Using census data to better understand engineering occupational outcomes

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STRUCTURED ABSTRACT

CONTEXT
University graduate employment outcomes are a topic of international importance. In Australia, in recent years, employment rates for engineering graduates have declined significantly. What has not been clear is what type of jobs those graduates in work have been obtaining. A clearer understanding of the occupational outcomes, both short- and long-term, are needed for the rational design of university engineering curricula.

PURPOSE
The research presented here seeks to understand the nature of the occupational outcomes for Australian engineering bachelor graduates. Of particular interest is the proportion of graduates working outside the discipline and how curricula prepare graduates for this.

APPROACH
Australian national census data from 2006, 2011 and 2016 were examined to identify the occupational outcomes for engineering bachelor graduates. This was combined with complementary census data identifying who works in a professional engineering role. The influence of student diversity is also considered.

RESULTS
Over the period 2006-2016, the percentage of engineering bachelor graduates in employment has declined across most age ranges, but the decline has been particularly stark for those in the typical new graduate age range. The proportion of engineering bachelor graduates working in a professional engineering role has also declined, and for new graduates this proportion reached very low levels in 2016. In Australia, engineering bachelor qualified people make up a minority of those reporting working in a professional engineering role.

CONCLUSIONS
The Australian national census data over the period 2006-2016 reveal the complexity/diversity of occupational outcomes for engineering bachelor graduates – many will work out of a professional engineering role if they wish to work at all, and the Australian professional engineering workforce is very diverse, including many people without an engineering bachelor qualification. These results have important implications for those with the responsibility for the design of undergraduate engineering curricula to best prepare students for the future work environment that they will graduate into, which are discussed in this paper. The analysis of three cycles of census data establishes a benchmark time series that will be useful for future research.

KEYWORDS
Engineering graduate occupational outcomes; Professional engineering workforce; National census data.
Introduction

In Australia, for many years, engineering graduates have enjoyed relatively high rates of full-time employment (Graduate Careers Australia, 2016). Norton and Cakitski (2016) note that the number of engineering jobs in Australia rose steadily from 2003 with the mining boom, as did enrolment numbers in engineering programs. Engineering jobs peaked in 2013 and have declined since, and while recent applications for engineering study have also declined, the student pipeline means that numbers of completing engineering students have remained high, leading to a general decline in graduate employment outcomes from 2013. A number of reviews of engineering education internationally, over an extended period of time, have concluded that there is a need to improve the quality, capability and employability of engineering graduates, and that design of undergraduate engineering curricula plays a central role in achieving this goal (Beanland & Hadgraft, 2013). Many prescriptions for achieving this improvement call for industry input into the design and review of engineering curricula to, “… enhance the industry relevance of engineering curricula” (Australian Workforce and Productivity Agency, 2014, p. 84). The regular appeals for engineering curricula to be more ‘authentic’, ‘real-world’, ‘industry-relevant’, etc. are almost always premised on a view that most, if not all, graduates from undergraduate engineering programs will go into professional engineering practice in ‘industry’. However, the reality is that, internationally, many engineering graduates never work in professional engineering practice, or if they do, they do not remain in that sector very long. Here, Australian national census data from 2006, 2011 and 2016 were examined to identify the makeup of the professional engineering workforce and the occupational outcomes for graduates of undergraduate engineering programs in Australia. This analysis presents important findings for those designing undergraduate engineering curricula that seek to equip students to prepare for the best employment outcomes, given the nature of the professional engineering work environment, and the short- and long-term occupations that engineering graduates actually pursue in Australia.

Method

To identify which occupations Australian engineering bachelor graduates are working in, the Australian Bureau of Statistics census online TableBuilder service (Australian Bureau of Statistics, 2018) was used to access the 2006, 2011 and 2016 publicly available Australian national census data. Those respondents that reported a bachelor-level degree in engineering were cross-tabulated with the occupations reported by those respondents. At the four-digit Australian and New Zealand Standard Classification of Occupations (ANZCO) occupation classification code level (the most granular census data publicly available), the census data contain 477 separate occupation categories, 12 of which are clearly associated with professional engineering roles. The census data occupation categories also include those not working and those whose occupation cannot be classified. ‘Not working’ takes in all those not currently employed, including those not seeking work, those seeking work but currently unemployed and those undertaking full-time study. Gaining an understanding of the occupational outcomes of recent graduates, and hence potential new graduate career destinations, is of particular interest for the design of undergraduate curricula. The trajectory of occupational outcomes of graduates over time/with age is also important, particularly given the objective for universities to equip graduates for life-long learning. While the census data do not indicate whether a respondent is a recent graduate, they do indicate the age of respondents. For all respondents reporting a bachelor-level engineering qualification, and grouped into five-year age ranges, the proportions of the three broad employment status categories of ‘working as a professional engineer’, ‘otherwise employed’ and ‘not working’ were graphed, along with the total number of respondents in each five-year age range. To identify what qualifications those working in professional engineering occupations in Australia have, the ABS TableBuilder service was used to cross-tabulate those census respondents who reported working in the same 12 professional engineering occupational categories noted above versus the highest educational qualifications reported by respondents. These two sets of cross-tabulated data were charted together to map out the relationship between those who graduate from bachelor-level undergraduate engineering programs, and those who work in professional engineering occupations, in Australia. The results obtained and their implications are discussed.

Results

In the 2006 Australian national census data, 152,037 respondents reported a bachelor-level engineering qualification, and 108,046 respondents reported working in a professional engineering occupation. In 2011, these numbers were 199,485 and 141,116 respectively. In 2016, these numbers were 260,176 and 140,963 respectively. Figure 1 presents the proportions of respondents reporting a
bachelor-level engineering qualification, in five-year age ranges, grouped into the broad employment status categories of ‘working as a professional engineer’, ‘otherwise employed’ and ‘not working’. Figure 1 includes the results from the 2006, 2011 and 2016 census, and is designed to permit direct visual comparison of the proportions of employment status between the age range groups. It also includes the total number of respondents in each age range in each of the three censuses, so that the displayed percentages can be converted to approximate absolute numbers via multiplication. In the data used for Figure 1, small numbers of graduates were recorded in the age range 15-19 years and above 70 years. However, Australian census data reported publicly via the ABS TableBuilder service are subject to small random adjustments to avoid the possibility of categories with very small numbers of respondents possibly leading to the re-identification of individual respondents. As such, these small results were excluded here for clarity.

Figure 1: Employment status of engineering bachelor graduates in five-year age ranges – based on 2006, 2011 and 2016 Australian census data

The left-hand column in Figure 2 shows the numbers and proportions, grouped in broad occupational categories, indicated by those respondents reporting having an engineering bachelor degree as their highest educational qualification in the 2016 census. The right-hand column in Figure 2 presents the corresponding numbers and proportions of respondents who reported working in a professional engineering occupation, grouped by the highest educational qualification reported by respondents. The census occupational categories used ensure that job roles that use the term ‘engineer’ in a colloquial manner (e.g., ship’s engineer, aircraft maintenance engineer) are not counted here.

Discussion

Data limitations and triangulation

There are a number of limitations in the use of the Australian census data. As noted above, publicly reported census data are subject to small random adjustments. The quality of census data are influenced both by the response accuracy of those completing the census, and the choices made by those coding those responses into the census database. Choices have to be made about the educational qualifications and occupation categories to include in the extracted data, although for professional engineering this is relatively straightforward. The data used here include both Australian- and foreign-born persons with both Australian and international engineering bachelor-level qualifications, however that is not unrealistic, as it represents the potential Australian engineering workforce at the time of the census. The census only asks respondents for their highest qualification. A respondent with an engineering bachelor qualification who has completed a higher degree is not counted as having an engineering bachelor qualification (Trevelyan & Tilli, 2010). This result systematically under-reports the number of people in Australia holding engineering bachelor qualifications, and hence also causes the inferred proportion of engineering bachelor holders working in non-professional engineering occupations to be under-estimated.
Figure 2: Engineering qualification & occupation data – based on 2016 Australian census data

It is difficult to directly confirm the results from the census data above. In a longitudinal investigation of US bachelor graduates, Choy and Bradburn (2008) found that, ten years post-graduation, only about half of engineering majors were still working in a related field. Using Australian census data, Trevelyan and Tili (2010) found that across the period 2001-2006, about half of all bachelor or higher engineering graduates aged 25-55 years were not working in engineering-related jobs. The proportions presented in Figure 1 do not seem out of accord with those findings. In Figure 1, it can be seen that, for the five year age ranges from 45-49 years onward, the annual totals of engineering bachelor graduates in one census approximately correspond to the totals for next higher age range in the following census. However, this correspondence doesn’t hold for age ranges below 45 years, and
this may be, at least in part, due to the significant number of engineers migrating to Australia in recent years, noting that, “... The [migration] points test always rewards younger engineers at the expense of older, more experienced ones” (Engineers Australia, 2017, p. 69). Figure 2 indicates that, in 2016, only about 60 per cent of those working in a professional engineering role held an engineering bachelor degree or higher. In the US, in 1999, it was reported that around 75 per cent of the people employed in engineering occupations had an engineering degree (Parker, 2004). Spinden (2014) noted that, while all states in the US require engineering practitioners to be licenced, the majority are not, due to exemptions that exist. In Australia, “... there is no legal ownership of the occupation title ‘engineer’. Anyone can call themselves an engineer ...” (Australian Workforce and Productivity Agency, 2014, p. 30). Given the absence of legal protection for the occupation of engineer in Australia, the 60 per cent figure for those with engineering university qualifications does not seem unrealistic. Acknowledging the known limitations of the data, we can consider the results obtained.

Findings from the results

Figure 2 indicates that, in 2016, approximately half of all engineering bachelor graduates, if they were working, were not working in engineering occupations, and as noted above, this is likely to be a systematic under-estimate. Nearly a quarter of the balance were not working, and, overall, 25.0 per cent of all Australian engineering bachelor graduates reported working in an engineering occupation. Note that the ‘Professional engineering’ category includes the occupational classification of ‘Engineering manager’, which is distinct from those graduates reporting work in general (non-engineering) management roles. Figure 1 shows how these proportions have varied with graduate age over the last three censuses. Even in the youngest age band, likely to include the majority of recent engineering bachelor graduates, the proportion working in an engineering role was less than half. In 2006 and 2011, the proportion of recent graduates working in an engineering role held at 40 to 45 per cent up to 29 years of age then declined with age, and initial unemployment was around 20 per cent. The recent graduate outcomes in 2016 were significantly different, with more than one third of graduates not working, and about one quarter working in an engineering role. These differences are also reflected in the next two age ranges in 2016, but seem to have particularly impacted new graduates. Figure 2 indicates that, in 2016, nearly 40 per cent of professional engineering roles were filled by people without at least a bachelor of engineering qualification. Figure 2 indicates that, even allowing for the significant group of graduates not currently working, the number of Australians holding a bachelor of engineering qualification exceeds the number of people reporting working in a professional engineering occupation by a large margin. Once the significant proportion of non-engineers currently filling professional engineering roles is considered, it is clear that it is a fundamental structural feature of the Australian employment market that many engineering bachelor graduates will have to find employment outside of engineering if they wish to work at all. We have previously speculated on the factors that contribute to these findings (Palmer & Campbell, 2016; Palmer, Tolson, Young, & Campbell, 2015), however here we are concerned with the empirical reality of these findings and their implications for Australian undergraduate engineering curricula.

Implications for undergraduate engineering curricula

Even though new engineering bachelor graduates in Australia have historically had relatively high levels of employment (Graduate Careers Australia, 2016), the census data here indicate that many new graduates, and in the longer-term most graduates, do not work in a professional engineering role. Other research suggests that this is not a new phenomenon. The census data also indicate that both general employment outcomes, and working in a professional engineering role, have significantly declined for new graduates between 2011 and 2016. Where engineering graduates do not practice in professional engineering, it is commonly framed in a negative light – as ‘wastage’ or ‘attrition’ (Department of Education Employment and Workplace Relations, 2009). The Australian Council of Engineering Deans refers to the ‘loss’ of engineering graduates, being a ‘poor return’ on the investment in their education (Australian Workforce and Productivity Agency, 2014). The compelling conclusion from the census data is that it is not just a matter of trying to recruit more and/or ‘better’ students into university engineering studies, or building a more ‘authentic’ curriculum or otherwise enhancing the employability of engineering bachelor graduates – there are literally not enough professional engineering roles in Australia for all Australian engineering graduates.

It is time to be more honest, positive and constructive with how engineering study is promoted to potential, intending and current students, and to the wider community. An engineering graduate working ‘out of field’ is not a second-class outcome. As Mellors-Bourne, Connor, and Jackson (2011) note, in the UK, the broad career options open to STEM graduates are viewed as a positive benefit in
promoting STEM careers to secondary school students. The Australian Department of Education Employment and Workplace Relations (2009) previously commented that:

…when engineering graduates do not enter the Australian labour market as an engineering professional the system could be deemed less successful. … An alternative view is that while the Australian Government invests in funded places for the purposes of building a prosperous society and economy, the means by which highly skilled graduates will achieve this are somewhat more diverse. … It may well be necessary for many of these graduates to explore options other than employment as an engineer in Australia on completion of their degree. … Graduates working in related occupations will bring their engineering background with them, providing them with a multi-disciplinary outlook that has the potential to make them the flexible, open minded, highly skilled employees that many industries need to develop new business strategies. (p. 8-10)

Historically, existing models of Australian engineering education have produced generally good overall employment outcomes for graduates, even if many graduates worked in non-engineering roles, so the argument could be made that "if it ain't broke, don't fix it". There have been previous calls to 'reform' Australian engineering education to improve graduate capabilities to make them more suitable / attractive for engineering employment (Johnson, 1996; Williams, 1988). The most recent census data suggest that, regardless of the preparation of undergraduates, many will work outside of professional engineering, and that more radical changes in engineering education should be considered. What is considered an authentic curriculum should be reconceptualised. If an 'authentic' undergraduate engineering education is one that best prepares graduates for the complexity of the world of work, then it would address the diverse and competitive makeup of the engineering workforce, and the wide range of actual employment outcomes for engineering graduates in Australia. Those significant number of engineering graduates who have historically found themselves working out of field have, knowingly or otherwise, turned a problem into an opportunity, finding gainful ways to use their engineering knowledge and skills. This empirically validated engineering solution offers guidance to engineering educators. An authentic undergraduate engineering curriculum is one that deliberately addresses graduate employment outcomes beyond professional engineering in its: philosophy and vision; student recruitment; intended learning outcomes; learning designs; curriculum content; assessment; and, most especially in its employability studies, including student projects, work experience and industry-based learning opportunities.

Conclusion

The nature of the Australian engineering workforce is the subject of much anecdote (Consult Australia, 2014; Engineers Australia, 2012). The Australian national census data over the period 2006-2016 reveal empirically the complexity/diversity of occupational outcomes for engineering bachelor graduates - many will work out of a professional engineering role if they wish to work at all, and the Australian professional engineering workforce is very diverse, including many people without an engineering bachelor qualification. These results have important implications for those with the responsibility for the design of undergraduate engineering curricula to best prepare students for the future work environment that they will graduate into. Over time, various models of reformed/contemporary/authentic engineering education have been proposed to make graduate more 'employable': project-based learning; sandwich programmes; service learning; study abroad; integrated studies; active learning; blended learning; management studies; flipped classroom; block teaching; etc. The next advance in engineering education in Australia is likely to come via the acceptance that it is educating many students for work outside of the profession, including for many immediately following graduation. It is acknowledged that reconfiguring the engineering curriculum to meet the broad and growing needs of graduates to work on nonprofessional engineering roles is difficult. It moves the curriculum away from the specialist education that is definitely required. Additionally it is impractical to add more to the curriculum. Therefore, designers of engineering curriculum need to become more skilled at mapping generic graduate skills to ensure that graduates see these skills more visibly within the curriculum and recognise their application to a broader sector of the job market.

The work presented here only considered engineering bachelor graduates as a whole. It is known that gender and nationality have an impact of engineering graduate employment outcomes in Australia (Australian Workforce and Productivity Agency, 2014; Trevelyan & Tilli, 2010). In Australia, engineering has one of the largest discipline gender differences in lifetime earnings premium (Norton & Cakitaki, 2016). The census data here were queried, and differences were found in the proportion of graduates working in a professional engineering role based on gender (female 16.8 per cent; male
26.6 per cent) and citizenship (Australian 29.4 per cent; non-Australian 13.1 per cent). Additional research is required to characterise and understand the impact of working out of field on other occupational outcomes such as location of work and salary. Importantly, additional research is required to characterise and understand in more detail the impact of demographic factors such as gender, nationality and geography on occupational outcomes for Australian engineering bachelor graduates. The Australian census provides a rich data source for exploring intersectional issues in professional engineering education and practice.

References


