Moving from crime and punishment to success and reward: transitioning from technical to educational research

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Abstract: *Many engineering academics interested in quality teaching and learning dabble with educational research. Some go further leaving their technical research field behind to embark head-long into what for many is an initially bewildering and conceptually challenging domain. Often peers perceive this transition as a crime (giving up on real engineering) liable to be punished with reduced access to funding and institutional recognition for one's research. The Australasian Association for Engineering Education (AAEE) has been sponsoring a Winter School in Engineering Education Research Methods since 2011, to help engineering academics change their transition story from one of crime and punishment to success and reward. While helpful, this transition is not a simple matter of learning new techniques but of altering one's perspective and habits of thinking and behaviour. Many participants find this challenging. In this paper, participants in the 2018 school ask the question "what enables and hinders the transition to educational research".*

Introduction

Engineering education remains an emerging field of research within the Australian context (Gardner & Willey, 2018) as well as in other parts of the world (Alias & Williams, 2011; van Hattum-Janssen, Williams, & De Oliverira, 2015). Few formal programs exist for training engineering education researchers, especially outside of the United States, which results in academics often completing their tertiary studies in technical engineering disciplines before later transitioning into engineering education research (Borrego & Bernhard, 2011). Many papers have been written about this transition, however these have tended to focus on the associated challenges in order to identify the knowledge and practices that need to be acquired (Borrego, 2007; Streveler, Borrego, & Smith, 2007). Of particular interest has been understanding the paradigm shift required to engage in quality engineering education research which is transferable across contexts and answers the deeper "why" questions for learning in engineering (Douglas, Koro-Ljungberg, & Borrego, 2010; Streveler et al., 2007).

The Australasian Association for Engineering Education (AAEE) has been sponsoring an annual Winter School in Engineering Education Research Methods since 2011 in response to an identified need to both assist the transition of current and new researchers into engineering education research and to improve the quality of this research. This is a five day program facilitated by researchers experienced in engineering education. The program's objectives are to:

- improve practice through workshops with experts identified by the participants and AAEE,
- share research methodologies and data analysis techniques,
- provide an opportunity for peer review of work, and the development of academic writing skills,

- build community and a reference group for students and academics whose interests are often unique in their home departments, and
- develop career paths for these participants through clearer articulation of skills and interaction with visiting industry and academic experts.

Each year the facilitators aim to meet what participants perceive to be their needs and although some years an emphasis on topics such as course evaluation or writing have been proposed, there has been persistent demand from participants to learn more about research. As a result, it has been found useful to spend the initial sessions of the school on the epistemology and methodology of qualitative research so that participants can gain a better understanding of why certain data-gathering methods might be used, as well as how best to use them. In 2018, the school spent the first two days on epistemology and methodology, the third day on methods per se, the fourth day on data analysis and the fifth day on writing. As well as the standard qualitative methods such as interviews, the methods part of the School introduces some less familiar approaches such as transect walks, sentence frames and systematic observation. As research methods are developed through experience involving collaboration, application, feedback and reflection, it is hard to achieve more than introducing participants to the skills in the short time frame available. To address this, participants are offered the opportunity to take part in subsequent online discussion of topics of their choice. In 2017 the post-Winter School discussions focussed on observational methods and resulted in a journal paper being published (Matemba, Parker, & Jolly, 2018) in the AAEE journal. In 2018 these discussions have focused on applying participant's learning from Winter School to a collaborative research project exploring their transition to becoming engineering education researchers.

In this paper the transition experience of five participants of the 2018 AAEE Winter School is examined through the lens of Bourdieu's Theory of Practice (Bourdieu & Nice, 1977). This theory incorporates three concepts – field, habitus and capital – offering insights into how individuals interact and behave (habitus) within their environment and social structures (field), based on the recognised currency (capital). Here the field is considered to be departments/faculties of engineering in Australian universities, which engineering education represents a part thereof. The aim of this paper is to explore the habitus and capital factors which enable or inhibit the success of engineering education researchers within the field.

Background

Bourdieu's Theory of Practice provides a useful perspective to investigate the transition of technical researchers into educational research as this theory allows insights and understanding of educational questions that are not readily visible with other approaches (Grenfell & James, 1998, p. 2). In the transition from technical to educational research, we seek to explore why transitioning researchers behave in particular ways within a given cultural context and how that can be understood using Bourdieu's Theory of Practice. This theory has three elements field, capital and habitus through which to view and investigate this transition.

The field can be best understood as a "configuration of relations between positions objectively defined, in their existence and in the determinations they impose upon the occupants, agents or institutions" (Bourdieu & Wacquant, 1992, pp. 72-73). A field is interpreted by Webb, Schirato, and Danaher (2002, pp. 21-22) as:

> *A series of institutions, rules, rituals, conventions, categories, designations, appointments and titles which constitute an objective hierarchy, and which produce and authorise certain discourses and activities.* (Webb et al., 2002, pp. 21-22)

There are different kinds of capital present in any field, and participants compete for and with the capital to improve their position in the field. In engineering education research, the capital available is similar to the wider engineering research field and to the broader field of higher education. Hence, to understand their transition it is important to understand the different forms of capital available and the sources of that capital (Jolly, 2016). It is in the competition for and distribution of the various forms of capital that the “configuration of relations” that make up a field becomes observable.

> *The medium of…relations [in a field] …is capital, which is hence both product and process within a field. All capital – economic, social and cultural – is symbolic, and the prevailing configurations of it shape social practice* (Grenfell & James, 2004, p. 510).

Bourdieu refers to the habitus as the subjectively generated rules, values and dispositions commonly held by members of a field. Mutch (2006) refers to habitus as “knowing what, knowing who and knowing how” (Mutch, 2006, p. 167). Hence habitus can be understood as the attitudes, beliefs and practices gained from our history that:

> *… generally stay with us across contexts (they are durable and transposable). These values and dispositions allow us to respond to cultural rules and contexts in a variety of ways (because they allow for improvisations), but the responses are always largely determined - regulated – by where (and who) we have been in a culture*. (Webb et al., 2002, p. 44).

There have been several previous instances of using Bourdieu’s theory in engineering education research. In particular, Jolly (2016) applied Bourdieu’s theory to pedagogical content knowledge in engineering education, while Kloot (2011) applied it to understanding engineering education foundation programs in South Africa.

Methodology

Academics who are not only interested but have already initiated their move towards the engineering education research are arguably in the best position to tell the story of transition. The AAEE Winter School participants were earnestly trying to step into the field of engineering education research, so willingly participated in the five-day program. All participants in the Winter School were invited to join a collaborative research project at the conclusion of the program.

Five participants from the 2018 cohort took part in this research. All five participants were from different institutions, academic rankings (ranging from PhD candidate, associate lecturer, lecturer, senior lecturer and reader (associate professor)) and geographic locations within Australia. After the Winter School, the participants and two Winter School facilitators collaborated on the project through regular meetings using the online video conferencing tool Zoom.

The five participants interviewed each other about their experience of moving into engineering education research and the associated challenges. The interviews were semi-structured and were guided by the interview protocol that was developed collaboratively by the participants. Consent was obtained from all participants in accordance with the ethical clearance.

The interview questions were designed to solicit information on capital within the field of engineering faculties in Australian universities. We were particularly interested in identifying the range of capital and the relative importance of each in enabling or inhibiting participation in engineering education research. We also investigated the habitus of the participants, and how this impacted the acquisition of capital as well as participation in the sub-field of engineering education research. The semi-structured interview protocol was divided into two parts. The first part focused on exploring the individual’s understanding of engineering education research, whereas the second part focused on their transition experiences so far and their future aspirations.

A Bourdieuvian analysis was applied to the data to uncover how these transitioning academics experienced the rules of the field and the pursuit of advantageous capital. We also analysed the impact of the habitus (or patterns of behaviour) they brought with them, and how this may be influenced to ease the transition to educational research and maximise effectiveness once there.

Results & Discussion

The participants in this study were prepared for professional engineering practice through their undergraduate degree in the science, technology, engineering and mathematics (STEM) disciplines. Some had pursued work as practising engineers before returning to a university position, others had moved directly into work in the university sector. For our participants, personal interest in teaching was a primary motivator for participating in the higher education field in engineering:

> *My intention when I came to Australia to do the PhD was to go back to India and do teaching …I got this teaching intensive position, and I was really happy because that was what I wanted to do.*

In contrast to other members of the field, our participants did not regard teaching as an interruption to a research career, but as the primary and intrinsically motivating core of their work. They had been actively engaged in the scholarship of teaching and learning before becoming aware of, and deciding to pursue, rigorous engineering education research. Participants expressed dissatisfaction with pursuing research in technical engineering research, being motivated to join the subfield of engineering education research by an appetite to experience the impact of their research and scholarship directly through their teaching:

> *I enjoyed the teaching and educational side of things much more than the PhD I was doing. I had a very fun time there so. I also thought I was much better at teaching and educational side of stuff and the impact I think I can have in education is lot bigger than anything I could have got out of … continuing research into the traditional mechanical engineering. So I think that is the main reasons that made me kind of jump.*

> *I really don't want to go back to technical research because I was enjoying the teaching, and if I was doing technical research, that time I could devote to doing education research, because that can help my teaching.*

They felt that the legitimacy of the engineering education research subfield is not widely acknowledged by other Engineering field participants. They expressed a view that many in the field see education research as a pursuit belonging to education faculties (hence not engineering research) or as being undertaken by discrete pockets throughout the engineering academy (hence, being niche, having less impact and importance). It was also expressed that the legitimacy of the education research endeavour has been undermined as academic roles in Learning and Teaching units are being replaced by professional staff, such as learning designers or teaching fellows. Given these roles are associated with reduced or no mandate to pursue research, it signals that the university does not consider teaching and learning a research pursuit.

Capital

As subfields of higher education, the capital associated with engineering education research is similar to the capital of typical technical engineering research. This includes publications in journals with a high impact factor, high citation counts, and increasingly grant income. Members of the field who accumulate this capital have a dominant position in the field of higher education, and conversely those without such capital do not. Journal impact factors vary across disciplines. For example, the impact factor for a selection of IEEE journals is listed in Table 1. The journals specific to a technical area have impact factors much higher than the IEEE Transactions on Education which has an impact factor of 1.6. Indeed, the highest ranked journal in engineering education research, the Journal of Engineering Education, has an impact factor of 1.976. However, education researchers in engineering departments are likely to be judged against their technical researcher peers. This practice contributes to the perceived lower status of engineering education research:

> *[The] faculty includes a lot of academics and most of them are involved in technical research so [engineering education research is] not really viewed highly by academics and also researchers that I speak to on a day to day basis …[and] other PhD students*.

This explains why another participant talked of the pressure to "pump out" technical research, taking time away from their educational research. As journal impact factors are linked to the potential readership of journal papers, the lower impact factors reflect a smaller research community. Engineering education is also a different research area in that often the research is focused on improving developmental and educational outcomes as opposed to stimulating other research. Hence, journal readers are not necessarily researchers but, for example, educationalists, practitioners and academic developers focused on improving educational outcomes. This is different to most technical engineering research areas where the end-users are typically other researchers who build on research and subsequently cite each other's papers.

Table 1: Selection of IEEE journal impact factors

Journal name	Journal Impact Factor
IEEE Industrial Electronics Magazine	10.429
IEEE Transactions on Pattern Analysis and Machine Intelligence	9.455
IEEE Communications Magazine	9.270
IEEE Wireless Communications	9.202
IEEE Transactions on Cybernetics	8.803
IEEE Signal Processing Magazine	7.451
IEEE Transactions on Education	1.600

In addition, the absence of a specific engineering education Field of Research (FOR) code contributes to reduced capital in the subfield of engineering education research within Australia and New Zealand. The Australian and New Zealand Standard Research Classification (ANZSRC) have FOR classifications that allows research and development (R&D) activity to be categorised according to the field of research. The categories in the classification include major fields and related sub-fields of research and emerging areas of study investigated by businesses, universities, tertiary institutions, national research institutions and other organisations. The FOR codes are a hierarchical classification with three levels, specifically, Divisions (2 digits, for example engineering is 09), Groups (4 digits, for example civil engineering is 0905) and Fields (6 digits, for example construction engineering is 090502).

Each Division is based on a broad discipline. Groups within each Division are those that share the same broad methodology, techniques and/or perspective as others in the Division. The ANZSRC states that the FOR codes consider the methodology used in the research area. Hence Groups and Fields of research are categorised to the Divisions sharing the same methodology rather than the Division they support. Currently there is no 09 engineering code for engineering education. This means many researchers have to categorise their research under a 13 Education code or 099999 Engineering not elsewhere classified. This has a tendency to reduce the visibility and value of engineering education research to the engineering field as it either does not contribute to the 09 engineering FOR or to the unclassified 099999 code and is thus perceived as peripheral to the discipline.

For many researchers across the whole higher education sector the viability of their project depends on whether it has attracted funding. Similarly, for our participants this means that when the money runs out the project often stops:

> *[The] money ran out and the college didn't want to keep supporting the … education space.... So after a few months of that I decided to leave.*

However, participants felt that technical engineering researchers have access to more sources of funds than researchers in engineering education:

> *Even tapping into the university funding I have found … quite hard to argue for funding… I'm sure there would be some kind of pockets that could be tapped into but I'm unaware of these.*

One participant knew of funding available through their Deputy Dean to support teaching and learning projects but in specific topic areas such as student success and retention. These funds available through internal Faculty sources are typically small amounts focussed on evaluating teaching and learning practices or creating new teaching and learning resources rather than supporting educational research. This contributes to the perspective that education is something we are all involved in and fails to recognise the need to include the evidence informed approaches of engineering education research in these activities.

While many of our American colleagues have successively accessed National Science Foundation (NSF) funding for engineering education research, in Australia successful access to the Australian Research Council (ARC) grants for engineering education research is generally viewed as being problematic and/or extremely difficult. There is a perception that without an engineering FOR code, an engineering education grant will find it hard to compete against broader educational research grants. Firstly, educational grants are often assessed by members of education faculties (who have their own habitus, expectations and perceptions of what they value as capital) not engineering education researchers. Secondly because project quality and innovation, assessed using the following criteria, represents 40% of the overall discovery grant selection criteria there is perception that applications focusing on engineering education will find it hard to compete with education applications with broader outcomes:

1. the extent to which the research addresses a significant problem;
2. evidence that the conceptual/theoretical framework is innovative and original;
3. potential for the research to contribute to the Australian Government's Science and Research Priorities;
4. the extent to which the research project includes aims, concepts, methods and results which will advance knowledge; and
5. the extent to which the research has the potential to enhance international collaboration.

We suspect it is probably a combination of the current habitus of engineering education researchers (being influenced by how the field and we view our research) combined with the often-unacknowledged need to improve the quality and impact of our research that contributes to this perception. In any case, the perception feeds the belief of there being reduced access to the existing capital for engineering education researchers.

With little access to the forms of capital mentioned above, intrinsic motivation was found to be the primary driver for pursuing engineering education research for the participants in our study – as mentioned earlier. They pursue this research as it aligns with their personal interests and values:

> *First of all it helps with my teaching, gives me a lot of data about my teaching.*

> *Anything that involves working with humans and trying to develop a better experience for humans is what I perceive engineering as and engineering education. That is what I am really interested in and that won't change for me.*

I always have found that sort of thinking about … learning processes and how people learn really interesting and stimulating, what it means to learn, what knowledge means.

Personal motivations and values played a significant role in participants' decisions to persist with engineering education research. These included an interest in understanding how people learn and how this could be improved, feeling a sense of wanting to help people, wanting to improve classroom teaching and learning experiences, and a desire to enhance how engineers operate in industry with respect to social and environmental considerations. These motivations align with those identified by Alias and Williams (2011) and Borrego and Bernhard (2011).

It's [education research] been always the interesting part of my job - reading the literature and then the question for me is whether doing the research is part of what I want to do or just to have time to engage in reading in what other people write in the literature and putting it into practice.

I really enjoy being in this space, I think that I can do a lot of things to help people again in this area more so than in their technical research that I was doing.

However, one participant believes that undertaking educational research will improve his teaching which will be rewarded at his institution:

I'll be doing more informed activities and so be doing the right things… and that will improve my teaching which will help me with my career as well as helping students

Habitus

Like most academics in engineering education research, the participants in our study completed technical undergraduate engineering degrees. With the exception of one participant, each had also completed their doctoral studies in a technical engineering topic and then took up engineering education research at a later stage of their career. Completing undergraduate and postgraduate studies in technical engineering disciplines usually presents a hurdle to be overcome for conducting engineering education research, as this experience typically prepares participants for a technical academic career. Most technical research does not provide an introduction to the qualitative methods, theories and approaches used in engineering education research. Hence this required participants to develop new habitus appropriate to the engineering education research sub-field as part of their transition. This was emphasised by participants when discussing their gaps in understanding engineering education research with statements such as:

I think I had a fairly clear view [of what engineering education research was] fairly early on in the process and it was just trying to develop the skills myself is something that I have not devoted much time to until now.

I have only a little information about [education theory]. I did not use anything so far. The project I'm involved in is not at a stage to use any theory.

I kind of stumbled across engineering education by mistake but … incorporated those different perceptions of reality and took them into consideration.

In line with the findings of Borrego (2007), participants described their technical research in terms of well-accepted theories and methods for collecting evidence. In contrast, participants described engineering education research as requiring measurement of things much harder to quantify. This distinction is an example of technical engineering studies not preparing academics for tackling educational problems where different methods need to be employed. Consequently, participants expressed that transferring from an established habitus to a different sub-field posed challenges:

My technical research was very much mathematical analysis, very much things that you could prove to make the world simpler or the problem simple enough - assume enough things so that you can then mathematically analyse everything and prove something and come up with a theorem.

[In my technical research] we could quantify the errors in it and say this assumption was made so obviously it would have impacts on the results. I feel like [engineering education research] is more difficult to quantify that kind of error.

The evidence was really looking at … an experiment that was already done physically in practice, and then comparing that to the model [I was developing]. And then obviously if it was similar then the model was validated.

In order to address the gaps, participants recognised the importance of socialising with peers to develop their expertise in engineering education research, and to increase their sense of belonging in the sub-field. Participants have shown to be proactive in seeking out developmental opportunities, both formal and informal, as well as generating their own opportunities such as forming a community of practice and identifying mentors that enable this sharing. Quotes from participants which support this include:

I would say that our winter school group is [one of] the most sustained group I've communicated with beyond my school

[I've got] a main person that I go to for anything specific about engineering education research.

So, because I don't have any research allocation in my role, I started doing a little bit of research in my own time last year. I started a small group with the physics people, like a physics education research group.

However, a lack of collaborators and community participating in the engineering education research sub-field, particularly at the local level, was identified as an inhibiting factor. Participants frequently discussed the lack of academics interested in engineering education research within their home institutions. For example:

Sometimes I just go and knock on my supervisor's door just to have a different type of talk and let out some of my frustration and to speak to someone that is interested in engineering education.

[There is] no one that I can talk with [about engineering education research]…not sure I can continue – like I said there is no team.

T&L [Teaching and learning] seminars for staff are not run often – there used to be a forum for engineering education every 2 weeks until the lead person left the School and the forum collapsed.

Given the difficulties previously discussed in transitioning to engineering education research, we ask what we should do as a subfield to strengthen our identity and assist those who wish to make the transition. The winter school experience has demonstrated the need to provide a sense of community and identity for these transitioning researchers. The fact that the participants have maintained weekly Zoom meetings for the last seven months demonstrates how much they value these discussions and the research practice involved in producing this paper. For most participants if not for these meetings they would be the sole member or at best a part of a very small group of engineering education researchers within their home institutions. This suggests that as engineering educational researchers we need to form cross institution research groups and collaborations. For example, the two winter school facilitators contributing to this paper are currently endeavouring to develop a collaborative engineering education research group between their two universities. This will increase the profile of engineering education research as the capital of research students, research supervision opportunities, publications, impact, grants et cetera will be contributed to by academics at both institutions. Hence, the volume and impact of these measurable forms of capital will be larger than either institution could achieve on their own. It also provides prospective transitioning engineering education researchers access to a wider pool of expertise and experience to collaborate with, be socialised into the subfield of engineering education research (change their habitus) and more opportunity to access the available capital.

Beyond this, like any emerging research domain, it is up to the established researchers to change the narrative around, and current perceptions of, engineering education research through improving the quality and impact of their research and increasing their access to the available capital. This would have a positive impact on engineering education research's recognition in the field (engineering) and the habitus and belief to access the field's capital for those transitioning to and participating in engineering education research.

Conclusions

In this paper, we explored the experience of five participants of the 2018 AAEE Winter School transitioning into engineering education research using Bourdieu's Theory of Practice. Each of our participants entered the field of higher education through an undergraduate degree in a technical STEM discipline, before being drawn to engineering education research later in their career. Each participant identified perceived constraints in accessing capital within the field caused by the transition. This included a lack of access to grant funding, a reduction in the perceived significance of research due to structural influences like impact factors and field of research codes, and more limited career progression opportunities. Strong intrinsic motivation to pursue educational research, which formed part of participants' habitus, was found to contribute significantly to their decision to pursue engineering education research in spite of the reduced access to capital. Here participants expressed motivations around understanding how people learn, wanting to help others, improving educational experiences, and enhancing how engineers operate in society. The formation of the cross-institutional community of practice which emerged out of the 2018 AAEE Winter School was identified as a key strategy in overcoming the small number of engineering education researchers within individual institutions, which enabled socialisation of engineering education research concepts and experiences in the field. Improving the transition experience of engineering education researchers in developing new habitus and effectively leveraging capital will enhance the uptake and reputation of engineering education research. However, this needs to be accompanied by current researchers recognising and responding to the need to improve the quality and impact of engineering education research and advocating for changes to structural factors such as the allocation of an engineering education FOR code. These changes will have a positive influence on the habitus and enable greater access to capital for current and future participants in the sub-field.

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