

Mapping the landscape of engineering education research: an Australian perspective

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Conference Topic: Educational Research Methods

1 INTRODUCTION

Engineering education research is still consolidating as a recognised research area in Australian universities [1, 2]. A current project funded by the US National Science Foundation is attempting to develop a taxonomy for engineering education as a research area [3]. 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 intention 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 both the community and individuals to articulate and understand observed changes in their and their peers' research as expertise is developed, as well as provide a language for researchers, particularly those new to the field to plan, discuss and evaluate this development if they so choose.

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 [4]. Borrego [5] cites a researcher developmental hierarchy proposed in [6] as shown in Fig. 1. This hierarchical trajectory has contributed to tension in the field of engineering education research between practice-based studies and theoretical research. Rightly or wrongly this trajectory has been interpreted as preferencing theoretical research irrespective of the quality of the work undertaken. We would argue that just because a research study is theoretically situated does not prevent it from being poorly conceptualised, conducted and / or reported. Conversely, many practice-based studies that the hierarchy would classify as scholarship of teaching exhibit the characteristics of what the hierarchy refers to as rigorous research. Furthermore, such a hierarchy suggests to a novice researcher (whether applied or theoretically focussed) that a single sequential path exists to improve their research.

Discussions at workshops on engineering education research at various locations around the world support a general perception that theoretical studies are preferred for publication and funding over practical studies [7]. There was also 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

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colloquium participants warned that a lack of strong researcher–practitioner ties could come with a ‘danger of elitism’. [7, p.126]

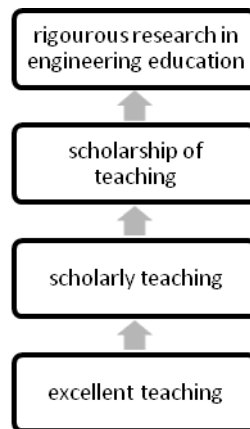


Figure 1: Levels of ‘rigour’ in investigation [5]

Tension between practical studies and theoretical research in this field has also been noted in the National Research Council report [8] 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.[8, p.2.14]

This paper 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. It is based on the premise that development of the field is a function of the development of the individual researchers within it and hence we focus on researchers and the progression of their research in our community. That such questions are relevant to our community are evidenced by recent editorials in JEE and EJEE [9, 10]. We encourage the community to use this research as a means of initiating discussions about how we define, understand, build and strengthen our research domain.

2 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 thirty-eight potential participants. Nineteen of these authors, shown listed in Table 1, accepted this invitation.

Participants were classified according to what type of university they work for as institutional identity has been shown to influence an individual’s academic identity development [11]. Participants were also classified according to their level of expertise in engineering education research, as intellectual development is another aspect of academic identity [11]. 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.

A model of the engineering education landscape (see Figure 2) was developed showing general aspects or topic areas of interest to the AAEE community. The categories were established from an overview of topic areas that people in the AAEE community have written about 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 suggest that this is influenced by engineering practice, another 'neighbourhood' encompassing professional engineers practising their profession in industry. We also suggest 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.

This model is not meant to definitively describe the engineering education research landscape, but was rather intended to provide a catalyst for members of the community to develop their research literacy building a language to articulate their area/s of activity and to assess and evaluate this activity and research in terms of its characteristics rather than typical and often misleading research metrics such as publication 'count'. We have since modified the model by removing the central circle as it was interpreted by some as being a separate domain rather than the parent activity within which the four specified neighbourhoods are all immersed, but present here the model as used with our participants.

Participants used one or two coloured adhesive stars (the colour was the participant's choice) to locate their paper on the landscape model 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.

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' (http://www.go8.edu.au/home) 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		

The landscape model was also used in a workshop at the 2013 AAEE conference. Posters produced by participants and recordings of the discussion of two groups at the workshop provide us with additional data. One group recorded were those who located their research work in the social science

neighbourhood of the landscape. This group had members with a mixture of expertise levels from emerging to established. The other recording was of a group who located their research in the teaching and learning neighbourhood and who were all emerging researchers.

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 AEE community are working i.e. what the domain looks like, and identify the characteristics of emerging, intermediate and experienced researchers.

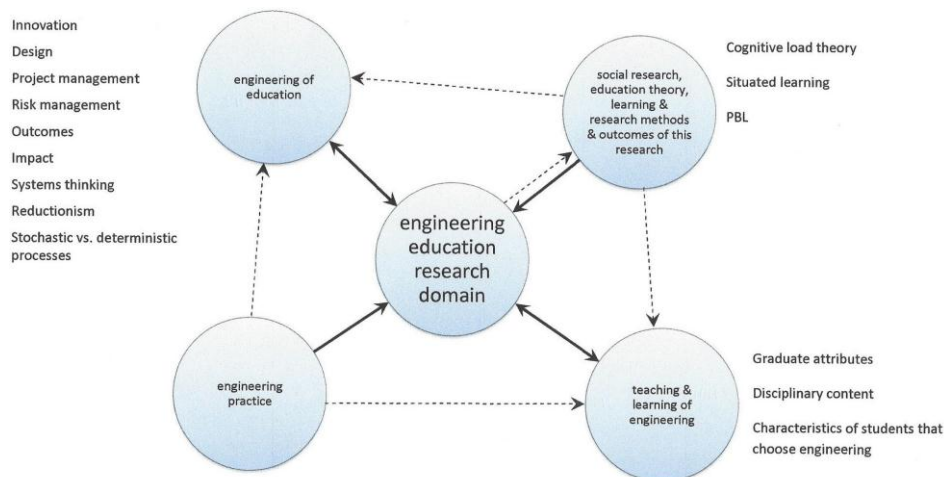


Figure 2: Engineering Education Research landscape

3 FINDINGS AND DISCUSSION

All interviewed participants could locate the topic of their conference paper on the presented model, although for some this required some thought and reflection. 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 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 represents a good approximation of our community's activity landscape:

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]

Most stars of both the interviewed and workshop participants 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.

The stars of emerging researchers' 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.

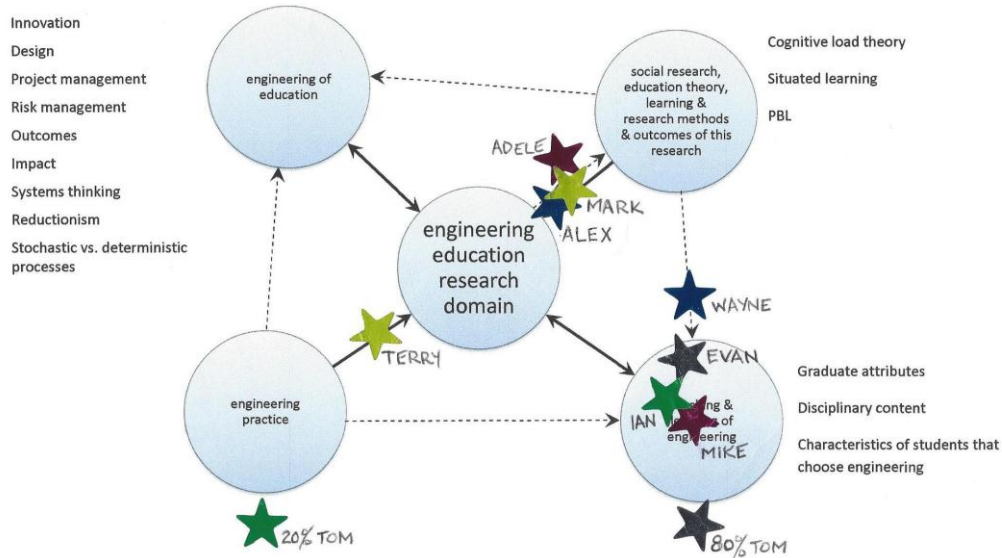


Figure 3: Where emerging researchers located their AAEE 2012 conference paper

Interestingly, Adele, Alex, and Mark who located their stars on the social science trajectory all worked closely with colleagues from a social science background in undertaking the research reported in their papers. We suggest that this strongly influenced their choice of research question, method and interpretation. Wayne collaborated with an established researcher whose wider perspective also moved him out onto the trajectory to the social research vicinity of the landscape. Given the positive developmental influence of these collaborations it is not surprising that the emerging researchers at the 2013 conference workshop were actively seeking mentors or an educational research guide:

I would like to have the Dummies Guide to Educational Research. [emerging, ATN]

I would like to get some collaborations going with someone who really does some educational research,,, to formulate my survey question better and evaluating properly what we've already done.[emerging, regional]

However they were able to assist each other by identifying a useful person at the conference or making a resource available:

You should talk to [name of another conference delegate]...

I have a USB from a good workshop on that – I'll bring it tomorrow and you can download it to your laptop...

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 may seem surprising that the emerging researchers did not locate their stars in the social research neighbourhood. Recalling that they were asked to indicate the dominant location for one particular paper, this is perhaps not so surprising. Established researchers may be using the methods of social research to achieve a particular outcome and it is the outcome that is foremost in their mind. It is also interesting that an established researcher, namely Dennis,

added the activity area of secondary school system to the presented model. The established researchers were generally involved in projects in a range of areas, or which integrate a range of areas requiring them to exercise multiple perspectives, discernment and judgement:

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

...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]

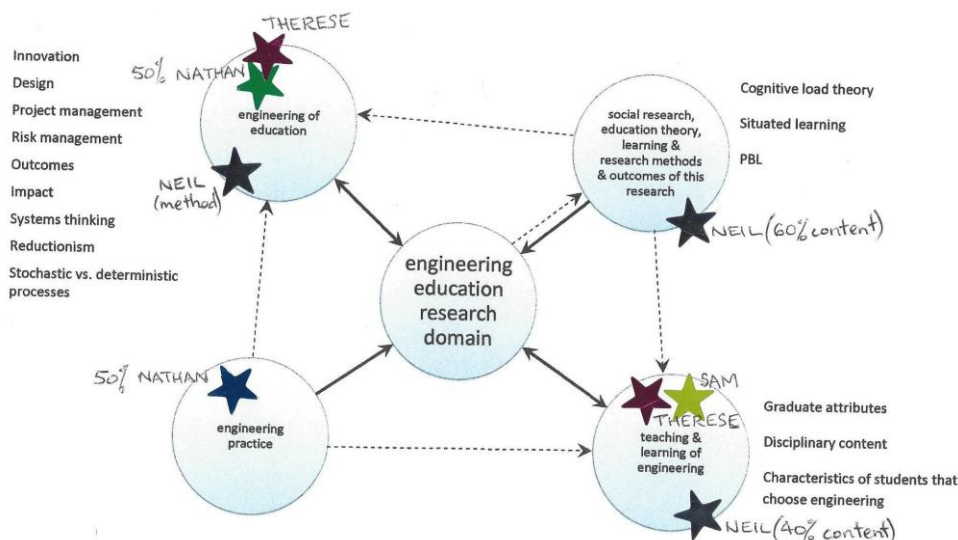


Figure 4: Where intermediate researchers located their AAEE 2012 conference paper

Figure 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. As previously stated this reflects that for many participants their educational research is inextricably linked to their practice of engineering teaching. 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 and that even those identifying with the social research vicinity at the 2013 AAEE conference workshop are "looking for change in teaching practices" as a result of their research. We argue that this conviction that research should be applied or implemented comes from our engineering discipline background, as Faculty of Education researchers that we have worked with are often content to develop theoretical understandings and leave it to others to interpret or identify how they can be adapted in practice. We are not advocates of our community becoming social science 'clones'. In the same way that we use the findings of science in our engineering work, we should use the findings of social science in our engineering education work. Engineering education researchers should allow their perspectives and skills to flavour their research providing perspectives and insights that often differentiates their work from educational research in engineering.

There were strong voices from our interviewed participants opposing what they interpreted as a move to make the annual AAEE conference focus more on theoretical research as a means of improving the quality of research within the community as suggested by the hierarchical shown in Figure 1. This was perceived 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 [7]. 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 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]

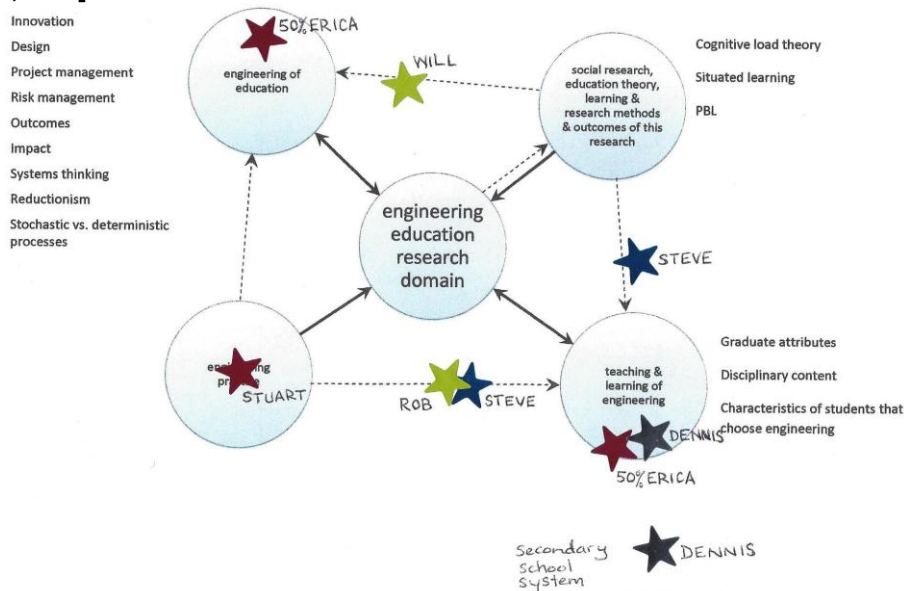


Figure 5: Where established researchers located their AAEE 2012 conference paper

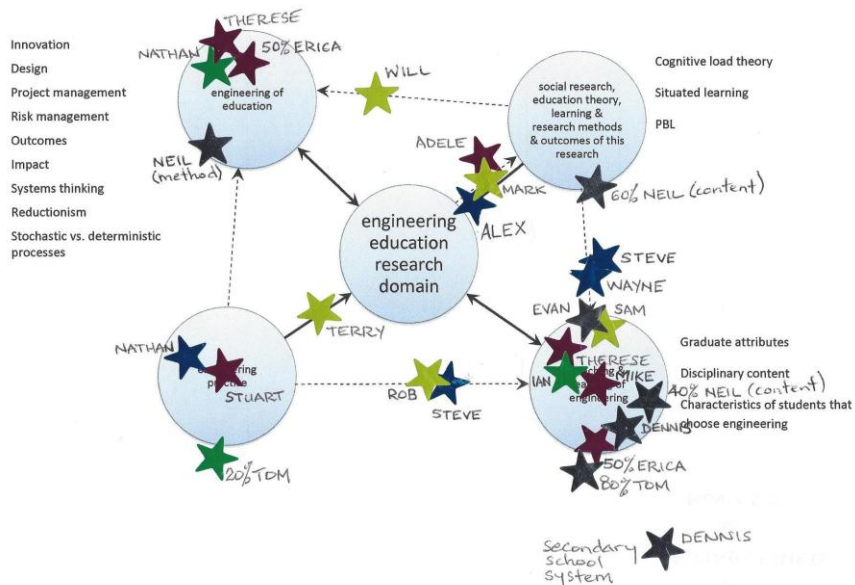


Figure 6: Where all researchers located their AAEE 2012 conference paper

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

This was reinforced at the 2013 conference workshop with one group asking:

How do we create an engineering education system where all people feel equally welcome to participate?

The landscape is an initial step in conceptualising the engineering education landscape of our community. We suggest our community would be better served by discussing, understanding and embracing the characteristics of research quality rather than focusing on the type of research that is

being undertaken. For participants' perceptions of what characterises 'quality' research we direct the reader to a companion paper at this conference 'Authors' perceptions of peer review of conference papers and how they characterise a 'good' one.' The landscape allows us to conceptualise engineering education as a knowledge domain that includes a variety of areas of endeavour. It allows community members to find a home within the landscape, instilling a sense of belonging and acceptance and an understanding of how they can contribute.

The landscape can also be used as the foundation for conversations to facilitate the social construction and subsequent shared understanding of the community standards and norms expected of the different endeavours and what constitutes quality research developing one's research literacy. This dialogue is important for a knowledge domain which is still emerging as a recognised area in Australian universities [1, 2] being necessary to allow informed judgements about research quality to be both made and understood. Such dialogue is also important for emerging researchers to learn the language of educational research since it is through learning this language that we frame out thoughts.

The authors share the view noted in an NRC report [8] that theoretical research is no more important than practice-based research. Furthermore we believe that high quality research can be achieved within the different parts of the landscape as demonstrated by some of our established researchers Erica, Dennis, Rob and Steve's research focusing on the teaching and learning of engineering. Hence in contrast to the model shown in figure 1 we propose a developmental model that combines the landscape model with an understanding of the characteristics exhibited in quality research as demonstrated by established researchers. We suggest that such a model would encourage improvements in quality of the studies in all areas of the landscape, rather than the perception that improvement can be achieved by adopting a specific approach or can only be achieved by moving to a particular area within the landscape.

We suggest that open discussion and engagement with such a model would also help both the community and individuals to articulate and understand observed changes in their and their peers' research as expertise is developed, as well as facilitate development of a language for researchers, particularly those new to the field to plan, discuss and evaluate this progression. This would also relieve the tension that has arisen from the perceived preferential status of theoretical research. An initial step would be an acknowledgement by our community that the quality of the work is not related to the position on the landscape nor the type of research but rather the quality of the processes, methods thinking and interpretation applied in the researcher's investigation.

To be a community we need to socially construct our understanding of the 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. Our developing model has the potential 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. One of the comments from a participant at the ASEE 2013 workshop was the realisation of "*what a rare event it is – feeling like people will help me with my research*" and another "*appreciated the mentoring, sharing issues and hearing some wisdom come back*". The comments made by both interview and workshop participants reinforced the importance of the annual conference for researchers at all levels of expertise with across-the-board comments highlighting the difficulties of being a lone active engineering education researcher in their institution:

It's a big thing for me coming to this here, for my first time, so many people are doing so many things but I've got no other way that I'd know about that...

4 SUMMARY

The landscape model presented in this paper stimulated dialogue around the nature of topics and research in our community and allowed participants to find a place to belong. We argue that such a dialogue will help us identify, develop and grow our research domain and support those seeking to participate in or move within it. We propose a developmental model that combines the landscape with active pursuit of the characteristics exhibited in quality research. We found that one indication of progress of an emerging researcher on their developmental journey is their use of multiple perspectives, interpretations and dimensions in their research. We suggest that such a model would

encourage improvements in quality of the studies in all areas of the landscape, rather than the perception that improvement can be achieved by adopting a specific approach or type of research. A practice versus research dichotomy is ultimately divisive and does little to assist researchers develop their expertise. We believe national conferences should provide a forum for all authors in an environment aimed at improving the quality of research, publications and the development of academics wherever they are on the landscape.

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