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***Engineering education for social and environmental justice:
Scaffolding multidisciplinary knowledge through multiliteracies***
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TITLE: *Engineering Education for Social and Environmental Justice: Scaffolding multidisciplinary knowledge through multiliteracies*

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INTRODUCTION:

This paper reports findings of a project funded by the Australian Learning and Teaching Council and titled *Engineering Education for Social and Environmental Justice (EESEJ)*. In a context of rapid globalisation, the EESEJ project aims to increase tertiary student learning for social and environmental justice through a new critical approach to engineering education, encouraging student engineers to situate their technical expertise and respond ethically in social, economic and environmental contexts, both locally and globally (see Baillie & Catalano, 2009). A multidisciplinary research team in Australia, the UK and USA engaged in a range of activities, such as designing and implementing critical problem solving in undergraduate engineering courses and undertaking collaborative writing tasks in small research teams. The EESEJ project is based on several assumptions: that social and environmental justice are interwoven and the holistic curriculum approach recommended by Engineers Australia is valid, with students undertaking community projects in ways that responsibly consider social, economic, cultural, environmental and ethical factors. The work of socially just engineers is integrated with community consultation and governed by anti-oppressive principles (Young, 2000), so as to avoid exploitation, marginalization, cultural imperialism, powerlessness and violence in communities. The aim of this paper is to describe the experience of a group of participants in the EESEJ project, the methods they used and the outcomes they achieved.

BODY OF KNOWLEDGE

Participants' experiences of the EESEJ journey are analysed through three interwoven theoretical lenses, each concerned with elucidation of learning processes. To illustrate these developmental stories, the analysis in this paper applies Green's elaborations about adult learners being scaffolded into new spaces; these spaces are explicated with Vygotsky's zone of proximal development (Vygotsky, 1978), capability theory (Bowden, 2004; Bowden & Marton, 1998) and the framework of multiliteracies (The New London Group, 1996).

(1) Capability theory and variation theory. Capability theory (Bowden, 2004) has been developed to explain the way that experiences of learning content in university programmes can be used by students to develop their capacity to handle previously unseen situations in their professional, social and personal lives. Such capabilities are developed through reflection on experience of variation (Bowden & Marton, 1998) and include the capacity to discern what are the key aspects of each new situation, what knowledge is relevant, how to design a response and how to implement it. Qualities of discernment and judgement are paramount and the knowledge required and responses devised in most real situations go beyond simple discipline knowledge. So-called generic skill development needs to be integrated with content learning and part of capability development. The notion of social justice as a central aspect of all engineering practice is one example of this.

(2) Vygotsky's zone of proximal development (ZPD) Vygotsky's sociocultural theory suggests that learning is constructed and negotiated through social experiences. Describing the relation between learning processes and capabilities, Vygotsky (1978) identified at least two developmental levels, the first involving a learner's actual development and the second measuring the learner's accomplishments with others' assistance. ZPD identifies the space into which the learner can progress, with help from more experienced peer(s) or expert other(s), and where shared knowledge is constructed and negotiated, prior to being internalized or mastered by the individual learner. In parallel, Wood, Bruner and Ross (1976) developed the metaphor of scaffolding to describe the process of graduated assistance as adults support children's problem-solving activities, with steps such as building interest, keeping the child on track, simplifying and/demonstrating the task. This original "linear" concept has been replaced by a widened metaphor of scaffolding that emphasises aspects such as temporality, physical context, interdependent and complementary roles of children, caregivers or peers and conflict in the learning process or associated relationships (Cumming-Potvin, Renshaw & van Kraayenoord, 2003; Rogoff, 1990). More recently, Green (2005) extended the metaphor to include a multiplicity of processes and key elements in supporting the learning of adults. Inspired by the work of Bowden and Marton (1998), Green argued that in such scaffolded learning spaces, the influential expert(s) does not have ready-made answers and supports the learner on a recursive, variable and unknown journey. Describing complex processes when an influential adult supports adult researchers within communities of practice, Green adapted Wood et al.'s original metaphor of scaffolding. She identified key elements, such as: motivating others, balancing dependence with independence, working from individuals' capabilities, engaging in explicit discourses and promoting reflexivity.

(3) Multiliteracies. Developed by the New London Group (1996), this theoretical perspective contends that due to increasing cultural and linguistic diversity and channels of communication, new ways of approaching literacy are required. A multiliteracies' approach aims to support access to evolving forms of language, critical civic engagement and power. This approach underpinned the work of the project writing teams and will be used in this paper to analyse interviews with writing team members and reflections on a particular project by one co-author, with an emphasis on the concept of co-creation. To support the EESEJ's collaborative writing efforts, a range of qualitative methods was employed, such as reflective journaling, semi-structured interviews, and an informal peer-review process involving critical friends. The interviews were generally with pairs of authors who had written together and focused on the following questions: What did authors have in mind when they first thought about the paper? What did they anticipate might be the other author's perspective? How did the contribution fit with or differ from what was anticipated? How did the two of them work out how to write the paper together? What was the plan for the paper? Did it all work out as planned? If not, what actually happened? Did either notice any shift in perspective for either of you? Most authors spoke about changes in their own ways of seeing. Some spoke about how their own frameworks had been expanded by the experience. At the very least, most authors saw considerable value in looking at familiar issues from the perspective of another discipline. These results link with variation theory and capability development (Bowden, 2004; Bowden & Marton, 1998)

CONCLUSIONS

Applications to learning in engineering education.

No application of learned engineering content to real situations can be value-free. Such aspects, often regarded as separate, even peripheral, must be integrated into core curriculum. Perspectives of other disciplines can be used to enhance students' experience of variation, thereby assisting capability development.

How will we use this knowledge? Drawing on multidisciplinary perspectives in pedagogy, curriculum and qualitative methodology, results will serve to develop 'good practice' guidelines and raise the profile of engineering education in Australia and abroad.

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