	AB
Website	B

Table 3: Program Strengths and Weaknesses from Thematic Analysis

Strengths	*Weaknesses*
Working on a real-life problem	Finding information
Students are helping people	Element of university unit
Working like an engineer	Time constraints
	Navigating EWBA website

The weaknesses identified here are those that were coded in at least half of the focus groups. One weakness mentioned in every focus group was trouble finding information. This refers to the challenge of doing research on the indigenous community as well as general research on possible solutions. Many students expressed frustration when talking about conducting background research. This weakness was directly tied to the weakness indicated by both the surveys and the focus groups of the EWBA website. Students in the focus groups were not satisfied with the website logic commenting that they "found the website very hard to navigate" and they "found one or two things that were useful, but it was a challenge." Students thought the only place to find information was through the website due to the limited information on the Challenge community causing one student to say, "There's not much information available by searching on the internet...maybe the EWBA site should be more accessible for the information we need."

Other weaknesses were related to components of the course on the university level such as group size, when the students were put into groups, the lab and lecture sections and disjointed information from the tutors. These issues were mentioned in nearly all focus groups. For example, not having enough time to complete the project was discussed in just over half of the focus groups. Students at each university expressed a desire for more time. The discussions about time ranged from the project groups being assigned too late in the semester, through to not having time to work on the project until the end of the semester. Some students suggested having multiple assessments throughout the semester to help them keep pace and gradually work towards the final report, where others merely wanted to be formed into groups sooner.

Students were also asked their opinion on hosting the Challenge in rural Australia with the indigenous Australians versus overseas, as in previous year's Challenges. This was a measure of student interest as well as of their recognition of cultural diversity throughout the program. A majority of the students indicated that they liked working on a project based in Australia because it was helping *their* country

and they did not realize there was a need before working on the Challenge. One student said, "It's better if we try and help ourselves first and I think it's good that we're trying to help a rural community." Multiple students had negative views about working on an Australian project; however these did seem to be in the minority and were generally only represented by one or two members of the group. A few of the students expressed that the disappointment wasn't with the location as much with the project itself. One student said, in previous years "students got to think of ways to help a community that was in such a poor condition that the occupants were dying, but …we're creating a tourist attraction which is an extreme downturn from helping some people stay alive." The tone of response to this question was in general more positive, with students enjoying the opportunity to learn about a different culture and not really caring where the location was, as long as they were making a difference with real people. One student said, "it being in Australia with the indigenous aborigines… there were a few issues that I hadn't really understood or comprehended with the Aboriginals and it kinda explained a few of those. I [now] have a better understanding of the context for which the aboriginals live within Australia." According to another student, "It doesn't really make a difference to me, domestic or overseas. But the only thing that is changing for me is that I'm really working on the real project for real people."

Discussion

From the preliminary analysis outlined in the paper, a number of strengths and weaknesses of the EWB Challenge have been identified. Many of the strengths relate to students learning about globalization, the multidisciplinary aspects of a project, how to work in a team, as well as offering students the opportunity to work on a real world problem where they feel they are helping people. The main weaknesses identified were: the EWBA website, students having trouble finding information, the university unit in which the Challenge was embedded and the limited time allocated to the Challenge.

One of the benefits of students participating in the Challenge is the complex real-life elements that push students to independently identify customer needs and design constraints, while considering the community's cultural differences. This evaluation found that some students had difficulty making the leap from traditional structured problems, where all the necessary information is provided culminating with a "correct" answer, to an ill-structured real world problem with many possible solutions. Students expressed exasperation with the inability to find proper resources or not being able to find them in a timely manner. The researchers hypothesize that this was exacerbated by the limited resources available outside of the EWBA website to provide information about the indigenous community selected for the 2010 Challenge. The limited alternative resources for the students resulted in a negative perspective of the EWBA website and increased the frustration when students had trouble finding the information from the website. To aid students in their research for the Challenge, it is recommended that EWBA redesign their website for easier student navigation. By creating a website that is easy to traverse, the students will be more likely to spend time investigating the provided resources and less time searching. The website is the main source of Challenge information and one of the few ways students can contact EWBA with questions or concerns. A redesigned web site would be a valuable resource addressing all of the Challenge learning objectives, helping students to adapt to an open-ended project.

Many students in the focus group cited issues related to the university course in which the Challenge was embedded as a weakness of the program. EWBA has little control over the implementation of the Challenge in the classroom. Each university utilizes the Challenge in a way they perceive to be most beneficial for their students. However, due to the non-uniform implementation of the Challenge, there are no overarching solutions for improving the university elements. It is recommended that EWBA make a continual effort to not only supply course coordinators with information resources, but also continue conversation with them about what other resources are needed. In the future, EWBA will have data on individual university programs and students views of these different objectives based on the overall monitoring and evaluation of the program. This information will provide an overarching perspective to find best practices for implementing the Challenge from the individual universities. EWBA is encouraged foster relations between the university course coordinators to form collaborations between programs where best practices can be openly shared and discussed. It would

also be beneficial to develop a "best practice" scenario for course integration with organisations such the Australasian Association for Engineering Education (AAEE) and the Australian Council for Engineering Deans (ACED), which would help promote a productive level of consistency.

To help improve cultural awareness and the real world aspects of working with a customer, it is recommended that EWBA provide direct connection between the students and the community. This will highlight and enhance program strengths (real world aspects and working like an engineer) while addressing the weaknesses (gathering information) of the program. Multiple focus groups either recommended an increase in descriptions of the community or direct contact with community members. Due to the size of the Challenge, this is a very large undertaking. However, the benefits of allowing the students to interact with the community and to gain the experience of working with a different culture, and with an actual customer, outweigh the challenge of coordinating the experience.

Future Work

The researchers are in the process of developing an evaluation system that will be implemented at all universities participating in the Challenge. The initial step will continue the small scale evaluation of the WA universities in second semester of 2010. A pre/post-test technique will be used in which students will be surveyed at the beginning of the semester and then again at the end. Two comparable surveys will be used, adapted from the survey used in the first semester. This will allow researchers to gage the students' improvement over the duration of the Challenge. The next step for continual evaluation will be to use the preliminary results as a stepping stone to develop a general questionnaire for the nationwide evaluation of the Challenge. This process will begin with a pilot questionnaire, based on the WA evaluation, potentially being developed with the aid of the AAEE and the recently awarded Australian Learning and Teaching Council (ALTC) grant for EWB Challenge evaluation. The ALTC grant would utilize the questionnaire at the participating universities during development allowing for broader implementation outside of WA. The next phase would be to implement the questionnaire nationwide as part of the students' final design report for the EWB Challenge as part of the self reflection. This will enable EWBA to gain feedback from all students participating in the Challenge. The overall goal of the total project is to ensure that any future questionnaires become sustainable and lead to both better integration of the Challenge into university courses and better learning outcomes for students.

The next phase of this research will be to review the Challenge from the course coordinator's perspective. The first semester course coordinators will be surveyed and interviewed to assess their views and opinions about the Challenge. These will be compared to the students' views of the Challenge to identify disconnects and further gaps where the EWBA can assist and improve the program. The course coordinator component of the research will also aid in the research of how EWBA can better coordinate the Challenge when they have limited influence over implementation in the classroom. As a future effort, following the surveys and interviews, it is recommended that EWBA assist in creating a course coordinator network through a voluntary workshop, which will outline the results of the most recent evaluation and actions EWBA could take in response to the evaluation. This workshop will allow course coordinators to offer input into the evolution of the Challenge to not only gain their input, but to also increase their investment in the program and their willingness to implement the changes in their classroom. Finally, a best practice model could be developed during the consultative process to provide academic staff with an initial pedagogy structure to use as a scaffold for the needs and requirements of their own particular courses and programs.

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