Review of the Enhancement of university curriculum through utilisation of sustainable engineering and appropriate technology workshops

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***Abstract**: In 2010 Engineers Without Borders Australia (EWBA) began to work with the Engineering faculties of WA based universities to develop a new education program designed to provide a practical and meaningful task for engineering students to undertake as part of their coursework through EWBA outreach activities. This program was designed to meet the broader requirements of Engineers Australia's Professional Engineering Attributes focusing on engineering sustainability outcomes and to facilitate engagement between university and secondary school curriculum via sustainable engineering and appropriate technology workshops.*

This paper builds on the work completed in 2010 to evaluate the success of the program in meeting its university curriculum objectives and students' satisfaction. Evaluation of the program though written feedback and online survey of participating students and schools found that the program was successful in meeting the university learning outcomes aligned with the Engineers Australia Professional Engineering Attributes whilst undertaking practical and meaningful service within the community. The feedback also demonstrated some opportunities to improve the quality of the Future Engineers program by providing more contextual information and details of professional practice and by improving the coordination of the location and timing of outreach visits which will be incorporated into the program next year.

Introduction

Engineers can play a major role in implementing sustainable development agendas. University engineering degrees need to produce graduates who are able to apply sustainability principles throughout their professional career. DeGrazia et al. (2001) have demonstrated that teaching engineering in secondary schools improves the content of classes through exposure to real world problems. The engagement of university students in these secondary school programs enhances the engineering curriculum by taking community into account.

Engineers Without Borders Australia's (EWBA) Future Engineers program has attempted to improve secondary students' understanding of engineering and science thus encouraging participation at higher levels. The purpose of this program is to engage university students with the broader community, whilst teaching them about sustainability, team work, communication and professional practices. In 2010, Engineers Without Borders Australia (EWBA) began conducting a curriculum based High School Outreach program in collaboration with Western Australian based universities (Loden & Biswas, 2010). Loden and Biswas (2010) worked on the feedback data of school students to determine how they benefitted from participation. In this paper, a detailed survey of engineering students was carried out to evaluate the success of the Future Engineering program in meeting its university curriculum objectives and students' satisfaction whilst identifying opportunities to improve

the program in future years.

Loden and Biswas (2010) identified eight Professional Engineering attributes that could be developed from the Program, which are assessed within this paper. These are outlined below.

Table 1: Learning Objectives used in the Evaluation (Loden & Biswas, 2010)

Professional Engineering Attributes	
PE 2.1: Problem Identification	PE 3.3: Creativity
PE 2.2: Sustainable Development	PE 3.4: Ethics
PE 3.1: Communication	PE 3.5: Teamwork
PE 3.2: Documentation	PE 3.7: Professional Attitudes
	Enjoyed the program

Methodology

The following framework, which is based on Loden and Biswas (2010), was applied to evaluate the success of the Future Engineering program in meeting its university curriculum objectives and students' satisfaction whilst identifying opportunities to improve the program in future years.

Step1 : Organizing High School workshops

As a part of the Future Engineers Program developed, High School Outreach (HSO) workshops were organized at local High Schools in Perth to enable university's engineering students to present to high school students about sustainable engineering solutions. EWBA developed resources to provide an interactive and educational experience for high school students (Loden, 2011) which were delivered by university students at the workshops. University students had to develop an understanding of the concepts they will present which enabled them to develop the eight engineering attributed identified (Loden, 2011). School visits were coordinated by the Curtin University school outreach program as part of their existing engagement with schools in the region. The workshop packs for conducting the outreach sessions were provided by the Curtin University Engineers Without Borders Chapter with support from the engineering faculty.

Step 2: Selection of Participants

University students applied to participate in the program with the best three team applications accepted to participate, with this work being undertaken in place of an existing piece of assessment. Depending on the possibility of timetable clashes with other subjects and the availability of interested schools participating in these workshops, three groups of four students was discerned to be the optimum number of groups participating the HSO workshop each semester..

Step 3: Participant Preparations and Assessment Requirements

Participating students undertook two training workshops in two consecutive weeks on water and climate change issues. Before completing these workshops, students presented their workshops to the lecturers, EWB volunteers and tutors to ensure quality in delivery. They were required to submit a 2 page report on their experience reflecting on the lessons that they learnt from participation.

Step 4: Survey design and information Gathering

Participating students from the Curtin Engineering's 'Engineering for Sustainable Development' unit were asked 32 randomly dispersed questions (Engineers Without Borders Australia, 2011) to measure their understanding of the identified attributes (Table 1) and identify improvement opportunities for future years of the program. The 2 page reflection report was also utilized in this process. Since the sample size was relatively small due to participation of three groups of students, this questionnaire was detailed by incorporating sub-questions for reasoning purposes and to reduce uncertainties associated with the sample size. Within the university student survey each attribute had between three and five questions with an average of responses used to determine the performance for each professional attribute. The standard deviation across respondents and questions was utilised to understand the variation within the university participants. Students were asked three additional questions to help

understand the benefits and challenges of the program to identify further improvement opportunities (Engineers Without Borders Australia, 2011).

Step 5: Data Analysis

A mixed methods approach was used to analyze the results of the survey and qualitative data from the students reports were used to validate the analysis (Creswell & Plano Clark, 2007). Whilst the sample size is small, the results of this survey and report provide the basis of the analysis of the Future Engineers program with 100 % of participating engineering students responding in this detailed survey.

Results and discussions

The results were analyzed to determine how the Future Engineering Program assisted students in developing the Professional Engineering Attributes and determine the benefits and challenges of participation to help further improve the program activities.

Achieving Learning Outcomes pertaining to Professional Engineering Attributes

The Environmentally Sustainable Development course at Curtin University has 5 learning outcomes (LOs). Two of these learning outcomes are delivered by the Future Engineers program and align with the Engineers Australia professional engineering competencies (Unit Outline, ESD 201, Curtin University). These are:

- PE 2.2 - Students developed an appreciation for the sustainable development agenda in the national and international contexts;
- PE 3.5 - strengthened students' "multi-disciplinary team work" skills through the group project work

Figure 1 below details the student response and variation in response to the development of these competencies.

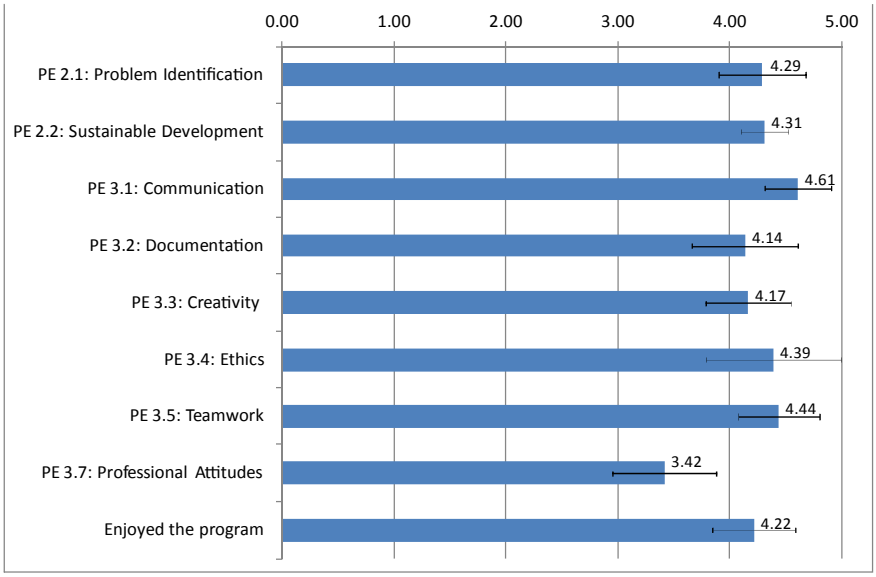

Figure 1: Average score with standard deviation for Professional Engineering Attributes resulting from the survey of the Future Engineers Program participants (SD = Strongly disagreed; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree)

This table demonstrates that for 7 of the 8 competencies the average score was between 4 and 5 meaning that on average students either agreed or strongly agreed with the development of these attributes. The 8th attribute "Professional attitudes" scored lower at 3.42 which is between agree and neutral. One of the ways of improving this attribute can be attained by involving students directly in engaging schools to conduct workshops, which is expected to make them more responsible for

demonstrating this attitude. Interestingly, two attributes, including teamwork and sustainable development, which are directly related to the LOs, scored highest by the participating students.

Figure 2 outlines the student response to the question of how they benefited from participation in the program.

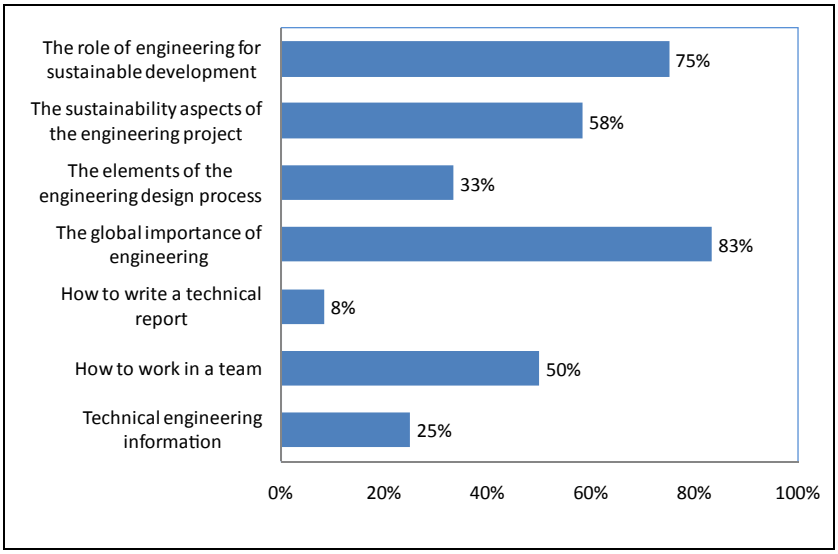

Figure 2: Student response when asked how they benefited from participation in the Future Engineers Program.

This table demonstrates that student participants found that they achieved a better understanding of a number of areas of engineering. Specifically 83% developed a better understanding of the global importance of engineering to society and 75% an understanding of the role of engineering in sustainable development. 50% achieved an improved understanding of team work practices whilst 58% developed deeper engagement with the aspects of sustainable development in an engineering project. This feedback reinforces how students are developing an appreciation for sustainable development (PE 2.2) and learning team work skills (PE 3.5), which are two of the key learning objectives of the program. Technical writing skill received the lowest marks, because the students have already practiced report writing in their other subjects.

The student participants were asked to select what they most enjoyed about participation which is displayed in Figure 3.

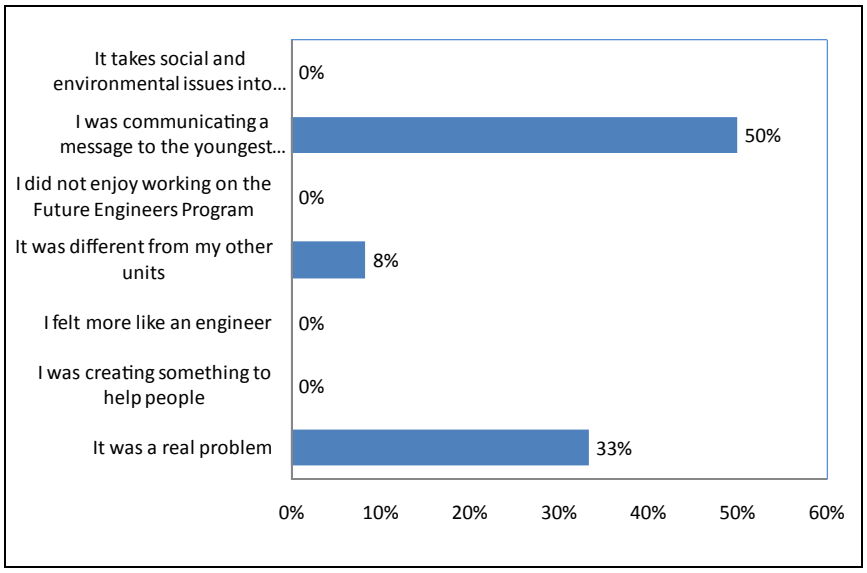

Figure 3: Participant Feedback on what they enjoyed most about participation in the Future Engineers Program

Students were only able to check one box for this question with 50% specifically enjoyed communicating with the youngest group of society whilst one third enjoyed the real world aspects of the activities and task. This further reinforces how the students have been able to develop their communication skills through participation and teaching others, which aligned with Professional Attribute 3.1 (Figure 1). This may be because the teachers and secondary school students found that the program has effectively engaged secondary school students (Loden and Biswas, 2010).

Program Improvements resulting from Student Feedback

As highlighted previously the 8th attribute "Professional attitudes" has the potential to be improved as a learning outcome from the program. This is attributed to two reasons; the students feeling that they already understood what an engineer's role was in society and that their perceptions had not changed as a result or that they did not agree with the information they were presenting.

In future years an improved response from the students could be achieved by including greater content within the presentations on the role of engineers to enrich their learning experience further and by providing further background information of the content conveyed so students feel comfortable with the concepts they are teaching.

Figure 4 outlines the challenges students faced during participation in the Future Engineers program.

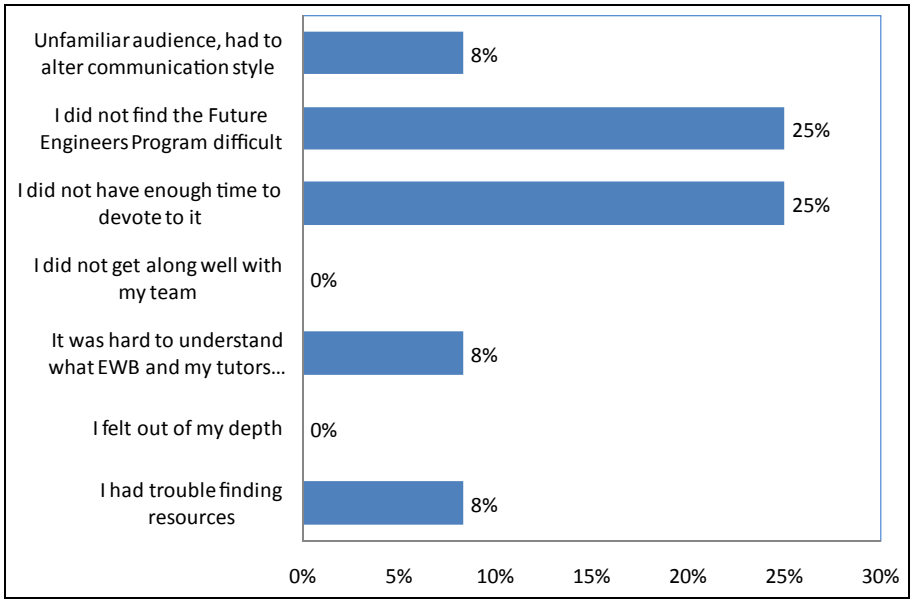

Figure 4: Graph demonstrating the difficulties that students encountered through participation in the Future Engineers program

This graph demonstrates that when asked the biggest challenge students encountered, 25% did not have any difficulties whilst 25% of students felt they did not have enough time to devote to the program. This response indicates that students may require greater support in coordinating their activities to reduce time consumption. This could be achieved by coordinating the visits to high schools during the previous semester to maximize the time students have to select and prepare for workshops. An additional constraint was scheduling time to train the students in the workshops they will deliver. To reduce this obligation on the academic staff and enable peer on peer learning it is proposed that the university teach the students the first lesson they deliver and then in the second week they swap lessons and teach each other. Most importantly, the students worked without any team dispute as the program and the assessment criteria were designed to enable all students to participate actively in the workshop.

Way Forward

The program is currently operational at Curtin University and the University of Western Australia. The UWA based program is to be scaled up in 2012 with in excess of 100 students participating in the program. The University of Sydney will be trialing the program in the second half of 2011, whilst RMIT has expressed interest in engaging in the program. EWB would like to continue to expand the program to other universities. EWB intend to continue to develop the resources supporting the Future Engineers program in line with the feedback from program participants and are seeking funding to support a part time role for this program. If successful this will enable the resources required to be allocated to drive both a deeper and larger engagement with the Australian engineering student cohort.

It has been identified that student participants are keen to continue their involvement in the program. In most regions of Australia the local volunteer chapters conduct their own high school outreach program on a voluntary basis. Willing student participants will be connected to local chapters so they can continue to engage high school students in engineering on a voluntary basis and continue their education journey. Engaging other faculties such as Science and education in the program could have some fantastic overlapping benefits within the universities and for student participants and is an area of further investigation.

Conclusion

The quantitative feedback received in the Future Engineers program has demonstrated that students have obtained a better understanding of engineering in seven of the eight learning attributes identified. The qualitative student feedback has reinforced the quantitative data that the Future Engineers program assists student learning. The feedback particularly highlighted students development of team work skills, communication and understanding of sustainable development, which are all key learning outcomes identified for the program.

The feedback also demonstrated some opportunities to improve the quality of the Future Engineers program. Specifically the following activities are going to be undertaken:

- Provide more contextual information and details of professional practice within the presentations to assist students in developing this learning attribute
- Coordinate the location and timing of outreach visits in the previous semester to provide clarity to students
- Conduct peer on peer learning for the second set of workshops

Inclusion of these aspects in the program will ensure a more successful program in future years.

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Acknowledgements

The authors would like to acknowledge the support of Larissa Andrews & Jacinta Kingdon, who coordinated the high school outreach visits, and Como, Santa Maria and Willeton High Schools and students who participated in the program.

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