Identifying career pathways to engineering education research in Australia

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***Abstract*— Currently there is limited understanding about the academic qualifications (or formal research training) which engineering education researchers possess, and which university departments they primarily reside in. The objective of this study is to capture information on these researcher characteristics via bibliographic analysis of publicly available sources.**

A list of 104 authors affiliated with Australian institutions who published in at least one of thirteen engineering education journals between 2018-2019 (inclusive) was retrieved. For each author, information about their qualifications and where they worked was compiled from available biographic information in their publications (e.g. often common in IEEE publications), ORCID profile, Scopus profile, the Australian TROVE database, and online university researcher profile. In total, 80 authors held a known PhD; 30 in technical engineering, 12 in engineering education, 3 in education, 21 in other disciplines, and 14 not specified. Of the 67 with known bachelor degrees, 69% were in engineering, the remainder widely varied. 92 authors worked in a university; 56 in engineering faculty, 9 in computing faculty, 13 in other faculty, 9 in teaching and learning departments, 4 in other capacities at a university. 4 authors did not work at a university.

Our findings show that while a minority of engineering education researchers hold technical engineering PhD degrees, PhD theses on engineering education topics are becoming more widespread and we can predict a growing community of Australian engineering researchers. These data can assist with planning strategies for further increasing engagement with engineering education research in the Australian context.

Keywords—engineering education researchers, qualifications, census, Australia

I. INTRODUCTION

A. Background

Engineering education research (EER) began to receive attention as a scholarly field of inquiry early this century [1] and attention was subsequently devoted to characterising pathways into EER. An early study by Allendoerfer et al. [2] identified a process in the US they called intentional serendipity in scholars' actions to gain entry to the field such as "applying for certain jobs, introducing themselves to key people, attending certain conferences or meetings, or simply making a point of being open to new ideas from outside their home disciplines". The same authors collaborated with other researchers to trace similar pathways in international contexts [3].

Meanwhile, in Australia, researchers used a landscape metaphor to describe EER as a knowledge domain [4] and identified three broad groups of domain participants: emerging, intermediate, and established researchers. More recent work in Australia has focused on emerging engineering education researchers and proposed a conceptual model of the EER transition process through the lens of Bourdieu's Theory of Practice.

All of these studies gathered their data via an approach we can classify as outreach, one where the authors contacted researchers to request an interview that was recorded and subsequently transcribed and analysed through a coding process. Interviewing participants can produce rich data but logistical limitations usually lead to relatively small data samples. Larger samples can be achieved by adopting an online survey outreach procedure but this also has limitations, in particular low response rates can lead to limited data reliability.

In recent years, use of both these outreach approaches has been further constrained by the recognition of ethical aspects of use of data obtained from research participants. With the above in mind, the authors decided to investigate the possibility of harvesting existing data made available by researchers in their publications, Scopus profile, ORCID profile, the TROVE database (database of publications by the National Library of Australia, including PhD theses) and online university research profile to explore their pathways into EER. Although this was expected to provide less rich data than outreach approaches, it could allow us to work with large datasets given that the information was already in the public domain. The study received human research ethical approval from each author's respective university.

B. Australian EER Landscape

PhD programs which are specifically targeted to the field of engineering education research are limited, and of those which exist, most are located in the United States [5]. Currently there are no PhD programs offered in Australia which are specifically targeted to the field of engineering education. While PhD students in Australia can undertake a doctoral thesis on an engineering education related topic, often they will officially have to enrol in a PhD program in engineering.

Many engineering education researchers begin their career doing technical research, then commence educational research later on. Engineering education researchers are likely to have trained in other fields of research (such as applied engineering) before commencing engineering education research at a later point during their careers [5], [6]. Studies have highlighted the phenomenon of Australian engineering academics adjusting their research work to commence engineering education research [6]–[10]. From a statistical viewpoint, Australian engineering academics who commence education research at some point in their career tend to do so 7 years on average after starting their research careers [11].

Conducting EER in Australia can be challenging as teaching-related research is often considered by academic colleagues (and universities) to be less legitimate than technical research [6], [10], which can be a problem for academics when it comes to performance reviews. Often researchers 'felt that they had to maintain some technical research even when they found it "boring"' [10].

C. Contribution of this study to the literature

While previous studies have investigated the experiences of becoming an engineering education researcher, there is a lack of studies which have attempted to map the qualifications and background of engineering education researchers on a nation-wide scale. It is important to build further understanding of how people become engineering education researchers, to what extent researchers in the field tend to do a technical PhD then start educational research later on, whether PhD's in engineering education are common or not, and whether researchers are primary in engineering or other university departments. This information will help to understand the diverse backgrounds and career paths of engineering education researchers, and how to foster interest in the research field.

D. Research Question

How can publicly available data enable us to construct a profile for Australian Engineering Education researchers?

II. Methodology

A. Approach

Existing studies which have investigated the phenomenon of Australian engineering academics commencing educational research have primarily used interviews, critical reflections, or surveys [6]–[10].

This study used a qualitative document analysis approach, which combines aspects of content analysis and thematic analysis [12]. Documents were deductively analysed to locate specific pieces of information about each researcher, including their academic qualifications (such as Bachelor of Engineering) and the location where they worked (such as a university department). The documents which were analysed biographic information in their publications, Scopus profile, ORCID profile, TROVE database and online university research profile.

B. Getting a list of Australian engineering education researchers

A list of 104 authors affiliated with Australian institutions who published in at least one of thirteen engineering education journals between 2018-2019 (inclusive) was retrieved. The thirteen journals were: Advances in Engineering Education, Australasian Journal of Engineering Education, (Education for Chemical Engineers, European Journal of Engineering Education, Global Journal of Engineering Education, IEEE Transactions on Education, International Journal of Electrical Engineering Education, International Journal of Engineering Education, International Journal of Engineering Pedagogy, International Journal of Mechanical Engineering Education, Journal of Engineering Education, Journal of Engineering Education Transformations, Journal of Professional Issues in Engineering Education and Practice (now Journal of Civil Engineering Education).

These journals were selected as they are indexed by Scopus, and were established journals that had been publishing for at least several years. Related journals which focused heavily on technology aspects (such as Computer Applications in Engineering Education and IEEE Transactions on Learning Technologies) or non-tertiary settings (such as Journal of Pre-College Engineering Education Research) were not included.

C. Determining the researchers' academic qualifications

A spreadsheet was used to record information for each author (including where all information was sourced from). For each author, their qualifications including bachelors, masters, and PhD degrees and where they worked was compiled from biographic information in their publications, Scopus profile, ORCID profile, TROVE database, and online researcher profile.

Where possible, details about the sub-discipline of each degree was also recorded (e.g. B.Eng. in Electrical Engineering), although this was not always possible as many authors only gave the main degree title (e.g. B.Eng.), especially for PhD degrees (sometimes only given as 'PhD'). Additional details given by authors were also used to determine sub-discipline of degrees. For example, several authors on noted they had a 'PhD, Engineering' but details which were given in their thesis made it clear the topic was actually in Engineering Education. For PhD degrees where the discipline/topic was unknown, an attempt was also made to locate the author's PhD thesis document in the TROVE database to determine this.

III. Results

A. Researchers' bachelor degree academic qualifications

Information about bachelor degrees was identified for 67 authors (Table 1). This was lower than those who had information about PhD studies (80), because researchers often only listed PhD credentials. Of the 67 researchers who held known bachelor degrees, 46 (68.7%) held a degree in engineering, with electrical engineering (15), mechanical engineering (8), and civil engineering (4) being the most common. 12 held a bachelor of engineering, but did not specify which discipline. The 21 researchers who held a bachelor degree in a field other than engineering were dispersed amongst a large number of fields. Interestingly, none held a degree in the field of education or teaching.

Researchers' master degree academic qualifications

Of the 104 researchers, information about master degree studies (coursework or research) was found for 39 (Table 2). The clear majority of these degrees were in engineering (23) or engineering science (2), with the rest being in distributed in a range of fields such as education, science, and arts. One author mentioned having a masters degree, but did not specify the field.

B. Researchers' PhD (or equivalent) academic qualifications

Of the 104 researchers, information about PhD or doctoral studies was found for 80 (Table 3). Of 80 researchers who held a PhD, 30 (37.5%) had completed a PhD in a technical engineering topic, 12 (15.0%) had completed a PhD in engineering education, and 2 (2.5%) had a PhD in computing education. 14 had completed a PhD but did not specify which field or topic the PhD had been completed in. 3 had a PhD in health, while another 3 had a PhD in education. The remainder

who possessed a PhD were dispersed amongst a large number of fields.

C. Where researchers work

Of the 104 researchers, information about where they work (if at all) was found for 95 (Table 4). Out of 95, 92 worked at a university, 3 worked somewhere other than a university. Unsurprisingly, most (79) authors worked in a faculty or department at a university. 56 worked in an engineering faculty, 9 worked in a computing faculty, 13 in other faculties.

9 researchers worked in a university Teaching and Learning (T&L) department or equivalent, which focus on developing the teaching skills of university staff or conducting research in tertiary settings (note this is not the same as the Education faculty, who train students to become teachers). Examples of this are the Engineering Learning Lab at the University of Melbourne, and the Academy of Learning & Teaching at Queensland University of Technology.

TABLE I. TYPE OF BACHELOR'S DEGREES WHICH THE AUTHORS (N=104) HELD

Type of Bachelor's Degree Detailed	*Frequency*
Applied Science	1
Arts	3
Business	1
Computer Science	2
Construction Management	1
Engineering - Aerospace	1
Engineering - Chemical	2
Engineering - Civil	4
Engineering - Electrical	15
Engineering - Environmental	2
Engineering - Geology	1
Engineering - Mechanical	8
Engineering - Naval	1
Engineering - Not Specified	12
Environmental Science	1
Geology	1
Health	1
Industrial Design	1
Not Specified	2
Nursing	1
Psychology	1
Science - Not Specified	3
Science - Physics	1
Social Science	1
Total	**67**
Could not be identified, or did not possess	**37**

TABLE II. TYPE OF MASTER'S DEGREES WHICH THE AUTHORS (N=104) HELD

Type of Master's Degree Detailed	*Frequency*
Arts	2
Chemistry	1
Computer Science	1
Education	2
Engineering	23
Engineering Science	2
Health	1
Marketing	1
Music	1
Not Specified	1
Science	1
Science - Other	3
Total	**39**
Could not be identified, or did not possess	**65**

TABLE III. TYPE OF PHD DEGREES WHICH THE AUTHORS (N=104) HELD

Type of PhD or Doctoral Degree Detailed	*Frequency*
Anthropology	1
Building	2
Business	2
Computer Science	2
Computing Education	2
Economics	1
Education	3
Engineering	30
Engineering Education	12
Health	3
Higher Education	1
In progress	1
Industrial Design	1
Linguistics	1
Mathematics	2
Music	1
Not Specified	14
Surveying	1
Total	**80**
Could not be identified, or did not possess	**24**

TABLE IV. LOCATIONS WHERE AUTHORS (N=104) WORKED IN UNIVERSITIES OR ELSEWHERE

Location	*Frequency*
University Faculty - Computing	9
University Faculty - Education	1
University Faculty - Engineering	56
University Faculty - Other	13
Other	3
University - Not Specified	3
University - Other	1
University – Teaching & Learning Department, Unit, or Office	9
Total	**95**
Could not be identified, or did not work	**9**

IV. DISCUSSION

The findings presented above have demonstrated that there is something of a general profile of Australian engineering education researchers: researchers predominantly hold technical bachelor and masters degrees, but at the doctoral level there is a higher number of social science programs.

At the bachelor degree level, the clear majority were in engineering (69% of those with a known degree). Masters degrees were less common than bachelor degrees. However, of the 39 researchers who held a master's degree, 25 (64%) were in an engineering field. Overall, this shows a high prevalence of technical qualifications at the bachelor and masters level. This reflects the previous findings of Dart et. al [6] who found that EE researchers had typically done an undergraduate degree in a STEM field, and Gardner & Willey [7] where EER participants had a first degree in engineering.

In contrast, PhDs in technical engineering were less common. Of the 80 researchers with PhD in a known field, 30 were in engineering. 18 out of 80 held a PhD in an education-related area, including 12 in engineering education (the remainder being in education, higher education, or computing education). This shows that the prevalence of engineering-centric qualifications decreases as the level of qualification increases from bachelor to masters, then masters to PhD. This reflects the work of Gardner & Willey [8] about identify reconstruction, where 14 of the 19 EER participants held a

PhD in a typical engineering field, and 5 were undertaking or had completed a PhD in engineering education. However, this study shows that there are a wider variety of pathways that appear as ways into EER, than those shown by Gardner & Willey [8] and Dart et. al [6]. There were numerous EE researchers who had a pathway outside of the main pathway (i.e. bachelor and PhD in engineering), and have a wider range of undergraduate and PhD degrees.

Perhaps surprisingly though, very few (if any) of the researchers were from fields such as educational psychology or higher education. It was expected that researchers from these fields may collaborate on engineering education research more frequently. However, this may be limitation of the journals which authors were selected from. Researchers in these fields may work in engineering education research, but may publish their related work in psychology or higher education journals.

Although there are no official engineering education focused PhD programs within Australia, researchers are still able to find ways to complete thesis topics in this field and PhD theses on engineering education topics are becoming more widespread. However, these PhD candidates may be relatively isolated and be the only one at their institution doing a PhD in this field. This is in contrast to the United States for example, where there are entire facilities specialising in engineering education research with dedicated PhD programs (e.g. Virginia Tech, Purdue, Clemson, Utah State University [13]).

It was also shown that most researchers work at a university, which was expected. Unsurprisingly, a majority of researchers work in university engineering faculties. Interestingly, a sizeable proportion of researchers also worked in university computing faculty (i.e. information technology, computer science, software engineering) and university teaching and learning departments, while others worked in areas such as student services. This is of note because it demonstrates that researchers in the field are primarily based in engineering faculty, but others in the university also participate in engineering education research.

V. Limitations

There are limitations of this study which must be noted. First, as noted above, the sample of researchers was only drawn from engineering education journals. Other journals which may include articles on engineering education topics were not considered. This may limit the diversity of the sample of researchers which was retrieved and analysed. However, by focusing on only engineering education journals, this builds an understanding of what is likely the clear majority or core of researchers in this area. A second limitation is that the findings presented here are specific to Australia, and may not be readily transferable to other countries.

An issue that was encountered while collecting data was also that the dataset may be incomplete, in that not all information could be found for all researchers. For example, Table 3 shows that 14 authors said they had a PhD, but never described the topic across the online profiles which were searched. Many authors also did not provide details of their bachelor and master degrees in their biographic information in applicable publications. It is possible that the authors could be asked about this missing information, but this arguably defeats the purpose of using this research methodology which relies on readily accessible information. Overall, while some data may be absent, it is likely that using this approach gathered data about more authors than if a survey was used (where response rates may be low), which builds a more accurate understanding of researchers in the field.

Finally, it is important to mention that these findings are specific to the Australian engineering education domain. We hope to apply a similar approach to analysing trends in the Portuguese context and that of other European countries

VI. Conclusions

Our findings suggest that there is a growing community of engineering education researchers in Australia despite the absence of doctoral programs formally dedicated to the field. While the majority of published authors in our sample had engineering or STEM first degrees the prevalence of engineering-centric qualifications decreased as the level of qualification increases from bachelor to masters, then masters to PhD.

PhD theses on engineering education topics are becoming more widespread and we can predict a growing community of Australian engineering researchers. These data can assist with planning strategies for further increasing engagement with engineering education research in the Australian context.

Disclosure statement

[Author blinded for review] is included as an author in the dataset gathered and analysed during this study.

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