

Engineering social change: Engaging undergraduate engineers in community development research

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Abstract: *As future professionals and volunteers who will work with communities in Australia and overseas, the opportunity for an engineering undergraduate to complete a research project with a real-world focus provides significant learning outcomes. This paper describes the development and implementation of an undergraduate research program by Engineers Without Borders Australia (EWB), designed to develop the intercultural skills and global competencies of engineering students. The program engages students in Australian-based research projects that align directly with EWB's community development work overseas and in Australia. Topics are provided for students to research as part of their university requirements, through which they can experience cross-discipline and cross-cultural research. Initial results from the early years of the program are provided, along with plans for further development of the program.*

Introduction

There has been an increasing emphasis placed on the role of engineers in alleviating poverty (Du, 2006, Grear, 2009). Singleton and Hahn (2003) identify sustainable, life-cycle, empowered and appropriate engineering as characteristics of sound engineering solutions to poverty alleviation. This role of engineers is just one application of a recent emphasis on 'global engineering' as identified by a number of researchers, engineers and educators (including Jesiek, Borrego and Beddoes, 2008, Buisson and Jensen, 2008 and Bourn and Neal, 2008). The benefit of externally coordinated, real-life engineering tasks and contexts have been described by academics and engineers alike (for example Smith, 2008) and subjects related to sustainable development, appropriate technology, cross-cultural skills and the role of engineering in poverty alleviation have been considered and included in a number of engineering undergraduate programs in recent years (for examples from overseas see Perez-Foguet, Oliete-Joas and Saz-Carranza, 2005, Amadei, Sandekian, Summers and Bielefeldt, 2006, Bourn and Neal, 2008, and Fenner, Ainger, Cruickshank and Guthrie, 2005).

Such opportunities have been integrated into final year undergraduate research or honours programs which are part of many engineering degree's in Australia and New Zealand (Littlefair and Grossman, 2008). The Automotive Cooperation Research Centre (AutoCRC) in Australia, for example, has been operating a student research program which brings together the AutoCRC's industry and academic partners on projects and scholarships for final year engineering students across eight universities (Neely and White, 2007). The main focus of the program is to build the capacity and skills of the automotive industry in Australia by exposing the next generation of engineers to industry partners, and

in turn employers to potential graduates. The AutoCRC is responsible for collecting project topics from industry partners of around 200 hours and matching those to academics. The AutoCRC coordinates student forums during the year, but is not directly involved with the supervision of students, or with any implementation of outcomes.

Engineers Without Borders (EWB) UK, which is a separate organisation from EWB Australia, operates a program for undergraduate engineering students (EWB UK, 2009). External community development and non-for-profit organisations submit a request for a specific research topic. These are collated and made available by EWB-UK, and students deal directly with the external partner during their project. Given the benefits of external programs to students and partners, EWB Australia have built a collaborative research program framework to provide opportunities for undergraduate engineers to work on development-related projects.

Objectives and Delivery

EWB is a not-for-profit community development organisation founded in 2003. Its vision is to work with disadvantaged communities to improve their quality of life through education and the implementation of appropriate and sustainable engineering. EWB is currently working with communities and organisations in countries including Nepal, India, Cambodia, Indonesia and Australia. Volunteers spend from three to twelve months working on the ground with community partners providing specific expertise or building capacity via skills development.

Within this context, the EWB Australia undergraduate research program engages final year students through involvement with research on the design and implementation of appropriate technology and sustainable engineering. The main objectives of the program are to:

- Undertake research on community needs.
- Expose undergraduate students to real world issues and challenges, to further develop their skills and experience.
- Facilitate the exchange and transfer of ideas, experience, skills, technology and resources between EWB, Australian research institutes and project partners.
- Provide opportunities for direct, practical implementation of outcomes, with potential application to Australian contexts to encourage additional research and development.
- Build the capacity and experience of EWB, its members and partners.
- Encourage and facilitate university engagement in community development.

The program is implemented as a partnership between EWB, communities, industry, other not-for-profits, policy makers, universities and research institutions. While student projects are identified by EWB's community partners so they are aligned with their needs and have the potential for later implementation, the research work is integrated into university academic programs. This ensures that the university provides sufficient time, resources and academic supervision to students and has meant the program must be flexible to suit different university structures, timing and requirements.

Potential research topics are identified by community partners and EWB field volunteers, project support teams and staff. Each topic is developed further to provide a project context, scope and set of outcomes. These are assessed against EWB priorities, themes and approach, and approved topics collated into a project list. Twice a year, at the end of the first and second academic semesters, the project list is promoted through EWB's members, chapters and university partners. Interested students discuss potential topics with an academic supervisor before applying to EWB to undertake a project. Topics are then allocated to students by EWB according to their background, relevance and experience, as, due to the resource requirements, only one student can be supported for each project.

In addition to an academic supervisor at their home institute whom ensure academic rigour and that university requirements are met, each student has an external supervisor or mentor from EWB or the community partner, to provide context, relevance and background. In addition to this support, a central coordinator and relevant EWB staff and field officers are involved as required, to assist in achieving outcomes that have the potential for later implementation. Additional training on sustainable community development and appropriate technology for students on the program is actively encouraged to also build a community of practice among students and staff involved.

Major university assessment items such as literature reviews, presentations and the final report or thesis are completed and assessed by universities inline with their requirements, time-frame and criteria. These are also provided to EWB for information dissemination and exchange purposes. Research results are presented to the community partner to facilitate implementation, potentially through EWB's volunteer program. Outcomes are further disseminated via multiple channels including the annual EWB Conference, local presentations, online knowledge hubs, workshops and publications.

Program Implementation

The number of projects, and the mix of female/male students, is shown in table 1 for completed projects up to 2008 and current projects in 2009. In 2009, 15 students at 7 Australian universities (ANU, QUT, RMIT, UQ, USyd, Charles Darwin and UWA) are being supported. The make-up of students by discipline they are studying (self-identified) for all projects is shown in figure 1.

	Completed (2006 - 08)	Current (2009)	Total
Number of Projects	13	15	28
Female / Male	6 / 7	10 / 5	16 / 12
Involved with Development	7	-	

Table 1: Summary of Projects

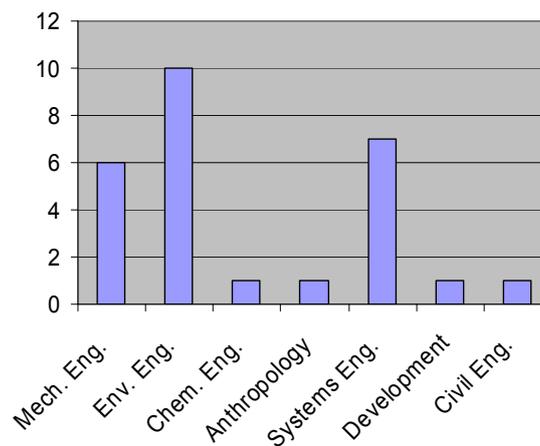


Figure 1: Projects by student discipline of study

The number of projects by country context, where relevant, and sector are shown in figures 2 and 3 respectively. Although the clear majority of projects are WatSan (water and sanitation) related, within this broad theme are various aspects including supply, modelling, treatment and sanitation.

Two completed projects are given as case studies to highlight the project process. The first example was undertaken as a minor thesis project in CIVL4569 as part of the civil engineering program at the University of Queensland. The project was to research, benchmark and develop a set of KPIs (Key Performance Indicators) for water quality, quantity and accessibility for the Tenganan region of East Bali in Indonesia. This topic was identified from a partnership started in 2006 between EWB, the Wisnu Foundation and the local communities that was formed to scope, design and construct a water supply system (for more detail see Third, Fun, Bowen, Micenko, Grey and Prohasky, 2007). The project was scoped by the EWB project team based in Perth, who provided supervision and input into the work. The project identified and made recommendations on specific KPIs before the construction phased commenced and provided additional capacity to the project team. In addition to the benefits to the partnership from the research outcomes, the student further developed their skills related to

working in developing and cross-cultural contexts, experience later applied through work as an environmental engineer in Mongolia.

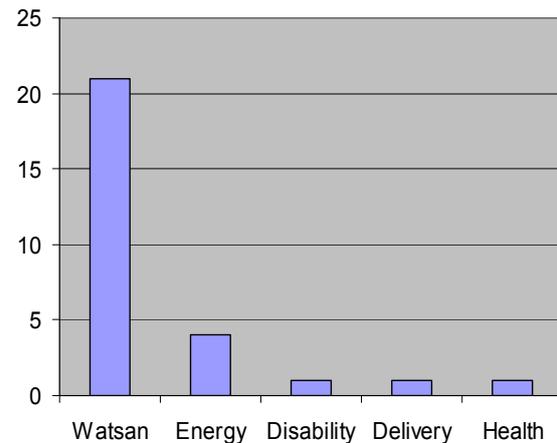
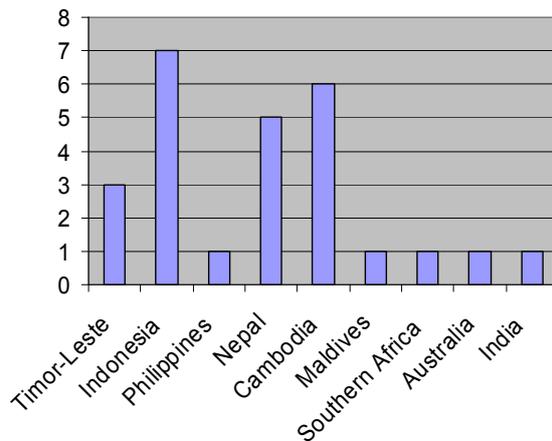


Figure 2: Projects by location context

Figure 3: Projects by sector (as defined by EWB)

The second case study was completed as a thesis in ENGN4200 at the engineering department at the Australian National University. This was to develop a design evaluation framework and initial concept for a water service system for a remote village in north-west Nepal. The project was identified and co-supervised from Nepal by EWB's partner Rural Integrated Development Services (RIDS). At the start of the project, a field survey developed by the student was completed by an in-country EWB field volunteer to provide data and details for the project including water needs, usage, topology and existing infrastructure. The outcomes were an evaluation framework for assessing designs, and a concept design including an initial costing. The thesis was provided to the partner to feed into their planning process and a presentation was given by the student at the EWB National Conference. The project highlighted key issues which were used to identify areas for field testing, further research, and assistance for raising funds for the ongoing project. The student has gone on to become an active member of their local EWB chapter.

Discussion

Through the use of a strong collaborative approach, involving universities, EWB, community partners, volunteers in the field and support teams in Australia, the program actively engages students in real, community-based projects to achieve sustainable development learning outcomes. Many of the students involved were undertaking combined degree's, which enabled them to utilise their skills from disciplines including science, arts, Asian studies, and commerce. For both the anthropology and development projects (from figure 1), the student was enrolled in a double degree with their other degree being an engineering discipline. This displays the cross-discipline nature of the research, from within and outside the campus environment. Such engagement in cross-discipline project teams is a key learning outcome that should be experienced by all engineers, as suggested by Daly, Mann and Adams (2008) and Hadgraft and Goricanec (2007), and can enable engineering students to experience the 'human side' of engineering (as described by Trevelyan, 2008).

Also significant is the number of female students involved in this program, more than 50% of projects undertaken so far, particularly high for an engineering program. This displays the trend seen for other EWB initiatives, where female involvement is typically higher than the general percentage involved with engineering. In this way the program, in addition to EWB's other education initiatives, can contribute to the much needed increase in women involvement in the engineering profession (as highlighted by Gravina, 2007, and Burrowes, 2007).

Supplementary student learning is supported through additional activities aligned to research, including the EWB National Conference, volunteer mentoring, development training (such as EWB's volunteer pre-departure training), and local EWB initiatives. In this way, projects are part of a broader

EWB learning pathway. At a university level this starts with the EWB Challenge in first year (see Brodie, 2008), continues with learning opportunities such as Development Education Experiences and local events, and extends beyond the completion of a research project in final year into field or office volunteer placements. These provide the ideal opportunity for students to implement their learnings directly with a community and EWB.

As EWB Australia is actively engaged in projects, outcomes from individual research have been incorporated directly by at least two community partners. It can also be seen from the completed projects in table 1 that a good percentage of students who have graduated are still involved with development, either through work with EWB or other organisations, both community- and industry-based, with graduates undertaking work in Indigenous Australia, Indonesia, Timor-Leste and Mongolia. Through this experience and engagement, as for the AutoCRC, the program is contributing the capacity of the engineering and sustainable community development sector as a whole.

Identifying and balancing the expectations and requirements of partners, students, academic supervisors and multiple universities is challenging, especially in the early stages of the program. Each university, and even departments within universities, have differing requirements for their projects, from timing, approaches for identifying and allocating projects, academic expectations, and support and supervision. However the benefits for students, universities and community partners in terms of the outcomes generated and the students' themselves far exceed these challenges.

Conclusions and Future Work

The Undergraduate Research Program developed by EWB Australia detailed here has provided opportunities to a growing number of final year students in Australia to be involved with external, real-world, community development projects as part of their studies, in addition to providing outcomes and additional capacity to EWB and its community partners. EWB plans to expand the program to support more students as demand increases, and secure funding for each student to enable them to undertake additional training. A number of projects will be linked to community partner programs to provide a field work component. The inclusion of industry partners to provide mentoring and additional resources will also be integrated.

There is scope for a higher-degree research program as project requests from in-country community partners continue. The same framework described here can also be utilised for later-year group projects, in terms of not only engineering specific teams, as is currently being piloted, but for cross-discipline projects. In this instance, a diverse team of students from backgrounds such as engineering, environmental science, social studies, commerce, law and health would work together on the same community development project, examining challenges and possible solutions for each discipline.

References

- Amadei, B., Sandekian, R., Summers, R. S., & Bielefeldt, A. (2006). *Engineering for Developing Communities: Integrating Education, Research and Development, and Service/Outreach into Engineering Education*, University of Colorado, USA.
- Bourn, D. & Neal, I. (2008). *The Global Engineer - Incorporating global skills within UK higher education of engineers*. Engineers Against Poverty, UK.
- Brodie, L. (2008). Assessment strategy for virtual teams undertaking the EWB Challenge. *Proceedings of the 2008 AaeE Conference*. Yeppoon, Qld.
- Buisson, D., & Jensen, R. (2008). STRATÉGÉ - Study of mobility of Australian and European Union engineering students and tools to assist mobility. *Proceedings of the 2008 AaeE Conference*. Yeppoon, Qld.
- Burrowes, G. (2007). 'Attracting more women into the profession', *The Magazine of Engineers Australia Vol 79(2)*, February, pp. 26-27
- Daly, S., Mann, L., & Adams, R. (2008). A New Direction for Engineering Education Research: Unique Phenomenographic Results that Impact Big Picture Understandings. *Proceedings of the 2008 AaeE Conference*. Yeppoon, Qld.

- Du, H. (2006). Opening Address. *Conference on the Role of Engineering in Poverty Reduction*. Dhaka, Bangladesh.
- EWB UK. (2009). *Research*. Accessed at <http://www.ewb-uk.org/programmes/research> on 10 Jun, 2009.
- Fenner, R. A., Ainger, C. M., Cruickshank, H. J., & Guthrie, P. M. (2005). Embedding sustainable development at Cambridge University Engineering Department. *International Journal of Sustainability in Higher Education*, 6(3), 229-241
- Grear, B. (2009). World View - Don't reduce commitment to Millennium Goals. *The Magazine of Engineers Australia*, 81(2), 65.
- Gravina, R. (2007). 'Focus on women - achievements and barriers', *The Magazine of Engineers Australia Vol 79(1)*, January, pp. 22-23
- Hadgraft, R., & Goricanec, J. (2007). Engineering Sustainability?! *American Society for Engineering Education*.
- Jesiek, B. K., Borrego, M., & Beddoes, K. (2008). Engineering Education Research: Global Trends and Collaborative Opportunities. *Research in Engineering Education Symposium 2008*. Davos, Switzerland, 7-10 July.
- Littlefair, G., & Gossman, P. (2008). BE (Hons) final year project assessment - leaving out the subjectiveness. *Proceedings of the 2008 AaeE Conference*. Yeppoon, Qld.
- Neely, K., & White, G. (2007). AutoCRC: Supporting collaboration between the automotive industry and undergraduate students. *Proceedings of the 2007 AaeE Conference*. Melbourne.
- Perez-Foguet, A., Oliete-Josa, S., & Saz-Carranza, A. (2005). Development education and engineering - A framework for incorporating reality of developing countries into engineering studies. *International Journal of Sustainability in Higher Education*, 6(3), 278-303
- Singleton, D., & Hahn, N. (2003). Poverty Alleviation - The Role of the Engineer. 4th *Brunel International Lecture*.
- Smith, W. (2008). Twenty-One Years of the Warman Design and Build Competition. *Proceedings of the 2008 AaeE Conference*. Yeppoon, Qld.
- Third, K., Fun, O. M., Bowen, J., Micenko, A., Grey, V., & Prohasky, T. (2007). Engineers Without Borders Australia - Lessons learned from an innovative approach to the upgrade of water supply infrastructure in Tenganan, Indonesia. *ASPIRE*.
- Trevelyan, J. (2008). 'Teaching the human side of engineering', *The Magazine of Engineers Australia Vol 80(30)*, March, p. 51

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