

# Mapping the engineering education research landscape in Australia

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## Structured abstract

### BACKGROUND

Engineering education research is still consolidating as a recognised research area in Australian universities. A current project funded by the US National Science Foundation is attempting to develop a taxonomy for engineering education as a research area. Our project takes a slightly different perspective by using a landscape model to describe engineering education as a knowledge domain that includes a variety of areas of endeavour.

### PURPOSE

This paper is motivated by questions around the range of topics being addressed in the AAEE community and as a means of initiating a discussion about how we define, evaluate, understand and move within our research domain.

### APPROACH

This paper reports data collected as part of a wider project examining the peer review process for the Australasian Association for Engineering Education (AAEE) annual conference. During semi-structured interviews nineteen participants used one or two coloured adhesive stars to locate their paper on a model of the engineering education research landscape presented in this paper. The location of the stars was then analysed in relation to various elements of the model and the explanations were coded in NVivo 10 for themes relating to the star location.

### OUTCOMES

All participants could locate the topic of their conference paper on the presented model, and articulate clearly why their star belonged in the selected location demonstrating an individual understanding of the focus and outcomes of their research. Not surprisingly most stars were clustered in the 'teaching and learning of engineering' element or on one of the trajectories leading to it. This reflects that for many participants, their educational publications are inextricably linked to their practice of teaching engineering. Interestingly, there were strong voices from participants across all expertise levels and university types against a perceived move to make the annual AAEE conference focus on theoretical research. This was seen as a move towards exclusivity and a lack of acceptance for practice-based studies.

### CONCLUSIONS

The landscape model presented in this paper successfully stimulated dialogue around both the nature and the areas of research in our community and allowed participants to appreciate where they are positioned in the landscape. Such a dialogue will help us define our research domain and support both colleagues and postgraduate students seeking to participate in or move within it. We suggest it can also be used to dissipate some of the tensions developing in AAEE about the standard and value of research. We argue that a practice versus theoretical research dichotomy is ultimately divisive and that our national conference should provide a forum for all authors in an environment aimed at improving the quality of publications and the development of academics wherever they are in the landscape.

### KEYWORDS

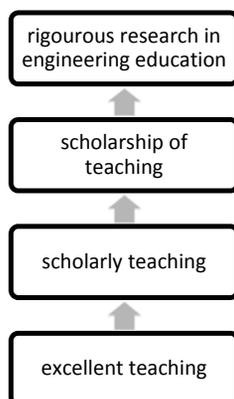
Engineering education research, academic development

## Introduction

Engineering education research is still consolidating as a recognised research area in Australian universities (King 2008; Kavanagh et al 2012). A current project funded by the US National Science Foundation is attempting to develop a taxonomy for engineering education as a research area (Finelli, 2013). Our project takes a different perspective. Finding out what topics members of the AAEE community are researching will enable us to view engineering education as a knowledge domain that includes a variety of areas of endeavour. Our intention is to assist engineering education researchers to appreciate the differences in methods, frameworks and theories typically used in different parts of the landscape. Our aim is for the landscape to be used as the foundation for conversations to facilitate the social construction and subsequent understanding of the community standards and norms used to judge research quality. This will help the community to articulate and understand observed changes in an academic's research as they develop their expertise in the research area, as well as provide a language for emerging researchers to plan this development if that is what they want to do.

Currently the differences within engineering education research discussed above are not well understood. A contributing factor is that the field is both emerging and interdisciplinary resulting in a wide variety of views as to what quality research looks like (Borrego & Bernhard 2011).

Borrego (2007) cites a researcher developmental hierarchy proposed by Streveler et al (2007) as follows:



**Figure 1: Levels of 'rigour' in investigation (Borrego, 2007)**

This hierarchical trajectory has contributed to tension in the field of engineering education research between practice-based studies and theoretical research. This trajectory appears to preference theoretical research irrespective of the quality of the work undertaken. We would argue that theoretical research studies can be poorly conceptualised, carried out and reported and that practice-based studies that would be classified as scholarship of teaching can be well conceptualised, undertaken and reported. Furthermore, such a hierarchy does not assist a novice researcher (whether applied or theoretically focussed) to develop their expertise.

Jesiek et al (2010) report the results of discussions at workshops on engineering education research at various locations around the world. They note the perceptions of theoretical studies being preferenced over practical studies and consensus around the need for strong links between teaching practice and theoretical research:

*One global colloquium group characterised engineering education research as 'stratified from local to rigorous' and they expressed concerns about the field being overly focused on the latter. Still other colloquium participants warned that a lack of strong researcher-practitioner ties could come with a 'danger of elitism'.(p.126)*

Tension between practical studies and theoretical research in this field has also been noted in the National Research Council report (2012) on discipline-based education research in undergraduate science and engineering:

*Publications intended for practitioners to support change in classroom teaching generally earn less professional recognition than research-focused journals ... High quality research papers published in journals that practitioners are less likely to read may have less influence on classroom culture.(p.2.14)*

This report acknowledges that both theoretical and applied studies are “*valuable and important*”.

A wide-ranging study by Jesiek et al. (2011) based on analysis of over 800 articles presenting empirical data in a large number of publications between 2005 and 2008 found

*...continued strong interest in many subjects long viewed as central facets of engineering education, including assessment, collaborative/team learning, design, and educational/instructional technologies. Further, we observe an historical shift away from research explicitly focused on teaching and toward studies that examine students and learning, global engineering education, problem- and project-based learning, and graduate outcomes/attributes. (Jesiek et al 2011, p.87)*

This shift in focus could be interpreted as a function of development of the field of engineering education research. It is pleasing to note that they identified Australia as a particularly active engineering education community, along with the US and Europe. However the development of the field is a function of the development of the individual researchers in it and hence we focus on researchers and the progression of their research in our community.

This paper reports data collected as part of a wider project examining the peer review process for the Australasian Association for Engineering Education (AAEE) annual conference. It is motivated by questions around the differences in understanding of how engineering education research is defined, how its quality is evaluated and improved, what the domain looks like and the characteristics of researchers at different levels of expertise. We hope that the community will use this research as a means of initiating discussions about how we define, understand, build and strengthen our research domain.

## **Method**

The study focuses on engineering academics at Australian universities with engineering qualifications, who are also ‘active’ members of AAEE. We defined engineering academics as ‘active’ members of AAEE if they authored a paper for the 2012 AAEE conference AND at least one of the three previous years’ AAEE conferences. The author list from these conferences (available in the proceedings) was used to identify potential participants. We wanted people to feel free to share their research experiences so excluded Sydney-based universities in deference to those academics who see universities as being in competition with each other. The remaining thirty-eight eligible academics were invited to participate in the research project. Nineteen of these authors, shown listed in Table 1, accepted this invitation.

Participants were classified according to what type of university they work for (Group of Eight (Go8), Australian Technology Network (ATN), regional, or metropolitan unaligned, as described in Table 1) as institutional identity has been shown to influence an individual’s academic identity development (McAlpine & Amundsen, 2011).

Participants were also classified according to their level of expertise in engineering education research, as intellectual development is another aspect of academic identity (McAlpine and Amundsen, 2011). A participant’s level of expertise was assessed by a number of indicators including the types and number of publications they had written in the last four years (conference papers, journal papers, book chapters), whether they had been a project leader of an educational investigation or research grant where the funding was provided through a

nationally competitive process, whether they are supervising research students working on educational related topics, and whether they were currently serving in an editorial role for an educationally related journal. Using this system, participants fell into three broad groups: emerging, intermediate, and established researchers.

**Table 1: Participants' pseudonym, level of experience & type of university**

Participants	Level of experience	Type of university	Description
Adele Evan Mark Tom	emerging	Group of Eight [Go8]	The 'Group of Eight' ( <a href="http://www.go8.edu.au/home">http://www.go8.edu.au/home</a> ) is a coalition of eight research-intensive universities located in state capital cities, which tend to be the oldest universities in Australia.
Neil	intermediate		
Stuart	established		
Therese	intermediate	Australian Technology Network [ATN]	The ATN is an alliance of five universities, each located in the capital city of a mainland state of Australia. These universities badge themselves as practice-based and their research is focussed on the needs of industry and the community.
Rob Steve	established		
Alex Wayne	emerging	Regional	Regional universities are those with their main campus in a regional city or town rather than a state capital city. As well as on-campus students, these universities are characterised by significant numbers of external/distance students.
Sam	intermediate		
Dennis Erica	established		
Terry Mike Ian	emerging	Metropolitan unaligned	The metropolitan unaligned universities are those based in a state capital city, but not included in the Go8 or the ATN.
Nathan	intermediate		
Will	established		

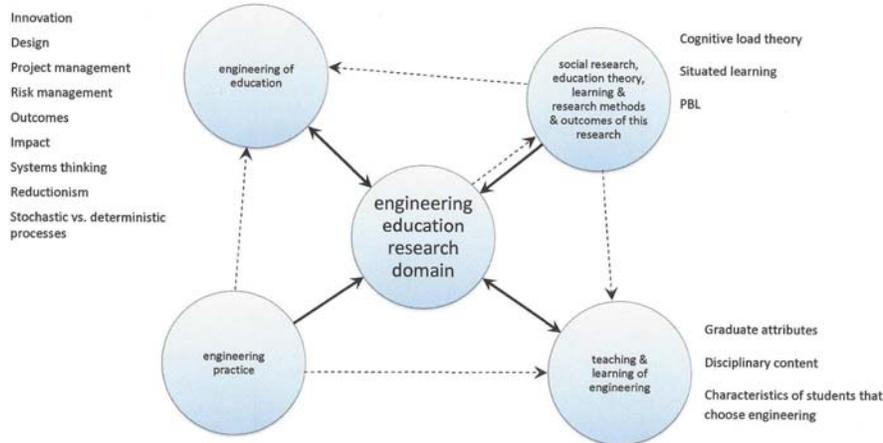
Participants used one or two coloured adhesive stars (the colour was the participant's choice) to locate their paper on a model of the engineering education research landscape as shown in Figure 2 and then explain why they had stuck their star/s in the position they did. The location of the stars was then analysed in relation to the various neighbourhoods and elements of the model. Transcripts were created from audio recordings of the interviews, which were then coded in NVivo 10 for the themes in participants' explanations for their selected location.

In this paper, we discuss how participant responses were used to:

- verify and refine the range of different research areas within which members of the AAEE community are working ie what the domain looks like,
- identify the characteristics of emerging, intermediate and experienced researchers.

The model (see Figure 2) represents broad aspects or topic areas of interest to the AAEE community. These broad categories were established from an overview of topic areas that people in the AAEE community have reported on in the last three AAEE conferences. One 'neighbourhood' in this landscape is the teaching and learning of engineering. This encompasses what we do in the classrooms, or workshops, or at university generally with engineering students enrolled in our subject, and the students that we do that with. We like to think that this is influenced by engineering practice, another 'neighbourhood' encompassing professional engineers practising their profession in industry. We also like to

think that the teaching and learning of engineering and research into the teaching and learning of engineering is influenced by the methods and outcomes from social research particularly in learning theories, so this forms another neighbourhood on our landscape. The final area on the landscape model is what we call engineering of education, and that's where we tend to use the same skills and ways of thinking and looking at things that we've adopted or learned because we've been trained as engineers, on our subjects and in our research on our subjects. This might be for example treating issues in our subjects as problems to 'solve' or products to design and we evaluate the outcomes of this process.



**Figure 2: Engineering Education Research landscape**

This model is not meant to definitively describe the engineering education research landscape, but was rather devised to provide a basis for members of the community to articulate their area/s of activity and evaluate their activity and research in terms of its characteristics rather than typical research metrics around a publication 'count' ie to start a conversation.

## Outcomes and discussion

All participants could locate the topic of their conference paper on the presented model, and clearly articulate why their star/s belonged in the selected location demonstrating an individual understanding of the focus and outcomes of their research and that the model is a good approximation of our community's landscape. Most stars were clustered in the 'teaching and learning of engineering' element or on one of the trajectories leading to it. This reflects that for many participants, their educational publications are inextricably linked to their practice of engineering teaching. There were strong voices from participants across all expertise levels and university types opposing a perceived move to make the annual AAEE conference focus on theoretical research. This was interpreted as a move towards exclusivity and a lack of acceptance for scholarship type investigations and non-theoretical research and echoes similar views reported in other geographical locations by Jesiek et al (2010).

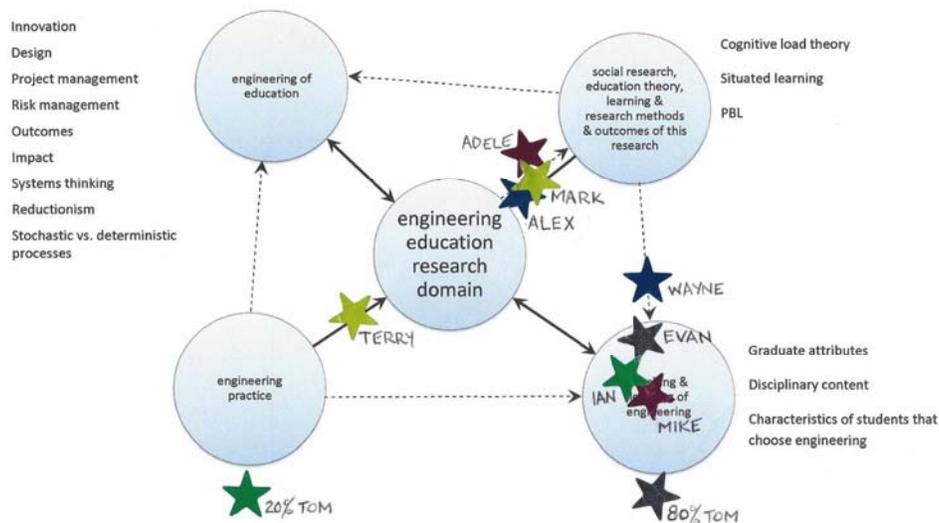
Firstly we observe that all participants could locate the topic of their paper on the presented model, even if it took a little thinking for some of them. One established researcher (Dennis) added a region of activity (secondary school system) to the model to be able to do this, and this area will be included in future. They could also articulate why their star belonged in that location:

*I think this is about teaching and learning of engineering. So it's about engineering education practice. So I think it sits here. [Mike, emerging, metropolitan unaligned]*

*We've brought something that was developed in engineering practice into teaching and learning to try and change the way we teach to look more like what happens in engineering practice. So that's a bit of an example of engineering of education. [Therese, intermediate, ATN]*

*I think it sits in two diagonally opposite corners and I think it sits quite clearly in both.... It's what we're getting the students to do, but it's about how we develop that assessment process so it's the engineering of it. It's the design of it in order to meet particular requirements. So I'd say 50 per cent in each. [Erica, established, regional]*

Emerging researchers' stars are shown in Figure 3. Except for Tom, these participants were able to locate the activity area of their paper with one star, with most clustered in the 'teaching and learning of engineering' neighbourhood. These participants typically wrote about the subject they were teaching and/or managing, except for Adele and Alex who were concerned with questions not specifically related to any one subject, but general sector-wide questions, which aligns with their stars being located in the 'social research' vicinity. Mark also stuck his star near social research because he is intentionally drawing on research from the education domain to investigate the subject he is teaching. Wayne located his star on the trajectory between teaching and learning and social research because he is starting to think about incorporating some findings from educational research into his own research design. Terry's area of teaching and mainstream engineering research is a practice-oriented aspect of engineering and his identification with this area is illustrated in locating his star on the 'engineering practice' trajectory, as shown in Figure 3, even though his paper is essentially about evaluating practice in the subject that he teaches.



**Figure 3: Where emerging researchers located their AAEE 2012 conference paper**

Figure 4 shows where intermediate researchers located their stars. We note in contrast to the emerging researchers, that all of these participants, except for Sam, used two stars to locate their paper. Also in contrast to the emerging researchers, all but one of the intermediate researchers placed at least one of their stars in the 'engineering of education' area. Stars were fairly equally clustered in the 'teaching and learning of engineering' and 'engineering of education' vicinities. This suggests to us that intermediate researchers may be addressing more integrated questions than those addressed by emerging researchers.

Established researchers (shown in Figure 5) were also generally split between two stars or placed their one star towards the middle of a trajectory between two activity areas, suggesting that they are addressing integrated questions. The exception here is Stuart who has taken a deep rather than broad approach to his research. It is also interesting that an established researcher, namely Dennis, added the activity area of secondary school system

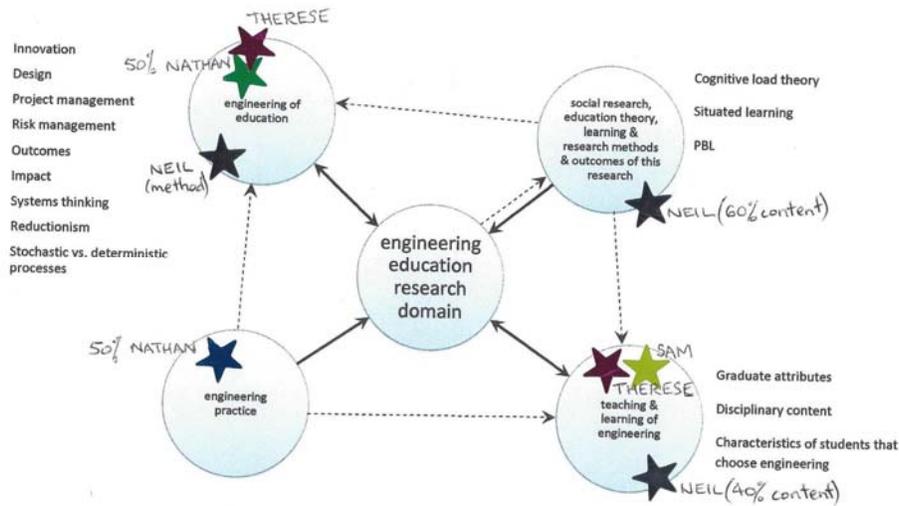
to the presented model. Apart from Stuart, these participants are involved in projects in a range of areas, or which integrate a range of areas:

*...it's that big scale stuff that interests me more than at the course level...so all of these things tend to blur. [Rob, Go8]*

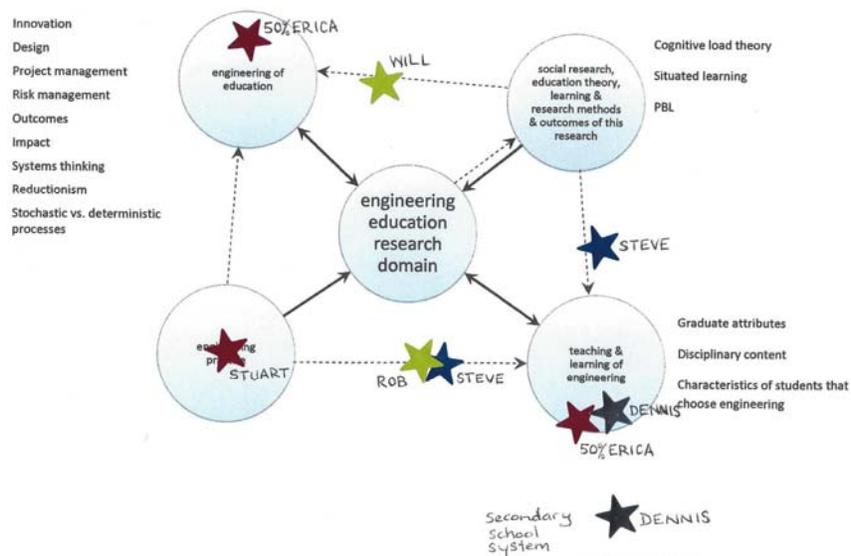
*...it's hard to actually pigeon hole because there are components that I do...I consider myself quite diverse...I move across different spaces. [Steve, ATN]*

*... the questions that I have are really sector wide but generally still within an engineering context. [Will, metropolitan unaligned]*

*I don't think that I've got any papers over the years that have been just in one of these domains.... I think most papers I've written would cross over... So yeah, I've got fingers in lots and lots of different pies. [Erica, regional]*



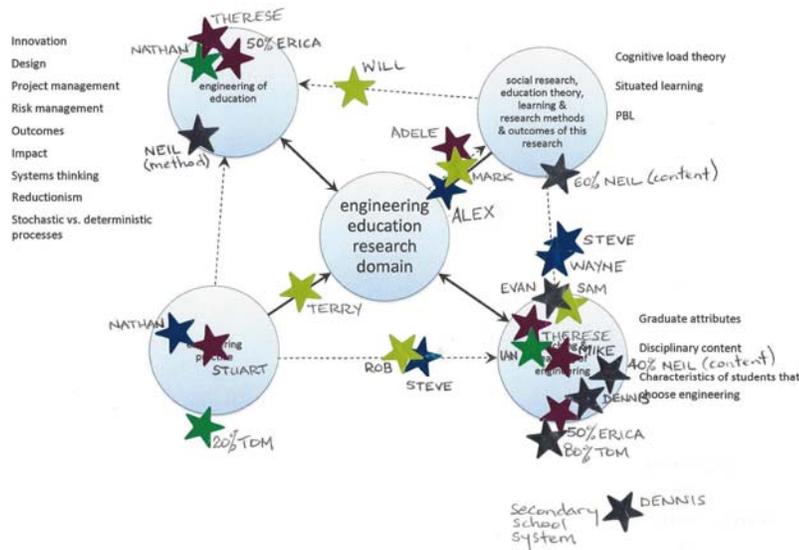
**Figure 4: Where intermediate researchers located their AAEE 2012 conference paper**



**Figure 5: Where established researchers located their AAEE 2012 conference paper**

Figure 6 shows the location of stars of all the participants interviewed. Most stars are clustered in the 'teaching and learning of engineering' element or on one of the trajectories leading to it. This reflects that for many participants their educational research is inextricably

linked to their practice of engineering teaching. How we think of ourselves influences what is important to us which in turn affects how we spend our time ie what we actually do. If we think of ourselves as researchers then we will do research-related activities. If we think of ourselves as teachers then we will do teaching-related activities. Being a 'professional' teacher or approaching our teaching 'professionally' would include reflective practice and evaluation that could result in writing a paper. Analysis of who put their star where (Figure 6) shows that those employed at regional and ATN universities were clustered around the teaching and learning neighbourhood (with Therese and Erica being exceptions) while participants employed at Go8 and unaligned metropolitan universities were more evenly distributed over the whole landscape. This aligns with the idea that the institutional environment may impact on our academic identity ie that institutions can either support or restrict an individual's academic identity development (McAlpine & Amundsen, 2011).



**Figure 6: Where all researchers located their AAE 2012 conference paper**

Figure 6 also allows us to interpret the extent of research activity in our community. This figure shows that there is much activity in the teaching and learning neighbourhood, some in the engineering practice area and some of this activity is aimed at bringing engineering practice into teaching and learning practice. What is interesting to note here is that those in the teaching and learning neighbourhood are across all levels of expertise ie emerging, intermediate and established researchers.

There were strong voices from our participants opposing what they saw as a move to make the annual AAE conference exclusively focussed on theoretical research, which comes from conceptualising researchers' activity in a hierarchy as shown in the model in Figure 1. These calls for the continued inclusion of practice papers in the conference came from participants across all expertise levels and university types:

*We want everyone to feel part of the community and to be valued for their contributions and not get into some kind of us and them... That's just not at all helpful. [Rob, established, ATN]*

*There's always been this idea that there's fundamentally two types of papers we see at the conference. What they call the show and tell paper and the research papers - the engineering research papers... Well, but the worry of that has been that it would divide the camp into the elitists and the apprentices, the people that aren't quite there yet, but let's patronise them for a while. I don't think it needs to be like that at all. I mean, I would hate to divide the community. I would hate to be perceived as becoming more elite. [Neil, intermediate, Go8]*

*This conference seemed to take the view that ... they were trying to move to a more research based place, and downplay the practice aspect... If you're reporting on practice... it tells those people that they're not valued at the conference [Mark, emerging, Go8]*

*...if engineering education and research doesn't inform practice in Australian universities, then it's missed the point...I got this overwhelming feeling that the people in the audience didn't feel connected to AAEE as an organisation, because they are all practitioners and AAEE seems to be running an agenda of engineering education research, which not is not necessarily related to improving practice [Mike, emerging, metropolitan unaligned]*

The landscape is a starting point for a different way of characterising papers and shows the range of types of topics academics in engineering education are involved in. We suggest a more fruitful conversation for our community is discussing the characteristics of quality rather than what is the best 'type' of research to be doing. By showing the range of topics that engineering education authors are writing about, a landscape model can also be used to demonstrate that engineering education as a knowledge domain includes a variety of areas of endeavour. In the interviews reported in this paper the landscape model successfully stimulated dialogue around the nature of topics in our community and allowed people to find a home in the landscape. This dialogue is important for a knowledge domain which is still emerging as a recognised area in Australian universities (King 2008; Kavanagh et al 2012), and when government research policies propagate the view of research as a commodity:

*This is particularly worrying in some of the newer disciplines and in education...where researchers may be endeavouring to establish new forms of inquiry." (Brew, p.283)*

We suggest that the landscape can also be used to help researchers articulate what area/s they might want their research to be located in, and encourage an attitude that it is acceptable to be in any part of the landscape.

As noted in the NRC report (2012) theoretical research is no more important than practice-based research. Hence, the authors believe that it is possible to achieve high quality research by staying within the teaching and learning of engineering part of the landscape, as demonstrated by some of our established researchers Erica, Dennis, Rob and Steve. More experienced researchers see their research from different perspectives and views and are aware that the impact of both variables and the investigation context is complex. Their papers typically contain focussed and critical literature reviews, and they use methods appropriate to the investigation. We argue that we should be looking to encourage improvements in quality of the studies we conduct within our community in all areas of the landscape using the characteristics of the work of our established researchers, rather than moving people to a specific area within the landscape. This could begin with an acknowledgement that the quality of the work is not dictated by the position on the landscape but rather the quality of the processes and thinking applied to the researcher's investigation. We believe this would dissipate tension arising from the perceived preferential status of theoretical research in the community.

To be a community we should be socially constructing our understanding of the accepted standards and norms in our field of research. We need a way of personally evaluating our research and what is required to make any movements or adjustments that we may choose in the level or location of the research that we undertake. The landscape has the capacity to assist the community to achieve both these goals and ultimately help us to establish our research field through more inclusive dialogue. The landscape also allows us to identify other community members working in the same vicinity and hence identify potential mentors and/or collaborators to help us develop as individual researchers and consequently the research field we work in.

## **Conclusions**

The landscape model presented in this paper successfully stimulated dialogue around the nature of topics in our community and allowed participants to find a place to belong in the landscape. We argue that such a dialogue will help us identify our research domain and support colleagues and postgraduate students seeking to participate in or move within it. One indication of progress of a new researcher on their developmental journey is the use of multiple perspectives and dimensions in their research. A practice versus research

dichotomy is ultimately divisive and our national conference should provide a forum for all authors in an environment aimed at improving the quality of publications and the development of academics wherever they are on the landscape.

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