Engineering Professional Skills Development: Imagined Lives and Real Solutions

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Abstract

This paper explores how providing real-life narratives can effectively internationalise a curriculum and lead to an enhanced, more engaged student experience.

Many first-year Australian university students are being required to confront stories of lives beyond their immediate cultural experience. The annual Engineers without Borders (EWB) Challenge involves them in the authentic task of creating low-cost solutions to a range of actual third-world needs. The national winners then implement their projects in partnership with recipients on site: what was story, previously an exercise in imagination, becomes real.

Flinders University has participated since 2008, with Engineering, Computer Science and soon Mathematics students involved. The recent Australian Standards Threshold Learning Outcomes for Science emphasise communication and professional skills. Students report that their EWB project work (so far in Cambodia, outback Australia, and India) has significantly developed these.

In the Sciences, the 'hard' skills are centred on discipline content, yet universities are expected to produce graduates who communicate effectively. The past decade has seen an interest in integrating so-called process or professional skills, 'soft skills'. Employers regularly rate such abilities as: team work, communication, and understanding of real-world issues as important, yet within tertiary degrees, teaching of such skills has been largely incidental and or at best haphazard. Recent research focusses on problem-based or experiential learning as a path to integrating professional skills that is, connecting the desired technical skills to applications in real life situations.

Conceptualising through story is an effective pedagogical pathway to developing student skills so that they can conceptualise real problems in needy communities and create practical solutions.

Key Words: Professional skills, narrative, engineering, computer science, Engineers without Borders (EWB), student engagement, first-year student experience, report-writing, internationalising the curriculum, pedagogy.

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1. Introduction (Kate)

In the mid-1990s I was a lecturer in Academic Writing sited within the university's Student Learning Centre and was hired out to a discipline area to teach engineering students. 'Language in Use' was a module within a stream within a topic; in those days taken in the second semester by second-year students. (I spoke of it in my paper ‘Skilful Deployment: Teaching Writing across Campus’ at the *State Of The Art:* AAWP (Australasian Association of Writing Programs) Conference, Canberra Australia in 2001). I was able to teach and assess a wide variety of reading, writing and oral tasks but it wasn’t considered the ‘genuine’ work; Language in Use was designed as support for an engineering Team Project that was facilitated by an off-campus ‘genuine’ engineer mentor. Though the students evaluated my contribution highly, I was nevertheless not a part of the final presentations to the faculty staff, but remained an outsider. I prepped the groups for the practise run talks, gave feedback, but never saw the ‘real deal’. I marked their reports, but only for technical writing features. I was not allowed to mess about with content.

Then came a fallow period where higher echelon decisions to wind back Engineering at our university lead to a reduction in student numbers, and the topic fell off the syllabus. But after a few lean years, new managers began pumping the course up and a sudden opportunity arose to remember that topic. In 2008, one week before classes began, Kenneth was tapped on the shoulder and asked to come up with something to offer. Fortunately, he saw it was a chance to re-imagine what Professional Skills could look like. An active participant in Engineers without Borders (EWB), he was aware of the organisation’s initiative to involve students in genuine projects that would assist selected areas of third world countries. With Professional Skills now to be available in the first year and across both semesters, and the Challenge only for first-years, Flinders would be able to participate.

I was by then a doctoral candidate in Creative Writing, having moved off campus into the technical education field for Professional Writing, and returned to study. Kenneth recalled me to teaching within the School - our daughters were friends through university childcare, and he remembered me teaching in Language in Use. But things would be different - this time, our classes would be more collaborative. Kenneth knew Anh was also completing her PhD, in engineering, and she valuably had senior experience in the EWB organisation. On board, she would be the entire student cohort’s mentor, rather than off-campus individuals, and she would be each group’s expert guide to participate in the Challenge. Finally, the topic itself and the experience for the students would be fully integrated.

In the 2011 accreditation of the Engineering courses at Flinders University the official examining panel wanted to know how ostracised I was. ‘Well, you are the only non-science person on staff, aren’t you?’ Assumptions and fears: the two demons that ravage good communication. ‘Hate me?’ I replied, in an opposite echo of Maxim’s response to Mrs. de Winter in the 1940 movie *Rebecca*, ‘They love me!’ Flinders may have one of the smallest Engineering schools in Australia, but it has always punched above its weight with undergraduate and postgraduate students winning prizes, particularly those that involve oral or formal presentations. The value the department always placed on students' acquisition of generic skills: team work, communication and real-world issues, is at the heart of this success. As Kenneth notes, Engineering is a profession much like editing – absolutely critical for functionality, but invisible if done properly. 'Engineering is essential for the sustainable development of modern society'[1]. Teaching engineering by its nature, involves storytelling. Content-rich discipline material relies on stories of failure and disaster, as much as on happenstance and any creative mix. Then, there are the other sorts of storytelling, firstly, the stories students tell about themselves. Finally, stories are used as part of pedagogy, told through the EWB Challenge, which might be able to broaden student perception to the global level.

2. Engineers don't tell stories, do they? (Kenneth)

At first I said that engineers didn't tell stories. Then I reconsidered: Engineers *think* they don't tell stories. But they do. Engineering cannot be self-taught, it is a profession that requires teaching. Firstly, I use personal stories to get students to 'care' about the lecturer, which encourages them to engage in the topic and that is good for their learning. Next, I program a series of lectures and tutorials on puzzle-based learning. These short, simplified puzzles enthuse students about solving real problems. I have another analogy: how poetry is the distilled essence of stories, and puzzles of engineering. Stories are what we remember: for instance, my undergrad memories of Antennas classes are mostly: simply strung wire as an antenna working better than the design. That stayed with me. Creativity is important in the education of engineers and it helps by telling stories of creative inventors like Edison, Marconi, Gutenburg, or Steve Jobs. Many studies have shown that when correctly implemented, cooperative learning improves information acquisition and retention, higher-level thinking skills, interpersonal and communication skills, and self-confidence[2]. Developing the topic, I aimed to introduce students to the general nature of engineering and the core professional practices associated with an engineering project. The topic is to develop an understanding of the nature of engineering a range of transferable skills and knowledge including engineering project planning, feasibility and design, oral and written communication skills, meeting procedures, and the ability to work as a group. On successful completion of this topic, students are expected to understand the role of engineers in society and the purposes of engineering projects, as well as the basic processes involved in engineering planning and design, and applying systems concepts and elementary optimisation theory to the modelling of engineering processes. Students should be able to use decision theory and basic economic analysis for the evaluation of engineering projects; and crucially, work effectively in a group on a complex problem (the EWB Challenge). As I outline in my Aims to the topic, this should:

> Demonstrate their ability to apply scientific and engineering methodology, and to work effectively as part of a team, in project formulation and the execution of feasibility studies; taking into account environmental and social issues and the human factor in analysing and designing engineering or other complex systems; while understanding the principles of sustainable development, acquiring basic competency in the use of word processors, spreadsheets, graphics packages and project management software; and learning how to use a style guide, write a report, present a set of logically related ideas in spoken and written form, implement appropriate meeting procedures, and prepare and deliver a seminar.

To the students, I offer this *US Presidential Council on Science and Engineering 1958* definition 'Engineering is the *profession* in which a knowledge of mathematics and natural science gained by study, experience and practice, is applied with *judgement* to develop ways to utilise economically the materials and forces of nature for the benefit of mankind,' and as I remind the students, *it hasn't changed since*.

As a part of his series of lectures, I feature 'Disaster' storytelling to encourage use of a methodology. I contrast 'Methodology' with 'Method-free': defining the problem, rather than 'Here's a problem (it looks interesting); generating alternatives, versus 'I'd like to do this'; and working out the details in order to implement, critically contrasting with the *without* method, which can only ask: 'Why *doesn't* it work?'(as it inevitably will). Then I then tell such stories as:

Disaster story one: Cost: $18.5 million**:** The Mariner 1 rocket with a space probe headed for Venus diverted from its intended flight path shortly after launch. Mission Control destroyed the rocket 293 seconds after liftoff.

Cause: A programmer incorrectly transcribed a handwritten formula into computer code, missing a single superscript bar. Without the smoothing function indicated by the bar, the software treated normal variations of velocity as if they were serious, causing faulty corrections that sent the rocket off course.

Disaster story two: Cost: $70 million plus another $20 million damage to the local economy**:** Just hours after thousands of fans had left the Hartford Coliseum, the steel-latticed roof collapsed under the weight of wet snow.

Cause: The programmer of the CAD software used to design the coliseum incorrectly assumed the steel roof supports would only face pure compression. But when one of the supports unexpectedly buckled from the snow, it set off a chain reaction that brought down the other roof sections like dominoes.

Disaster story three: Cost: Nearly all of humanity: The Soviet early warning system falsely indicated the United States had launched five ballistic missiles. Fortunately the Soviet duty officer had a 'funny feeling in my gut' and reasoned if the US was really attacking they would launch more than five missiles, so he reported the apparent attack as a false alarm.

Cause: A bug in the Soviet software failed to filter out false missile detections caused by sunlight reflecting off cloud-tops

This definition of a system is a good reason why students have to learn to relate to others – to speak their own stories, listen to stories of others, close to them and far away: 'a system is a set of interrelated elements': each of which is directly or indirectly related to every other element and which cannot be decomposed into independent subsystems.

4. EWB Storytelling for Team Meetings (Anh)

I use stories to help the first world privileged understand or 'get' third-world country situations to do good decisions of for the EWB Challenge.

First Story: A cracked water filter: Failed! - Lessons from the field Technology without Education. This story comes from an Australian colleague who was working with Cambodia communities investigating water access for families living in floating houses.

The EWB volunteer was working with floating communities on the Tonle Sap in Cambodia. She was investigating the quality of drinking water for these families who live on floating houses. Many families collect rainwater from their roofs to drink because it is clean but during the dry season when this runs out, they scoop water from the Tonle Sap around their houses. Drinking this water without any form of treatment has bad health side-effects as the E-coli levels around these houses are sometimes 46 times higher than WHO (World Health Organisation) recommended level of 0 E.coli/100 mL. This leads to diarrhoea and other intestine, stomach and blood diseases, a leading cause of deaths for children under the age of five.

Some families do treat their water before drinking using simple purification technology such as ceramic water filters permeated with silver particles that eliminate pathogens. One family she spoke with had a ceramic water filter that was given to them for free. That was great however the filter was cracked as it was shifted around the house just a week ago. The crack made it ineffective in treating the water. The family asked if that was the reason why they were getting sick in the past week. They were explaining that they had to go to the doctors for their children and that cost $1 per visit including medication for the stomach bugs. The volunteer said that there was a high probably that it was due to drinking contaminated water. A replacement filter cost US$2. The family member thought that was quite expensive. The volunteer mentioned that if they invested in a new filter, then they would save the medical costs, though in the meantime, they would need to boil their water if they didn’t want to get ill. Ironically, the mother used her mobile phone to call her husband on their second mobile phone to talk about the water issue. Typically, mobile phones cost $20 each and then there is the ongoing call cost each month – much larger than the $2 required to buy a new filter.

Lesson learnt – Technology without education regarding pathogens pathways and how ceramic filters work will lead to a continual cycle of illness and poverty. Once the value of the ceramic water filter, both in a health and economic sense was conveyed, then the family was convinced that it was important to invest in a new filter.

Second story, Personal: Arsenic and water: technology and ethics: This second story is a personal story of my work with Engineers without Borders Australia in Cambodian communities investigating water quality for families living in Kandal Province. I was involved in a team of engineers and local field officers from a local non-government organisation that were investigating the water quality of deep wells in the Kandal Province. Many of the shallow tube wells in the past were installed to give communities access to drinking water to prevent people from drinking bacteria-contaminated surface water. These organisations had good intentions however they failed to test the ground water for arsenic. It was later discovered that many of the wells in Kandal Province were contaminated with naturally occurring arsenic. Long-term chronic consumption of drinking water contaminated with arsenic causes arsenic poisoning and leads to skin lesions, increase risk of cancer and eventually death. One of the wells we tested was above the WHO recommended levels of 10 parts per billion. The family was visibly concerned about their health after hearing that they have been drinking from contaminated wells. We marked the well and worked with the community to educated the local farmers not drink from the marked wells.

Lesson learnt – Technology without thorough and rigorous testing will lead to unethical practices that harm the people that you are trying to assist – potentially even kill them. This is unacceptable practice and as professionals, we need to take responsibility for the design, implementation and testing of system that we develop for these communities.

5. Life 'out there' brought inside (Kate)

Students switch on after exposure to these stories. In my workshops, outside of the team meetings with Anh, students note their own 'conversion', taking them out of their own comfort zone and expanding their horizons. 'It was a real eye-opener' said Adrian [3], another student exclaiming, 'I knew they were poor and all, but I didn't expect they wouldn't have electricity!' Because his passion was computing, his connection to the community, was through what he considered important – the ability to operate a computer – and with sufficient bandwidth. The Challenge affects local and international students, some of whom give their mini three minute in-class orals on aspects from their own homes. This raises the consciousness of the class, considering 'one of their own' comes with insider knowledge. Australian-born students, too, were confronted when the 'third world community' EWB chose for 2010 was outback rural remote indigenous community in South West Queensland. Students report both fear and excitement at participating in an authentic project for which real-life outcomes transpire. Jeremy wrote:

> It was scary because it was a project based on real issues. So intimidating – it felt like a good transition to university life because I realise I am going to have to work to a higher standard. Understanding that Engineering isn't just about physics and maths and that I will hopefully achieve so much more as an engineering in regards to helping humanity and personal achievements was the most enjoyable part of undertaking this project

This contrasts to what Chris says:

> The most enjoyable part of the EWB Challenge has been knowing that what you are working on has real life applications and could benefit a community immensely. It was great to finally feel like your product had some worth, which was greater than that of getting a good grade.

5. Conclusion

Current computer science and engineering courses may grapple with creating practical and meaningful activities for students to undertake[4] that incorporate not only the technical solutions, but an understanding of social, cultural, global and environmental responsibilities of the professional. Participating in a team project aims to address this need by providing university students with the opportunity to meaningfully engage with the broader community while educating the application of science and technology to solve real world, important problems. This paper explores how providing real-life narratives can effectively internationalise a curriculum and lead to an enhanced, more engaged student experience. These first-year Australian university students are required to confront stories of lives beyond their immediate cultural experience. The EWB Challenge involves them in the authentic task of creating low-cost solutions to a range of actual third-world needs, solutions to contaminated drinking water, inadequate shelter, and poor transportation. The national winners then implement their projects in partnership with recipients on site: what was story, previously an exercise in imagination, becomes real.

> The narrative process enables these learners to begin to restory and reconstruct lives in an educational setting. Transformative learning can occur when groups of people come together in community or social groups to critically reflect on the conditions that constrain their actions and create difficulties[5].

Recent research focusses on problem-based or experiential learning as a path to integrating professional skills that is, connecting the desired technical skills to applications in real life situations. These correlate with improved academic performance[6]'can be used within the wide range of working environments that graduates operate throughout their lives'[7] form a 'stabilising characteristic of work'[8]; are linked to student engagement; and influence how 'inspiring' students find their degrees[9].

Conceptualising through story is an effective pedagogical pathway to developing student skills so that they can understand real problems in needy communities and create practical solutions.

Notes

1 Julie E. Mills, Mary Ayre and Judith Gill. *Guidelines for the Design of Inclusive Engineering Education Programs*. ALTC 2010. Available from: http://resource.unisa.edu.au/course/view.php?id=568 or at the Australian Learning and Teaching Council website for the project: http://www.altc.edu.au/project-gender-inclusive-curriculum-unisa-2008

2 Johnson, Johnson, and Smith, 1998 cited in Kaufmann, Felder & Fuller 2000.

3 All student comments from cohort Professional Skills in Engineering / Professional Skills in Computer Science ENGR/COMP1401 Semester One 2012

4 Daniel Loden and Wahidul Biswas, 'Enhancement of university curriculum and secondary school education through utilisation of sustainable engineering and appropriate technology workshops' Proceedings of the 2010 AaeE Conference, Sydney, 2010

5 Heather J. Richmond. 'Learners' Lives: A Narrative Analysis' *The Qualitative Report*, Volume 7, Number 3 September, 2002 available: http://www.nova.edu/ssss/QR/QR7-3/richmond.html

6 Tomas Chamorro-Premuzic, Adriane Arteche, 'Soft Skills in Higher Education: Importance and Improvement Ratings as a Function of Individual Differences and Academic Performance', Goldsmiths: University of London, 2010.

7 (Fraser 2001, p. 1

8 Tomas Chamorro-Premuzic, Adriane Arteche, 'Soft Skills in Higher Education: Importance and Improvement Ratings as a Function of Individual Differences and Academic Performance', Goldsmiths: University of London, 2010.

9Tomas Chamorro-Premuzic, Adriane Arteche, 'Soft Skills in Higher Education: Importance and Improvement Ratings as a Function of Individual Differences and Academic Performance', Goldsmiths: University of London, 2010.

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