

Citation for Outstanding Early Career Contribution to Engineering Education 2021

Applicant:

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Citation:

For development of engineering curricula, resources or services that reflect a command of the field

This application outlines my contributions to **critterion 2** which includes the *development of engineering curricula, resources or services that reflect a command of the field.*

Overview of Contribution and Context

There has been an explosion of education programs in humanitarian engineering in recent years (Keogh et al. 2020; Smith et al. 2020). While these offerings are growing passionate cohorts of socially engaged engineering students, previous research has raised alarm over the potential disconnect between student expectations and the career pathways that await them upon graduation (Litchfield and Javernick-Will 2016). To address this gap, humanitarian engineering curricula needs to move beyond just teaching awareness of the contextual factors important for marginalised and low-income communities. There is a need to create curricula that professionalises humanitarian engineering, establishing a signature pedagogy (Shulman 2005) that can build the competencies to connect student motivations with global development and humanitarian practice (Reed and Fereday 2016).

My teaching draws on **project-based service-learning pedagogy** (Bielefeldt et al. 2010) to present coherent and imaginative resources, equipping students to apply engineering knowledge to address global development challenges. Incorporating industry collaborations as an integral part of my teaching, I seek to *immerse* students in engineering judgement among broader social, economic, and environmental constraints. Drawing upon partnerships with communities globally, my teaching makes contributions to advancing the *cultural competence and integrated professional, ethical, and personal identity* of graduates.

Professionalising Humanitarian Engineering

As one of two staff currently responsible for teaching in humanitarian engineering at the University of Sydney, I have developed and delivered content to students across the Faculty of Engineering. I was responsible for developing CIVL5320 (Engineering for Sustainable Development) in 2018, one of three engineering units delivered as part of a humanitarian engineering major – the first to be offered in Australia beginning in 2017. I also co-coordinate CIVL5330 (Global Engineering Fieldwork), which offers students the opportunity to travel overseas to gain exposure to engineering in resource-constrained settings. Across both units, I have drawn on project-based service-learning within professional industry partner contexts to provide an engaging context and foster more substantial learning outcomes.

In CIVL5320 (Engineering for Sustainable Development), I introduce students to the theoretical foundations of global development, provide an overview of humanitarian engineering project tools, and provide a survey of designing in resource-constrained settings (including water, sanitation, shelter, and energy). My teaching incorporates various assessments that anchor and tie to an underlying, semester-long service-learning project. Students work with a community and industry partner to design an engineering system to meet an identified basic need. Over the last three years, I have partnered with six organisations, including non-profits, governments, engineering firms, and foundations. These organisations include Build Change, Partner Housing Australasia, the Municipality of Carigara (Philippines), Tupua Tamasese Meaole Hospital (Samoa), Arup, and the Indigo Foundation. These have included projects in Samoa, Indonesia, Philippines, South Africa, Afghanistan, and the Solomon Islands, ranging from designing water systems to reducing fire risk in informal settlements. Student designs are used as inputs into projects being implemented (with oversight and review by partner organisations), inspiring students to recognise the tangible role of engineering in lifting the standard of living for low-income and marginalised communities. As one student commented in an evaluation, *"This was the first subject I have taken where I feel like I have learnt the technical skills required of my role and can see and understand how they would be applied."* Another student noted, *"Having the freedom to think critically and design solutions on our own – and be accountable for those solutions – was really rewarding."*

In CIVL5330 (Global Engineering Fieldwork), I have co-coordinated programs in Samoa and twice in India. Over the last three years, these units have resulted in field-based placements with twelve organisations on 21 student projects. These projects have ranged from designing more accessible toilets in primary schools to low-cost improvements of solar fruit drying supporting more resilient livelihoods for farmers. These partnerships have allowed students to engage directly with clients and communities on low-cost engineering solutions, strengthening their *inventiveness* in a global context. As evidence of the learning outcomes, one student noted in their evaluation, *"this unit of study has put engineering into a global perspective."* I have also continued to support the growth of our fieldwork programs and was successfully awarded a New Colombo Plan grant (\$66,000) from the Department for Foreign Affairs and Trade (DFAT) to deliver a multi-disciplinary program in 2022 (the award was initially for \$247,500 over 3-years but reduced by DFAT due to COVID-19).

The quality of my teaching is reflected in my student evaluations. For those units I am individually responsible for delivering, my average evaluation scores have been 4.6 (out of 5) and above over the last three years, while those I co-coordinate have all exceeded 4.3 (see Table 1). These have all greatly exceeded the average evaluations for the School of Civil Engineering, Faculty of Engineering, and University of Sydney. All my units have received Faculty commendations (except one which narrowly missed the minimum response rate to be considered). In evaluations, one student commented, *"Aaron has been one of the best lecturers that I have been involved with during my university life. His enthusiasm towards the content and broad range of knowledge made the unit of study exciting and informative."*

Table 1: Overview of student evaluations for units of study delivered between July 2018 – June 2021

Unit of Study	Enrolments	Year	Period	Opdyke	School	Faculty	University
CIVL5330 (Samoa)	23	2018	July Intensive	4.68	4.17	4.05	4.10
CIVL5320	16		S2	4.78			
CIVL5330 (India)	14	2019	December Intensive	4.35	4.20	4.05	4.11
CIVL5320	11		S2	4.61			
CIVL5330 (India)	32	2020	July Intensive	4.43	4.33	4.13	4.17
CIVL5320	21		S2	4.79			

CIVL5320: Engineering for Sustainable Development, CIVL5330: Global Engineering Fieldwork. Data on evaluations for School, Faculty, and University are listed for teaching period 2 for respective years. Scores are listed on 5-point scale.

My students' placements upon graduation establish an alignment of my teaching with contemporary best practice. As a demonstrable sign of these outcomes, several of my past students are now in positions where their work is principally focused on global development at an entry level, while others are incorporating learning outcomes within more traditional engineering roles. Examples of immediate placements post-graduation include as a Project Engineer for Cardno's International Development team, a PhD Candidate at the Australian National University (focused on decolonising engineering practices), and a Fire Engineer at Arup (who has led internal pro-bono efforts on fire engineering in informal settlements). Yet another student who took my class was hired by one of the class partners for a UNICEF-funded sanitation program in the Solomon Islands. This student commented, *"Without your course, I don't think I would have had such an early opportunity in professional humanitarian engineering."*

Pedagogical Pillars for Humanitarian Engineering

Preparing engineers to work in challenging contexts – in disaster response, amidst armed conflict, or international development – requires pedagogical teaching tools that can introduce students to the constraints they will face without exposing them to the physical risks. Opening the accessibility of these contexts for student learning, with space for reflection on ethical practice, is a core pillar of my teaching. For example, content I developed for my CIVL5320 class used immersive virtual reality (IVR) (360° images and audio collected during my own research fieldwork in the Philippines) to allow students to 'walk' freely around an informal settlement affected by coastal hazards and at risk of sea-level rise (see Figure 1). This context was used to teach needs assessments for project planning and identifying biases when entering communities. As a student noted in their evaluation, *"Aaron was essential to guiding the class in its study navigating the complex interrelated web of politics, supply, logistics and resource allocation in crisis response and he achieved this successfully through the use of VR."* I was part of team in 2020 who was recognised with a Dean's Award for Teaching Innovation for these efforts. My contributions extend to scholarship of teaching and learning, supporting others in my Faculty designing IVR activities. I was part of a team awarded a Faculty of Engineering Education Innovation grant (\$29,518) in 2019, which identified best practices in immersive virtual reality (IVR) design. This project developed and assessed new immersive virtual content across four units of study, with outcomes shared at the 2019 Australasian Association for Engineering Education (AAEE) conference (Hadigheh et al. 2019).



Figure 1: Examples of virtual reality scenes developed for CIVL5320

My teaching methods also challenge students to create, source, and assess data quality for their designs – a particularly important competency for engineers working in humanitarian response and development. For example, in CIVL5320, students use open elevation data combined with their own crowdsourced mapping of building footprints using OpenStreetMap to inform the design of a gravity-fed water system in the Solomon Islands. I have students critically evaluate the precision and accuracy of this data and the impact on tolerances in their designs. By engaging with external, open data, these learning activities enhance *information and digital literacy*, strengthening skills to source data for open-ended, real-world problems.

In addition to overcoming the accessibility of contexts and data, my teaching methods also seek to prepare students to work *with* marginalised or low-income communities. Within my project-based service-learning approach, I encourage students to reflect on power dynamics and ethics, considering not only how their engineering design outputs benefit (or potentially harm) communities (Birzer and Hamilton 2019) but also their *design process*. We explore this through case studies, industry guest speakers, and serious games. I also use structured learning activities that utilise reflection (Adams et al. 2003), such as at the end of CIVL5320 after students have completed their semester-long project. This reflection reinforces learning outcomes, importantly allowing students to examine their positionality. For example, in this learning activity, a student commented that their most significant takeaway from the class was *"The importance of designing with communities instead of 'for' communities."* I continue to support further development of these outcomes and I have obtained two internal, competitive grants from our Office of the Deputy Vice-Chancellor (Indigenous Services and Strategy) as co-lead on a 2020 project (\$9,000) and lead on a 2021 project (\$9,500). The latter project is engaging with Aboriginal organisations to develop modules for CIVL5320 on cultural competency for engineers working with Indigenous communities.

Professional Expertise and Leadership to Shape Curricula

As evidence of my contributions to supporting and enhancing broader humanitarian engineering curricula, this year I contributed to Engineers Australia's accreditation review as a civil and humanitarian engineering discipline expert for Central Queensland University's programs (which included a new humanitarian engineering degree). I have also provided strategic advice to the University of Queensland on curriculum design to establish their own humanitarian engineering program and been invited to guest lecture in the University of New South Wales (UNSW) humanitarian engineering program. I have also served on the organising committee, mentored, and judged for the [Humanitarian Engineering Innovation Pitch and Hackathon](#) run through the Warren Centre in partnership with RedR Australia. The event is a national competition that seeks to expose university students to the role of engineering innovation in addressing global development challenges. Started in 2019, 366 students from across 25 universities in Australia have participated in the hackathon. The event has grown from 60 students (across ten universities) in 2019 to 162 students (across 20 universities) in 2021. I was named a *2021 New Face of Civil Engineering* by the American Society of Civil Engineers – an award which recognises 10 individuals annually as the next generation of civil engineering leaders. My leadership in humanitarian engineering education was specifically cited in the recognition. As these examples attest, I have continued to influence, shape, and strengthen the growth of humanitarian engineering education both domestically and internationally.

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