

# Making a difference: creating opportunities for undergraduate students to contribute to humanitarian engineering projects

Fiona Johnson<sup>a</sup>, Stephen Foster<sup>a</sup>, Carla Frankel<sup>b</sup>, Sam Johnson<sup>c</sup>, Stephen Moore<sup>a</sup>, Richard Stuetz<sup>a</sup>, Jacqueline Thomas<sup>d</sup>

*School of Civil and Environmental Engineering, UNSW Sydney<sup>a</sup>, Water and Environment, BMT WBM Pty Ltd<sup>b</sup>, United Nations Economic and Social Commission for Asia and the Pacific<sup>c</sup>, School of Civil Engineering, University of Sydney<sup>d</sup>*

*Corresponding Author Email: [f.johnson@unsw.edu.au](mailto:f.johnson@unsw.edu.au)*

---

## Context

Within the student body of engineering undergraduates there are a number of students with passion and enthusiasm for becoming involved with Humanitarian Engineering (HE). However there are generally limited opportunities for them to contribute in practical ways to HE projects locally or overseas. Organisations such as Engineers without Borders and other Non-Government Organisations working in HE generally recognise the limited resources of overseas or local partner organisations to support volunteers. How can the energy and enthusiasm of students be engaged in an effective way to make a difference to HE projects?

## Purpose

The purpose of this study was to investigate the most effective mechanisms for providing opportunities for students to contribute to actual humanitarian projects.

## Approach

Four case studies are presented here to compare and contrast the success of student teams contributing towards solving a number of different engineering challenges. The nature of the projects varied from literature reviews to design and analysis of projects. Students have participated through extra-curricular activities and honours thesis projects. The experiences of these students have led to the development of new HE courses at UNSW Sydney to provide opportunities for students to gain course credit for their endeavours.

## Results

The case studies have had varying levels of success in achieving the aims of engaging students in HE projects and contributing to tangible outcomes. It is anticipated that the results will show that success depends on a well-defined scope, mentorship, drive of students, buy-in and/or need of the project partner and an established partnership where cross-cultural exchange is supported.

## Conclusions

Providing opportunities for students to contribute to areas that they are passionate about enables them to become more engaged with their engineering degree and develop different skills further than they would in a traditional engineering program. Significant time commitments are required from students and academics and project partners are required to make these projects succeed. Mechanisms to enable students to count these endeavours for course credit are likely to enable students to prioritise these time commitments.

## Keywords

Humanitarian Engineering, student led experiences

## Introduction

Interest in Humanitarian Engineering (HE) in Australia has been steadily increasing over the last decade. At the University of New South Wales (UNSW Sydney) this interest has until recently been implemented through student involvement with Engineers without Borders student chapter and similar student clubs and service organisations. Many of the activities that the students get involved with have focused on high school outreach or inter-university competitions and collaborations. Many students would like to further increase their involvement in design and research for HE projects. However due to the students' limited technical skills the opportunities for them to contribute in practical ways to HE projects locally or overseas can be limited. In general meaningful volunteer opportunities require extended placements to build relationships and fully understand the wider community, technical and cultural context for project tasks. Organisations such as Engineers without Borders and other Non-Government Organisations working in HE generally recognise the limited resources of overseas or local partner organisations to support unskilled volunteers.

How do we best then harness the enthusiasm and energy of undergraduate students and provide opportunities to contribute to HE projects? A number of different options have been trialled at UNSW Sydney and this paper reviews the outcomes and lessons learned from each of these approaches. The first and second case studies review two projects where students carried out extended literature reviews and project synthesis for Australian engineers working overseas on HE projects. These projects could be considered as examples of service learning which has been shown to “extend students’ learning in ways that cannot be accomplished in the class room” (Bettencourt, 2015). Two teams of students were formed in the second half of 2014 and in 2015 and this paper discusses these projects as case studies in building student skills and interest in HE. The third case study reviews the involvement of students in HE research through enrolment in an honours research thesis course. Finally the development of two final-year student project courses at UNSW Sydney is discussed as a flexible mechanism for recognising student effort with course credit. The paper is structured to present the details, successes and failures from each of the case studies, concluding with a final synthesis and recommendation section.

## Case studies

### Case Study 1: extra-curricular student research project 1

This project was developed to work with a UNSW Sydney alumni who was undertaking a volunteer placement in a South Asian country. The volunteer placement was 12 months and the volunteer’s job was to assist the local small team in developing systems to assess and protect the water catchments of the country. The context to the project is that the country had low levels of development to date. The major demand for water from many catchments is for hydroelectricity schemes, which have a number of requirements in terms of the quality of the water. The impacts on the catchment from these hydroelectricity schemes include increased discharge velocities as well as the higher temperature of the released water. Increasing urbanisation of the capital also creates pressures on the nearby catchments. Small scale agriculture also creates pressure on catchment health with unrestricted access of livestock to watercourses causing some erosion problems. Compared to many parts of the world, the catchments are in relatively good condition.

Due to limited resources, detailed catchment management plans can only be developed for the most at-risk catchments. Therefore a multi-criteria ranking approach was required to ensure that the different competing pressures and attributes of different catchments can be sensibly compared. The UNSW Sydney student team was tasked by the volunteer to research and compare existing approaches for ranking catchments and to make suggestions

as to the best system that would take into account the unique pressures on and characteristics of the specific catchments of interest.

A team of 8 students was selected from members of the EWB student chapter by calling for expressions of interest in this project and the second project described below as Case Study 2. Students ranging from first year to fourth year were selected. The student team split into two sub groups based on the task with one group researching other examples of catchment classification methods and the second group considering multi-criteria approaches for ranking. This group was also responsible for researching the context of the country of interest and its catchments and using this information to guide the thinking of both groups in terms of ensuring that solutions were appropriate.

The work by the students on the project was mainly carried out over a 4 month period. An additional three months was required at the start of the project to formulate the idea and define the scope. Student involvement and enthusiasm was strongly affected by the timing of the project with respect to the academic year. In the middle and end of semester students had less time available for extra-curricular activities due to assessment tasks and exams. Initially it was thought that one advantage of having a team of students at varying stages of their degrees was that not every student would have the same assessment schedule and they therefore could work continuously on the project. In reality the work was driven by a few individuals so the progress was not as smooth as expected and students found it challenging to work in a group of otherwise unconnected people with different aims and desired outcomes (Downey et al., 2006).

Student meetings with an academic mentor were arranged once every few weeks to provide some accountability throughout the project and to workshop issues and problems. The academic mentor provided the communication link between the volunteer and the students. Once a draft report was prepared, then a skype meeting was arranged between the volunteer, academic mentor and three of the students for them to present their findings and rationale. This meeting proved to be really useful for the students in comprehending the context of the work in a developing country and the constraints on resources both in terms of financial and human resources. Although this had previously been explained in emails and group meetings, the contrast between what the students found to be world best practice and the realities of working in a developing country was very stark. In some ways it may have been better to organise this skype meeting earlier in the project although until the students were immersed in the materials, earlier meetings may not have been as productive. Students also identified that an initial briefing working in low-resource and low-capacity environments would have been useful to better prepare them.

The final report was prepared in just enough time for the volunteer to incorporate in his reporting and presentation to the government department. Students found that working on the project was helpful for understanding what a professional role in HE involves rather than an idealist view of this field of work that may be formed from professional seminars. For all the students this was the first time that they had the opportunity to work on a project where the motivation was not good marks but by making sure that they did a good professional job as well as the benefit of knowing that they have contributed (Litchfield & Javernick-Will, 2015).

## **Case Study 2: extra-curricular student research project 2**

Project 2 was set up with similar aims to project 1, working with a UNSW Sydney alumni based at a research institute in East Africa. The alumni also had an adjunct position at the UNSW Sydney so this project also aimed to strengthen links between the two organisations. As part of a funded grant, the researcher had opportunities for three small projects featuring targeted literature searches and design tasks that students at the UNSW Sydney could contribute to.

It was identified by the researcher that this collaboration was a good opportunity for both learning and contribution from the students from UNSW Sydney and for the East African Water, Sanitation and Hygiene projects to receive some extra scientific input. However, early on in the project initiation it was emphasised that the risks for the researcher was that the time taken to communicate with the students to answer questions and give guidance outweighs the research/design output gained. This highlights the important balance that is required in providing students with meaningful and useful experiences in HE whilst not creating a burden on overseas organisations.

Due to the researcher's other supervision experience and research commitments, her expectations for the nature of the collaboration with the UNSW Sydney students were much clearer and formally arranged compared to Case Study 1. It was suggested by the researcher that three teams of 2-3 committed people each would be ideal, and that it was necessary to be selective about to who was to participate in this opportunity. As such, a formal student selection process was implemented with students required to provide their existing skills, time availability and nominating their preference out of the three projects on offer.

This process of selecting students and providing descriptions for the scope of the projects and more detailed work briefs took longer than expected due to workloads and barriers to communication such as email misunderstandings and frequent power and internet network cuts in the East African country. For this project, a student led the communication and liaison with the overseas researcher. This was primarily because the academic mentor who initiated the project was not able to devote sufficient time to working with the students during its setup and implementation. The difference in positions and project experience (researcher vs student) and also the lack of long term personal connections contributed to the extended time period being required to set up the project, which was in the order of 6 months. The importance of building networks and communication channels over time is clearly highlighted by this experience.

A Terms of Collaboration document was signed by all selected participants, and further details about each project was provided to each team. The three project teams initially had a face to face meeting with the researcher when she was visiting the UNSW Sydney. The research staff from the Eastern African institute who would be the point of contact for each of the three projects joined this meeting via skype. The skype session was a good experience for the students to learn first-hand what the projects were about, and provided an opportunity for cross-cultural exchanges between the students and researchers. From this meeting, it was expected that each team would liaise with their designated project leader from the East African research institute.

This process did not run as effectively as intended. This was due to decreased motivation from students due to exam period and other university commitments. Additionally, the projects did not progress due to various constraints faced by the researchers in the East African institute (staff on maternity leave, overseas travel, delays in contracts leading to reduced staff numbers) which resulted in no resources being available to follow up links to the student projects at UNSW Sydney. Additionally, the East African project officers were hesitant to reply directly to UNSW Sydney students, without consulting the project leader. The main reasons that they were not confident in replying directly was due to being judged for their English and also were not always sure of what the students were asking for. The development of an informal connection between the two groups before the project outcomes would have overcome this barrier.

This experience highlights the difficulties faced when trying to establish a project with researchers working in an institute that has many priorities and limited resources. As the research to be undertaken by the students at UNSW Sydney was not deemed a core priority, the limited resources of the organisation were allocated to other functions.

A key lesson learnt from this experience is that the logistics of the collaboration need to be arranged prior to the start of a university semester, as to provide maximum time for students to engage in the actual research assignments. These logistics include: required time commitments from students, skills matrix of interested students, general project scope, training in cross-cultural communication, background information on the partner research organisation and nature of the collaboration (i.e. the Terms of Collaboration Document).

### Case Study 3: Honours research

Honours research projects are an important component of engineering degrees providing students with the opportunity to experience a research project as well as working one-on-one with an academic or research only staff. For students with an interest in HE the opportunity to undertake a research topic in an aligned area has in the past relied on either the student having a clear research question or finding an academic with current HE research projects. Through the UNSW Sydney partnership with Engineers without Borders, the opportunities for students to undertake an honours research project on a HE topic has substantially expanded. Over the last two years as academics and students have become more aware of opportunities, the number of students undertaking such research has increased (Table 1).

**Table 1: Number of students undertaking EWB Honours Research at UNSW Sydney**

Year	Number
2012	2
2013	0
2014	0
2015	0
2016	8
2017	7

Historically in the School of Civil and Environmental Engineering at UNSW Sydney, honours research in HE is the first opportunity that many students have to integrate HE into their program. This means that students need significant support to develop both their research skills, in common with all students undertaking honours research, as well as their ability to understand the context and challenges of research affecting developing and/or remote communities.

Honours research requires students to develop their understanding of how research is undertaken which for many students can take the first few months of their honours project (Linn, Palmer, Baranger, Gerard, & Stone, 2015). One of the challenges for students undertaking a HE topic is that they also need to define the scope of a project in a context that they are not familiar with. Frequently, students are in direct contact with partners from developing countries in order to share data or find out additional information. To facilitate this type of communication students need awareness training in common cross-cultural communication strategies when working with partners with lower capacity, such as poor command of English and limited access to internet. It is important to note that this is likely to include more than developing what is commonly referred to as 'global competence' (Hunter, White, & Godbey, 2006) because the constraints of low capacity organisations and countries require more than just empathy, current event knowledge and positive attitudes (Hunter et al., 2006). Support for both students and supervisors in these early few months of honours research is vital to build research momentum and to ensure that the literature review process allows the student to effectively define the research problem statement. Another specific challenges faced by students include preparing the documentation for ethics approvals for research which is relatively uncommon in many traditional engineering research projects.

With plans to introduce new HE courses in coming years, it is expected that students undertaking honours research in HE will have a stronger background on appropriate frameworks for analysing the context and constraints in these problems which will enable them to more quickly determine the research problem scope and project requirements.

One of the benefits of doing an EWB honours research project is that the EWB partners have identified the research project need, which is satisfying to students knowing that their research outcomes will have an impact. Dean and Van Bossuyt (2014) note that the traditional semester model of such projects can lead to some difficulties in achieving these impacts for honours students and can lead to less optimal project designs. Depending on the research topic, connections from these projects allow students to build their industry and research section connections which are useful for students who want to pursue international development sector careers. As per the extra-curricular case studies, research in HE allows students to further explore the realities, pressures and constraints that are an important part of international development. Ensuring that projects are people-centric rather than design-centric is a useful parallel that should be emphasised with these projects as with larger HE projects (Dean & Van Bossuyt, 2014).

#### **Case Study 4: Student-initiated project and Humanitarian Engineering courses**

To address some of the weaknesses addressed above at UNSW Sydney in terms of involving students in HE, a number of courses have been developed over the last 2 years. The first is of these is a student-initiated project course which allows for cross-disciplinary engagement of high achieving student teams to develop, manage, solve and report on a project, or solve a significant problem that they have identified or developed with support from an academic mentor. Although not designed for HE specifically, projects like those in Case Study 2 could lead to students pitching ideas for this course. This course was approved in 2016 but has yet to have any projects proceed. Future research will evaluate the learning outcomes from the course.

In addition to the broad student initiated course, a new course on Fundamentals of HE has been approved to commence in Semester 2, 2018 at UNSW Sydney. This course will enable engineers to analyse and design infrastructure and appropriate technology to support the well-being and welfare of individuals and communities in disadvantaged circumstances. This includes developing countries as well as marginalised or remote communities in Australia. The course will provide students with frameworks to analyse and respond to complex multi-disciplinary engineering problems. The usefulness of case studies for HE has been demonstrated by Perez-Foguet, Oliete-Josa, and Saz-Carranza (2005).

A second course, HE Project will allow students to further develop their skills and learning around international development by providing students the opportunity to undertake a design project related to HE. This may include a field work component if appropriate which would provide students with further context and skills in HE. The course will be problem based, with context aligned with clearly identified needs for a marginalised community, either locally or internationally.

These courses have been designed to address a number of points that the earlier three case studies have raised, namely 1. that students are underprepared for the context of HE work when undertaking an honours research project in this area, 2. to ground students' expectations of the nature of international development and HE in the reality of field work in resource constrained contexts, and 3. to provide extrinsic motivation for students to learn through structured assessments. Finally as noted by Swan, Paterson, and Bielefeldt (2009), although involvement in project based and service based learning is beneficial for students, academics find that involvement in these projects not rewarding in terms of promotion. By providing formal courses for credit in this area, the contribution of academic staff in mentoring students on projects can be recognised through academic workload models.

Fieldwork provides engineering students with very valuable learning outcomes. To deliver quality teaching and reduce risk academics are required to supervise fieldwork, especially where subject credit is awarded. The time commitment for academics are presently not well acknowledged or compensated for at most universities. The time to recruit and prepare students frequently occurs outside of the teaching period. For example, fieldwork usually occurs in summer and winter breaks but recruitment activities happen during semester which takes time away from normal teaching and research commitments. In order to continue offering valuable fieldwork opportunities, universities need to address these special travel and time requirements for academic staff involved in fieldwork teaching.

## Conclusions and recommendations

In this paper, four case studies of students contributing to HE projects have been described. The main recommendations that will be useful for other universities and organisations aiming to implement similar programs for student engagement are summarised below.

Student groups working on short term HE projects require a dedicated academic mentor. Experience suggests that fortnightly meetings are required to ensure progress and accountability of the student teams to a client. Although in theory these meetings could be with the external research partner, UNSW Sydney experience shows that international volunteers and NGOs are already under substantial resource and time pressures so an internal mentor/client at the University can ensure progress and provide students with a first level of support to address concerns and problems. When there is a conflict, it is our opinion that the benefit needs to be provided to the NGO rather than the students at UNSW Sydney. This tension between the benefits to students compared to the benefits to the community where the project is based has been explored by VanderSteen, Baillie, and Hall (2009) and these issues are vital for universities working in this space to explore. Other possible problems of such service based learning projects from universities have previously been identified by Riley (2008) and Schneider, Leydens, and Lucena (2008). Our experience shows that without a substantial commitment of time and enthusiasm from the academic mentor these projects have not achieved the desired aims. Mechanisms for recognising mentors for their contribution still need to be developed.

There is a clear need for focused support for academics supervising HE research projects early in the first semester through a workshop or similar to help train academics in assisting students in HE research including requirements and processes for ethics approvals, how to define a suitable scope of possibly large 'wicked' research problems as well as clear expectations of support provided by Engineers without Borders or similar research partners.

In all these case studies, skype or face to face meeting with the NGO or researchers is also vital to allow students the opportunity to get direct feedback and information on the specific challenges of working in developing community contexts. These structures also help to train students in professional skills by the academic mentor modelling to students' professional communication styles, project management skills and reporting methods.

New courses to provide students with course credit for participating in HE research are a promising way of providing further extrinsic motivation for students to complete the research projects. This will benefit both the students and the academics involved with the programs through formal recognition of their contribution in workload models. Further work is required to capture the actual work load involved with field work courses.

## References

- Bettencourt, M. (2015). Supporting Student Learning Outcomes Through Service Learning. *Foreign Language Annals*, 48(3), 473-490.
- Dean, J. H., & Van Bossuyt, D. L. (2014). Breaking the Tyranny of the Semester: A Phase-Gate Sprint Approach to Teaching Colorado School of Mines Students Important Engineering Concepts, Delivering Useful Solutions to Communities, and Working on Long Time Scale Projects.

*International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, 222-239.

- Downey, G. L., Lucena, J. C., Moskal, B. M., Parkhurst, R., Bigley, T., Hays, C., . . . Ruff, S. (2006). The globally competent engineer: Working effectively with people who define problems differently. *Journal of Engineering Education*, 95(2), 107-122.
- Hunter, B., White, G. P., & Godbey, G. C. (2006). What does it mean to be globally competent? *Journal of Studies in International Education*, 10(3), 267-285. doi: 10.1177/1028315306286930
- Linn, M. C., Palmer, E., Baranger, A., Gerard, E., & Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. *Science*, 347(6222).
- Litchfield, K., & Javernick-Will, A. (2015). "I Am an Engineer AND": A Mixed Methods Study of Socially Engaged Engineers. *Journal of Engineering Education*, 104(4), 393-416. doi:10.1002/jee.20102
- 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. doi:doi:10.1108/14676370510607241
- Riley, D. (2008). Engineering and Social Justice. *Synthesis Lectures on Engineers, Technology, and Society*, 3(1), 1-152. doi:10.2200/S00117ED1V01Y200805ETS007
- Schneider, J., Leydens, J. A., & Lucena, J. (2008). Where is 'Community'? Engineering education and sustainable community development. *European Journal of Engineering Education*, 33(3), 307-319. doi:10.1080/03043790802088640
- Swan, C. W., Paterson, K. G., & Bielefeldt, A. R. (2009, 18-21 Oct. 2009). *Panel - measuring the impacts of project-based service learning in engineering education*. Paper presented at the 2009 39th IEEE Frontiers in Education Conference.
- VanderSteen, J. D., Baillie, C. A., & Hall, K. R. (2009). International humanitarian engineering. *IEEE Technology and Society Magazine*, 28(4).