The short- and long-term relationships between gender and occupational outcomes for Australian engineering bachelor graduates

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The Australian census data revealed that in 2016 only 25 per cent of all engineering bachelor (BE) graduates were working in a professional engineering (PE) occupation. Other research indicates that this overall result will mask differences in outcomes for BE graduates based on gender and age. Here, we use the latest Australian census data to identify the impact and interaction of gender and age on occupational outcomes for Australian BE graduates. The analysis here includes the outcomes of broad occupational classification, weekly income, and weekly hours worked. Compared to BE graduates overall, female BE graduates are less likely to be working in a PE role, less likely to be working at all, more likely to have a lower income, and more likely to be working less hours per week. Compared to BE graduates overall, new BE graduates are less likely to be working at all, and more likely to be working in a part-time work pattern. Of all BE graduates, new female BE graduates are least likely to be working at all, have the lowest median income range, and most likely to be working in a very low weekly hours work pattern. We present the methods used to collect these data and a discussion of the implications of these results for Australian undergraduate engineering education.

Keywords: engineering education; Australian census; occupational outcomes; gender; new graduate

Introduction

Until recently, new engineering bachelor (BE) graduates in Australia have enjoyed relatively high rates of full-time employment (Graduate Careers Australia 2016). Norton and Cakitaki (2016) noted 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 in more recent years. Figure 1 summarises previous research using the latest Australian census data from 2016. The left column of Figure 1 shows that only 25 per cent of all BE graduates were working in a professional engineering (PE) occupation. Approximately half of all BE

graduates were not working in PE occupations. Note that the PE category includes the occupational classification of 'Engineering manager', which is distinct from those graduates reporting working in general (non-engineering) management roles. The right column of Figure 1 shows that nearly 40 per cent of PE roles were filled by people without at least a bachelor qualification in engineering. Note that the census occupational categories used ensure that job roles that use the term 'engineer' in a colloquial manner are not counted here. Collectively, the two columns in Figure 1 indicate that there were nearly twice as many BE graduates as PE occupation respondents. Figure 1 illustrates that it is a fundamental structural feature of the Australian employment market that many BE graduates will have to find employment outside of professional engineering if they wish to work at all.

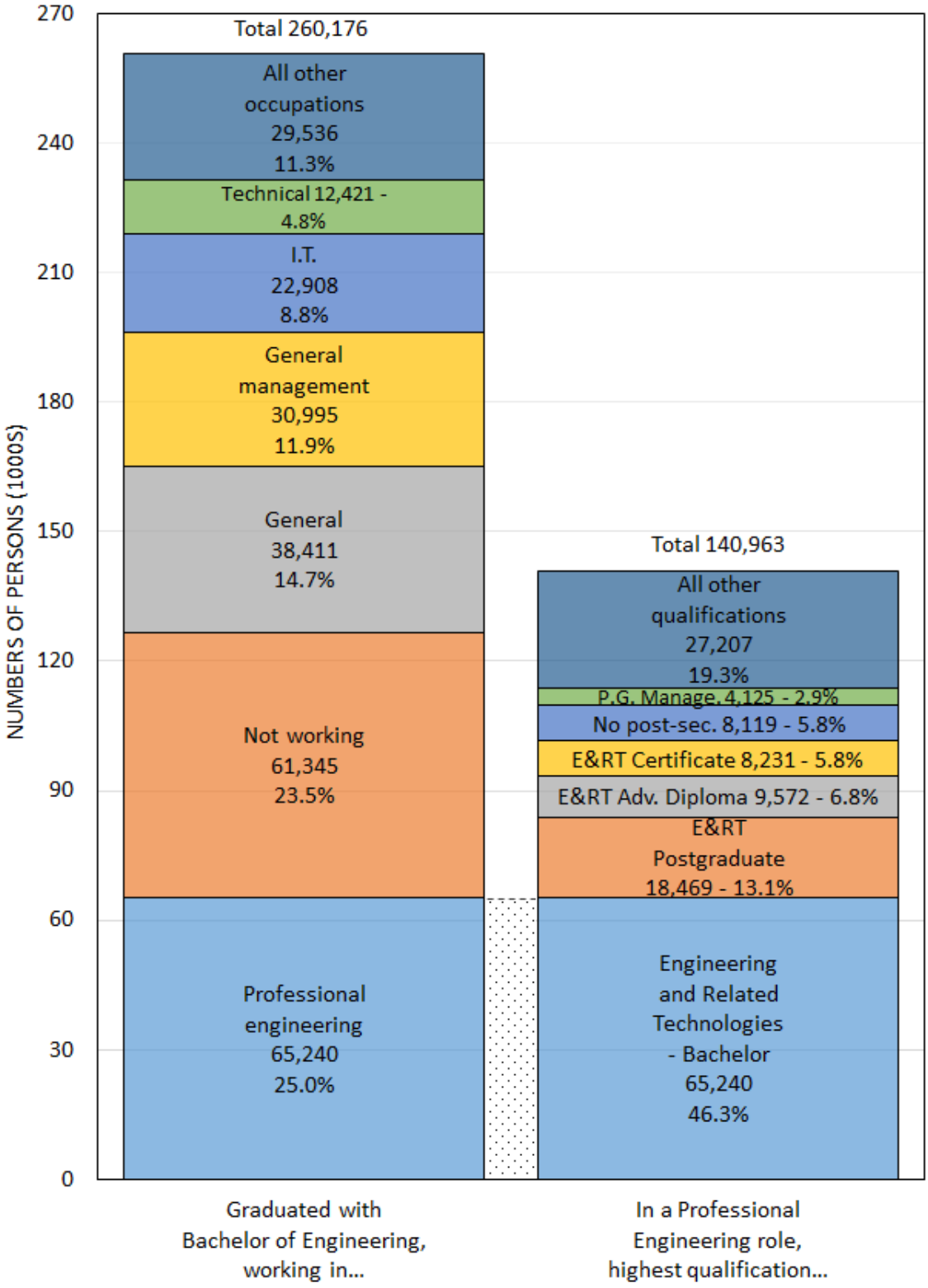


Figure 1. Reported engineering qualification & occupation data – based on 2016 Australian census data (Palmer and Campbell 2018).

The results presented in the left column in Figure 1 are for all respondents reporting a BE qualification in the 2016 Australian census. Internationally, it has been observed that a range of demographic characteristics have an impact on the occupational outcomes of BE graduates. Using a large, longitudinal survey of US bachelor graduates, for STEM (science, technology, engineering and mathematics) graduates collectively, it was found that, while STEM graduates had a lower unemployment rate than non-STEM graduates, female student participation in STEM majors overall remained low, and gender disparities in employment status and salary were significant from the beginning of post-graduation employment (Xu 2015; 2017). Using data from a representative sample of US STEM workers across the period 1995 through 2008, a complex picture of occupational outcomes for female engineering graduates was revealed (Michelmore and Sassler 2016; Sassler *et al.* 2017). While they noted a closing of the gender pay gap for more recent engineering graduates during the time period 1995 to 2008, they also noted that for engineering graduates of all ages, "[r]esults indicate a persistent gender pay gap in the two STEM fields with the smallest female representation—engineering and computer science … These differences remain even after accounting for observed characteristics such as disparities in years of potential work experience." (Michelmore and Sassler 2016, p. 195) Litzler *et al.* (2005) reported on research from the US that indicated that female STEM graduates were more likely to work outside of STEM, starting shortly or immediately after graduation. Drawing on EngineeringUK (a collaboration between UK engineering employers and professional bodies) sector data, Lyons (2011) noted that a high proportion of STEM graduates did not work in the STEM sector, and that the proportion was higher for female graduates (70 per cent) compared to male graduates (50 per cent).

Research that attempts to quantify the influence of demographic characteristics on occupational outcomes specifically relating to engineering in Australia is hard to find. A report from the Office of the Chief Scientist (2014) noted generically that, 'Women also continue to leave STEM in unacceptably high numbers at secondary, tertiary and early-career level.' (p. 21) The 2014 Engineering workforce study by the Australian Workforce and Productivity Agency (2014) reported a number of data sources. The study ran focus groups with female engineers that revealed discrepancies in remuneration levels between male and female engineers (p. 117). The study reported results from Professionals Australia's annual engineering salary survey in 2012 that indicated an average starting salary package for male graduates of $77,652 and for females of $74,720 (p. 117). The study reported Australian Bureau of Statistics (ABS) labour force survey data indicating that, while the number of female engineering professionals increased over the period 1993 to 2013 (21,100 to 36,500 female workers), the proportion of females working as engineering professionals decreased by 0.7 per cent (p. 104). Finally, citing the same ABS source, the study noted that women retired from the engineering workforce earlier than men (p. 105). Norton and Cakitaki (2016), drawing on ABS and Graduate Careers Australia (GCA) data, noted that employment for new Australian BE graduates had declined in recent years as the general engineering employment market declined following the mining boom. They also found that, in Australia, engineering has one of the largest discipline gender differences in lifetime earnings premium (average extra lifetime income compared to someone of the same gender who completed no post-secondary education).

In their large US investigation of the influence of gender on employment outcomes in STEM, Michelmore and Sassler (2016) and Sassler *et al.* (2017) found that, not only was gender a significant influence on graduate occupational outcomes for

engineers, but that the interaction between gender and other demographic factors, including age, was also significant. These findings and the available Australian research presented above suggest that the overall results presented in Figure 1 will mask both differences in, and more nuanced interactions between, the occupational outcomes for Australian BE graduates based on gender and age. Age is important generally for universities, as most of their new graduates will be young adults. Gender should be centrally important engineering education, as the latest (2017) Department of Education domestic higher education enrolment data show that Engineering and Related Technologies had the lowest proportion (16.9 per cent in 2017) of female students by enrolment count of any broad field of bachelor education (Department of Education 2017).

Here, we use the latest Australian national census data to identify the impact and interaction of gender and age on occupational outcomes for Australian BE graduates. We use census respondent age as way to contrast occupational outcomes for new BE graduates compared to all BE graduates. The census data incorporate several occupational outcomes – the analysis here includes broad occupational classification, weekly income, and weekly hours worked. We present the methods used to collect these data, the limitations of the data, a discussion of the implications of these results for Australian undergraduate engineering education, and identify a rich intersectional research agenda enabled by the Australian census data. This analysis presents important findings for those designing undergraduate engineering programs that seek to prepare students for the best employment outcomes, given the nature of the PE work environment, and the short- and long-term occupations that BE graduates actually pursue in Australia.

Methods

The ABS census online TableBuilder service (Australian Bureau of Statistics 2019) was used to access the publicly available 2016 Australian national census data. The census data include reported respondent gender, although this is currently limited to female or male only. The census data do not explicitly include whether a respondent is a recent bachelor graduate, but does include reported respondent age. The last detailed GCA Graduate Destinations report (Graduate Careers Australia 2016) indicated that the majority of new bachelor degree graduates available for full-time employment were aged under 25 years. The number of people aged under 21 reporting hold a BE qualification in the census is very small, and outside of the age range likely for a genuine new university BE graduate. As a proxy measure for identifying 'new' BE graduates, we include all census respondents holding a BE age between 21 and 24 years inclusive. In the work presented here, 'all' BE graduates include those census respondents holding a BE aged 21 years or older. In the work presented here we are not considering census respondents reporting a masters or other types of higher degree in an engineering discipline. The ABS TableBuilder service allows the census data categories to be cross-tabulated in complex ways to produce rich customised views of the census data.

The TableBuilder census data contain 477 separate occupation categories, 12 of which are clearly associated with PE roles. The census 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. For all respondents reporting a BE qualification, the proportions in the three broad employment categories of 'working as a professional engineer', 'otherwise employed'

and ‘not working’ were graphed. On the same chart, these employment categories were also separately presented for: i) all female BE holders; ii) all male BE holders; iii) all recent BE graduates; iv) all female recent BE graduates; and, v) all male recent BE graduates. The census data include reported total weekly income in 15 ranges. For each of the six demographic groups of holders of a BE qualification noted previously, the proportions in each of the 15 weekly income ranges were graphed on the same chart. The census data include reported weekly hours worked in eight ranges. For each of the six demographic groups of holders of a BE qualification noted previously, the proportions in each of the eight weekly hours worked ranges were graphed on the same chart.

It is possible to compare the proportions of the three broad employment categories between the two gender groups for all graduates, and, for new graduates, using a Chi-squared test. Here we used a statistical significance level of $p < 0.01$. It is possible to perform post hoc pairwise comparisons between individual broad employment categories and gender using the Chi-squared test table cell residuals and applying the Bonferroni correction to the significance level to allow for the fact that multiple tests are performed in the overall crosstabulation. In a similar manner, it is possible to compare the proportions of the three broad employment categories between other groups via crosstabulation and significance testing, for example, for all graduates and new graduates.

There are several limitations with the Australian census data as used here. The data are from the census conducted in 2016, hence already somewhat dated. Reported census data 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. The quality of census data is influenced both

by the response accuracy of those completing the census, and the choices made by those coding those responses into the census database. The Australian census only asks respondents for their highest qualification. A respondent with an BE qualification who has completed a graduate qualification in another discipline (for example in education or business) is not recorded as having a BE qualification. In the context of examining occupational outcomes differences based on gender, Broadley (2015) notes that there is often greater variation within groups than between groups, so care needs to be taken in generalising results based on gender or other characteristics. Acknowledging these limitations of the data, the results obtained and their implications are discussed.

Results

Figure 2 presents the proportions of census respondents reporting a BE qualification grouped into the broad employment categories of 'working as a professional engineer', 'otherwise employed' and 'not working' for each of the six demographic groups previously identified. Figure 2 is designed to permit direct visual comparison of the proportions of employment status between the six demographic groups. It also includes the total number of respondents in each of the demographic groups, so that the displayed percentages can be converted to approximate absolute numbers via multiplication. Note that the totals for the demographic sub-groups do not exactly sum to their respective demographic total due to the small random adjustments made to reported census data noted above.

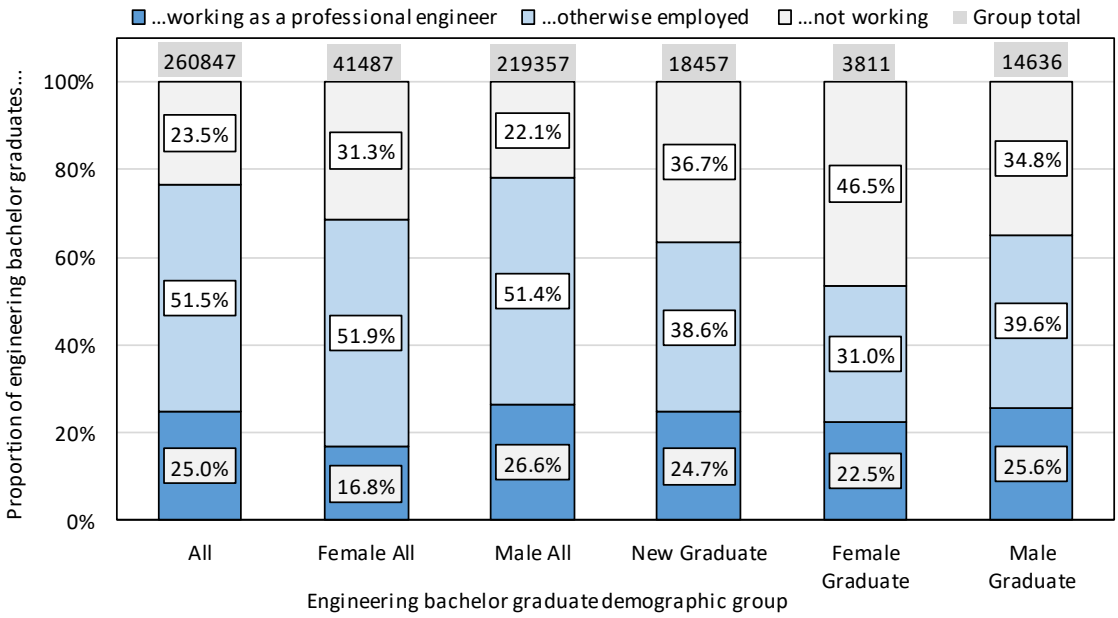
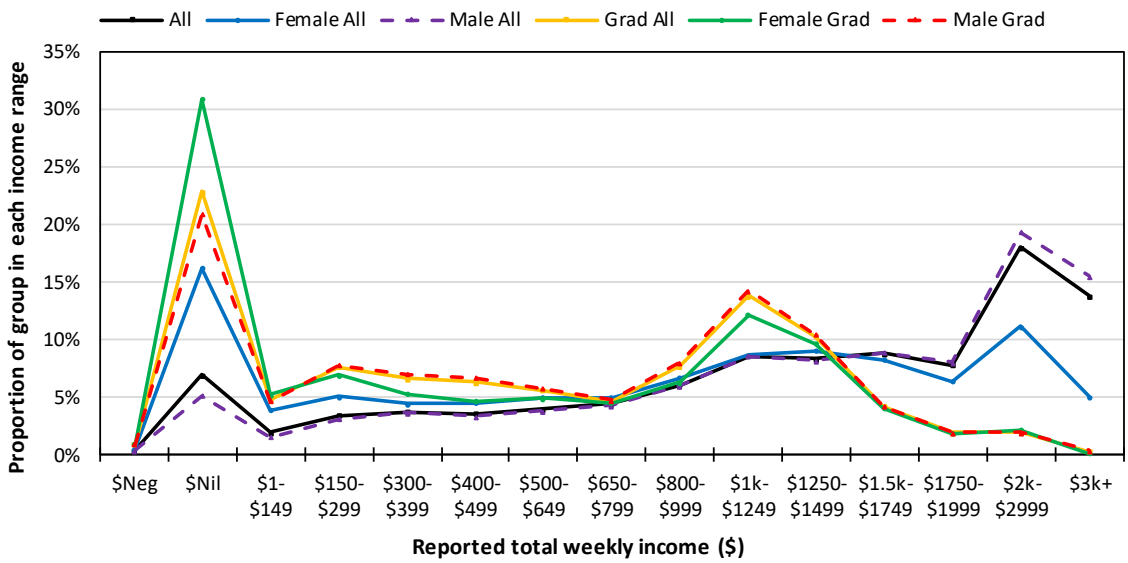


Figure 2. Reported broad occupational outcomes for categories of engineering bachelor graduates – based on 2016 Australian census data.

Using a Chi-squared test, the result for the overall crosstabulation of employment category and gender for all graduates was X^2 (2, N = 260817) = 2598.781, p = 0; the overall proportions were significantly different. The Chi-squared test is an omnibus test, and doesn't say anything about significance of observed differences between individual broad employment categories and gender. Post hoc pairwise comparisons between the individual broad employment categories and gender were performed, including the Bonferroni correction of the p value to account for the multiple pairwise tests. In the case of all graduates, the proportions by gender in the 'otherwise employed' group were not significantly different (p = 0.233), but the proportions by gender in the 'working as a professional engineer' and 'not working' groups were significantly different (both p = 0.0). The result for the overall crosstabulation of employment category and gender for new graduates was X^2 (2, N = 18021) = 174.339, p = 0; again, the overall proportions were significantly different.

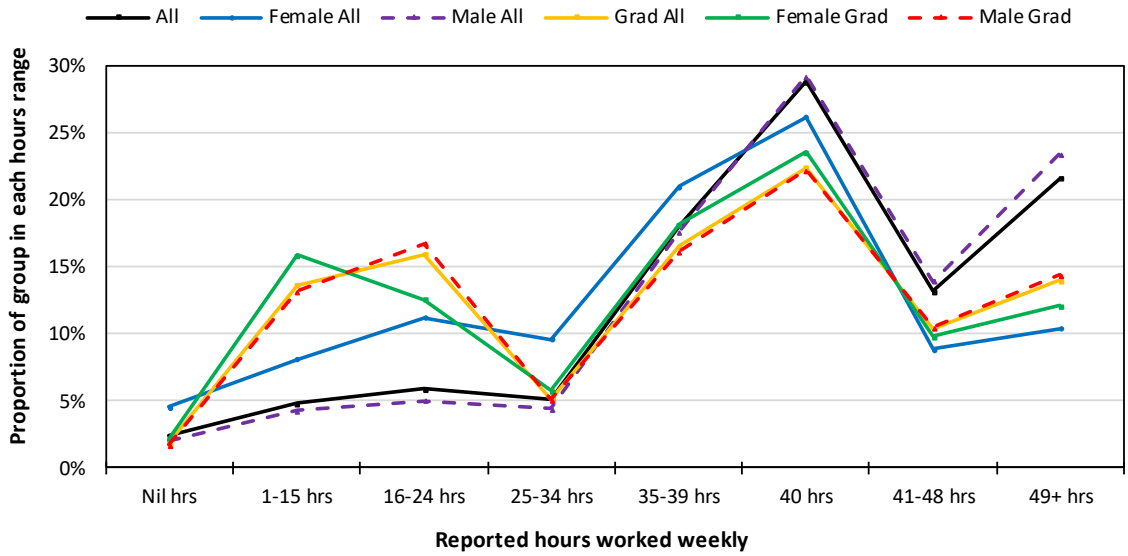
Post hoc pairwise comparisons between the individual broad employment categories and gender were performed, including the Bonferroni correction. In the case of new graduates, the proportions by gender in all employment categories were significantly different (all $p = 0$). Additional specific significance tests are reported in the Discussion below.

Figure 3 presents the proportions of census respondents reporting a BE qualification grouped into the weekly income categories used in the census for each of the six demographic groups previously identified. Note that Figure 3 excludes those respondents who are unemployed or not in the labour force. Figure 4 presents the proportions of census respondents reporting a BE qualification grouped into the weekly hours worked categories used in the census for each of the six demographic groups previously identified. Within the limitations of the census data on income and working hours being reported in ranges, Figures 3 and 4 are designed to provide a comparison of the relative income and weekly working hours distributions of the six demographic groups in a form approximating a continuous distribution. Proportions for each range in Figures 3 and 4 can be read by projecting up from the middle of the range on the horizontal axis, to the chart line corresponding to the group of interest, and then left across to the vertical axis. Proportions can be converted to approximate numbers of respondents by multiplying the proportion by the corresponding group total given in Figure 2. Because the data on income and working hours are reported in ranges, it is not possible to report discrete measures of central tendency (mean, median, etc.). However, Figures 3 and 4 include the relevant median range for each of the six demographic groups.



Group	All	Female All	Male All	Grad All	Female Grad	Male Grad
Median weekly income range	$1250-$1499	$800-$999	$1.5k-$1749	$500-$649	$400-$499	$500-$649

Figure 3. Reported weekly income data for categories of engineering bachelor graduates – based on 2016 Australian census data.



Group	All	Female All	Male All	Grad All	Female Grad	Male Grad
Median hours per week range	40 hours	35-39 hours	40 hours	35-39 hours	35-39 hours	35-39 hours

Figure 4. Reported weekly hours worked data for categories of engineering bachelor graduates – based on 2016 Australian census data.

Discussion

General observations on occupational outcomes

It is difficult to directly confirm the results from the census data above (Palmer and Campbell 2018), however previous investigations in Australia (Trevelyan and Tilli 2010) and the US (Choy and Bradburn 2008) that found about half of all BE graduates were not working in an engineering-related role, are not inconsistent with the results presented in Figures 1 and 2. Our previous observations on the consolidated results for all BE graduates presented in Figure 1 are summarised in the Introduction above, and we have previously speculated on the factors that might contribute to these findings (Palmer *et al.* 2015). Where BE graduates do not practice in PE, it is commonly framed negatively - the 'loss' of engineering graduates, being a 'poor return' on the investment in their education (the Australian Council of Engineering Deans in (Australian Workforce and Productivity Agency 2014)); and, a 'concern' not only for engineers, but also for other professions and the wider economy (the Organisation for Economic Co-operation and Development in (Lavoie and Finnie 1998)). However, we have previously argued that engineering graduates working out of field is not a second-class outcome.

Around the world it has been observed that such graduates take their skills and knowledge into productive roles in the wider economy (Benderly 2015; Department of Education Employment and Workplace Relations 2009; Mellors-Bourne et al. 2011). Regular appeals for engineering curricula to be more 'authentic', 'real-world', 'industry-relevant', etc. are almost always premised on a view that most graduates from BE programs will go into PE practice in 'industry'. Figure 1 shows that it is not a matter of making 'better' engineers at university. Many new engineering graduates will never work in PE practice; the jobs for them literally do not exist in Australia. We have

previously contended that it is high time for universities to be more honest with both intending and current engineering students about their likely occupational outcomes. If an 'authentic' BE curriculum is one that best prepares students for their likely post-graduation occupational role(s), then there is also a need for the BE curriculum to actively address the preparation of students for a productive, rewarding and successful career beyond PE practice. Beyond identifying the occupational outcomes for BE graduates collectively, the purpose of this research is to disaggregate the impact and interaction of gender and age on occupational outcomes for Australian BE graduates.

Occupational outcome differences by gender

Figure 2 indicates that female BE graduates are less likely to be working, and less likely to be working in a PE role, than their male counterparts. Figure 3 shows that female BE graduates have a lower median weekly income range, are less likely to be in a higher income range, more likely to be in a lower income range, and more likely to have nil income (likely to be an indicator of not working), than their male counterparts. Figure 4 indicates that female BE graduates are less likely to have a full-time weekly working hours pattern, and more likely to have a part-time weekly working hours pattern, than their male counterparts. As noted in the Introduction above, these results are broadly in accordance with international findings relating to female graduates in STEM generally, and in engineering particularly. Other data relating specifically to occupational outcomes for female BE graduates in Australia are hard to find – the most significant research reported in this area is from the US.

Using US Current Population Survey data from 1979 to 2009, Cha and Weeden (2014) showed that at least part of the observed gender gap in wages in the general labour force was due to the greater likelihood of males to 'overwork', that is, work 50 hours or more per week. Figure 4 shows that for all engineering graduates, males were

more than twice as likely to be working 49 or more hours per week. Xu (2017) notes that women who commence work in STEM fields and then take on family responsibilities often experience social pressure to assume primary caring and/or domestic duties, and may have to decide between a professional career and family responsibilities. Based on qualitative coding of 1863 statements from 1464 women engineers who had left the profession following working as an engineer, Fouad *et al.* (2017) identified the most common theme by nearly a factor of two was related to workplace setting, including, 'poor and/or inequitable compensation, poor working conditions, inflexible and demanding work environment that made work-family balance difficult' (p. 1). Xu (2017) noted existing research that indicated women and men in STEM have comparable academic performance, but that masculinised STEM workplace cultures place expectations and limitations on professional behaviour, and may lead to marginalisation and low job satisfaction for women. They also noted research indicating that women make educational and occupational decisions based on rational cost-benefit assessments, and suggested that, 'women are less likely to pursue a career in STEM fields knowing that they may experience persistent earning disadvantages and a male-dominated unsupportive workplace culture.' (p. 6) Such outcomes disadvantage not only individuals, but society as a whole. In many countries, women outnumber men as university graduates, but the under-representation of women in STEM, and particularly engineering, contributes to a general gender-based inequality of income (Leaper and Starr 2018; Michelmore and Sassler 2016).

Occupational outcome differences for new BE graduates

Figure 2 shows that new BE graduates are less likely to be working than BE graduates overall X^2 (1, N = 68034) = 1606.055, p = 0. Figure 3 indicates that new BE graduates have a lower median weekly income range, are much less likely to be in a higher

income range, more likely to be in a lower income range, and much more likely to have nil income, than BE graduates overall. Figure 4 shows that new BE graduates are less likely to have a full-time weekly working hours pattern, and much more likely to have a part-time weekly working hours pattern, than BE graduates overall. Other data relating specifically to occupational outcomes for new BE graduates in Australia overall are hard to find. Norton and Cakitaki (2016) observed that the historical favourable employment outcomes for BE graduates peaked in 2013 and declined thereafter. Comparing the last three sets of Australian census data that are publicly available, we showed that in 2016 there had been a decline the proportion of BE graduates aged 20 to 24 years who were employed, and particularly employed in a PE role, compared to 2011 and 2006 (Palmer and Campbell 2018).

The results in Figure 3 are not unexpected - more new graduates with nil income (unemployed), a peak weekly income for new graduates equating to the 2016 average BE new graduate salary of $62,600 (The Social Research Centre 2016), and a peak weekly income for all BE graduates of about twice the new graduate salary. However, the results in Figures 2 and 4 are potentially more concerning. Not all of the 36.7 per cent of new graduates not working in Figure 2 might be seeking work. However, in 2016, the proportion of new BE graduates in further study was 13.6 per cent, only about half the national average rate (The Social Research Centre 2016), so it is likely that many new BE graduates were seeking work at the time of the census. Figure 4 shows similar proportions of both new and all BE graduates reporting a full-time work pattern (35-39 and 40 hours per week), but new BE graduates are more likely to report a part-time work pattern (1-15 and 16-24 hours per week). For all groups in Figure 4, there is a noticeable dip at the 25-34 hours weekly hours worked category. The 25-34 hours per week pattern falls in between common part-time and full-time working patterns in

Australia, so is less likely to be reported by respondents. While not all of the approximately 30 per cent of new BE graduates reporting a part-time work pattern might be seeking additional weekly hours of work, it seems likely that some Australian new BE graduates are underemployed.

Occupational outcome differences for new BE graduates by gender

In previous sections, occupational outcome differences have been examined based on gender for all graduates, and based on new graduate status. Here we take an intersectional perspective and consider the occupational outcome differences for new BE graduates by gender. Figure 2 shows that, while new female BE graduates are more likely to be working in a PE role than female BE graduates overall X^2 (1, N = 7771) = 76.212, $p = 1.3\text{x}10^{-18}$, they are less likely than all other demographic groups included here to be working at all X^2 (5, N = 136074) = 966.822, $p = 4.6\text{x}10^{-207}$. We can infer over time that some unemployed new female BE graduates will find work, but that it will be largely outside of PE, and that some of those new female BE graduates working in a PE role will leave for a non-PE role.

Figure 3 indicates that new female BE graduates are less likely to be represented in the range of normal graduate incomes, have the lowest median weekly income range of all demographic groups, and are more likely than all other demographic groups to report nil income. Figure 4 shows a distribution of weekly hours worked for new female BE graduates that is like their male counterparts, in that about 30 per cent of respondents reported a part-time work pattern. However, the peak part-time range for new female BE graduates is 1-15 hours per week, compared to 16-24 hours per week for males.

Implications for undergraduate engineering bachelor programs

The census data, and other data sources, show that, historically, many Australian BE graduates have, and will have to, work outside of PE. There is also research from Australia (Department of Education Employment and Workplace Relations 2009), the UK (Atkinson and Pennington 2012; Mellors-Bourne *et al.* 2011), and the US (Benderly 2015) that indicates many BE students do not actually envisage a long-term career in PE practice. We have previously suggested that, because neither universities nor BE graduates can alter the structural characteristics of the national PE employment market, there is a need for BE programs to best prepare students not only for PE practice, but also for other likely occupational possibilities (Palmer and Campbell 2018; Palmer *et al.* 2015). The additional disaggregation of the census data examining the occupational outcomes for BE graduates by gender and age presented here, shows that, compared to BE graduates overall:

- Female BE graduates are less likely to be working in a PE role, less likely to be working at all, more likely to have a lower income, and more likely to be working less hours per week.
- New BE graduates are less likely to be working, and more likely to be working in a part-time work pattern.
- New female BE graduates are least likely to be working at all, have the lowest median income range, and most likely to be working in a very low weekly hours part-time work pattern.

The direct capacity of BE programs to influence students and their engagement with their work environment decreases rapidly after students graduate, and BE programs have a responsibility to prepare all students well for life post-graduation.

However, the results presented here indicate that BE programs have a particular responsibility to support female engineering students during their studies to best succeed in their university academic endeavours, and to develop their career intentions in an informed and deliberate manner. The research literature offers a range of possible resources, activities, learning designs and other interventions that educators might employ to support female BE students. For example: providing female peer mentors (Dennehy and Dasgupta 2017); exposure to female STEM role models (Herrmann *et al.* 2016; Xu 2017); avoiding student workgroups were female students are the minority (Dasgupta *et al.* 2015); resilience-building activities (Walton *et al.* 2015); and, employing design project topics that are likely to appeal to a broad range of student interests (Richard *et al.* 2015).

Historically, women in engineering (WIE) programs for students have been a popular initiative, and have been shown to improve retention of female engineering students, particularly in first and second year, which seem to be critical points for female students when academic self-confidence may drop (Brainard and Carlin 1998). Litzler *et al.* (2005) found that, compared to students that didn't use WIE services, participants in a WIE program reported greater self-confidence in some areas, attended more job interviews, were more satisfied with university careers services, and were more concerned with aspects of prospective employment that would allow them to balance work and family requirements. They also observed that WIE program participants were significantly more likely to indicate they did not intend to work in a field related to their undergraduate discipline, and they expressed concern that WIE programs were providing female students with too much information about realistic career expectations and scaring them away. We argue that honesty is always the best policy, and, given the PE job market described in Figure 1, that students making

informed career decisions during their studies and actively preparing for the post-graduation job market is a desirable outcome.

Seron *et al.* (2018) undertook a project between 2003 and 2007 at four major US engineering schools that tracked the study experiences of 41 students, including 28 women, through diary entries completed fortnightly across four years. Their research findings showed that female engineering students clearly recognised their marginality, and provided criticisms of their experiences. However, these experiences did not generally lead to critical views of their university or the profession, nor to overt calls for structural change. Rather, the female students tended to adopt the prevalent engineering ideologies of individualism and meritocracy (that career and professional rewards will come to those who deserve it), even in the face of obvious examples of sexism and discrimination. They concluded that engineering education efficiently reproduces gendered inequalities through a process of socialisation that leads many female students to conceive of it as an objective and apolitical environment. They also noted that most of the female students in their study participated in the Society of Women Engineers (SWE), a US national association for the advancement of women in the profession that runs regional local events open to student members. The accounts of SWE events attended by the female students describe them as uncritical, non-political, focussed on technical problem-solving, and, providing tips on navigating the cultural norms of engineering, rather than challenging them. We suggest that WIE-style programs and other campus-based support for female engineering students should aspire to not only present ways for female students to pragmatically negotiate the existing cultural norms of engineering practice, but that such programs should also assist female students to develop a critical perspective on the gendered nature of PE education and practice.

Opportunities for further research

We have used the latest Australian national census data to identify the impact and interaction of gender and age on occupational outcomes for Australian BE graduates. A range of related and additional research questions could be explored using the census data. The data used here include both Australian- and foreign-born persons with both Australian and international BE level qualifications. This is not unrealistic, as it represents the Australian engineering workforce at the time of the census. However, using 2001 and 2006 census data, Trevelyan and Tilli (2010) previously found that international students who studied engineering in Australia had a significantly lower chance of working in engineering compared to Australian-born students. In future work, it would be possible to expand our work here to consider the impact of respondent country of birth.

Research indicates that STEM occupations command a salary premium compared to many other occupational areas (Anlezark et al. 2008; Leaper and Starr 2018; Xu 2015), and that working in an occupation congruent with your study area is also associated with a higher salary (Xu 2017). It would be possible to investigate the impact of working out of field on salary outcomes, and similar research questions, for Australian BE graduates using the census data.

As noted above, the census data include reported respondent gender, although this is currently limited to female or male only. Gender intersectional issues create barriers to the participation of individuals in STEM, and little research has been conducted on understanding the impacts of gender intersectionality and STEM participation in Australia (Australian Academy of Science 2019). There is a pressing need for Australian research that considers this important issue.

Using a large US STEM occupational data set and multivariate analysis, Michelmore and Sassler (2016) and Sassler *et al.* (2017) found that, not only was gender a significant influence on graduate occupational outcomes for engineers, but that the interactions between gender and other demographic factors were also significant. The crosstabulations of census data presented here suggest that multivariate analysis of a larger set of census occupational and demographic data might reveal similar significant factors and interactions contributing to the occupational outcomes for BE graduates in Australia. However, to perform multivariate analysis the complete individual census data records for the sub-population of interest (here BE graduates) would need to be available. For privacy reasons, individual Australian census data records are not publicly available. The ABS census online TableBuilder service only provides aggregated results (with small random adjustments to ensure respondent privacy) in the form of a spreadsheet containing a specified crosstabulation.

Conclusions

We used the latest Australian national census data to identify the impact and interaction of gender and age (as a proxy for new graduate status) on occupational outcomes for Australian BE graduates. Differences between groups were clearly evident. Compared to BE graduates overall, female BE graduates are less likely to be working in a PE role, less likely to be working at all, more likely to have a lower income, and more likely to be working less hours per week. Compared to BE graduates overall, new BE graduates are less likely to be working at all, and more likely to be working in a part-time work pattern. Of all BE graduates, new female BE graduates are least likely to be working at all, have the lowest median income range, and most likely to be working in a very low weekly hours part-time work pattern. Some of these findings are likely to be interdependent, for example, working part-time is likely to lead to a lower weekly

income. However, the interdependence may be subtler. As noted above, the pay inequities experienced by women in STEM may lead to women leaving STEM fields of work, and may even deter female students from entering in the first place.

Figure 2 shows that 30-40 per cent of new graduates are likely to work out of field, and that this will ultimately increase to 50 per cent. BE programs need to consider the workforce roles that new BE graduates undertake, recognising that there are as many occupational opportunities available to graduates outside of the profession as there are within the profession. The transferable employability skills that are valuable to BE graduates in PE practice have potentially even greater value for those BE graduates seeking to gain employment in a non-engineering occupation. The value of transferable employability skills should be reinforced in the undergraduate engineering curriculum. The curriculum also needs to identify how all students can be better supported so that they can begin to alter the gender and other cultural stereotypes that exist in engineering, so that the profession, and ultimately society, benefits from a more equitable and diverse workforce, both in engineering practice, and wherever else BE graduates make their career.

The Australian census data offer additional opportunities for further exploring the occupational outcomes for BE graduates, including rich intersectional investigations. In addition to 2016 census data set used in the research presented here, the 2006 and 2011 Australian census data sets are also publicly available, and the data from the recent 2021 census will join them in time, allowing the possibility of time series and trend analysis. In closing, it is important to acknowledge that the authors of this paper are two middle-aged white male engineering graduates. Research into gender and intersectionality in engineering education and practice demands a diversity of

voices and perspectives, and we encourage others with a stake in this agenda to pursue research in this area.

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