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Beyond the classroom: STEM, employability and the student voice

Emily Bennett

University of Western Australia, Perth
22252596@student.uwa.edu.au

Dawn Bennett

Curtin University, Perth
d.bennett@curtin.edu.au

This paper explores the thinking of undergraduate science, technology, engineering and mathematics (STEM) students in relation to their study choices and future careers. The paper reports on a pilot study with first-year engineering students, who completed an online self-assessment tool. Most of the first-year undergraduate students chose engineering as their major because it was an area of interest, they had enjoyed academic success in STEM subjects, or because they thought of engineering work as practical, challenge-based work. No significant differences were observed in the students' responses when correlated with age, gender or work history. The paper reports first-year students' responses to their career-related confidence and their perceptions of career, career development learning and career intentions.

Keywords: Higher education, engineering, career development, undergraduate research

Students of science, technology, engineering and mathematics (STEM) can struggle to grasp the myriad opportunities available to them as graduates (Lent, Brown et al., 2005). Logically, effective career development learning in STEM would assist students to become both career- and self-aware through opportunities for real-world learning through a constructivist pedagogy featuring authentic learning experiences and broad-ranging career conversations (Bennett, Roberts, & Creagh, 2016; Blackley & Howell, 2015; Kitchen, Sonnert, & Sadler, 2018). However, broad STEM career thinking is difficult to embed within curricula which demand that students make decisions on their specialisations early in their programs. The purpose of this pilot study was to ascertain the thinking of first-year undergraduate engineering students in relation to their study choices and future careers. The paper reports students' career-related confidence and their perceptions of career, career development learning and career intentions.

Background and context

The term employability is often used to describe skills and attributes which relate to employment in a single position and/or profession. However, people have an average of five different careers and around 17 different jobs across their working lives (Foundation for Young Australians, 2017). Five years ago, many of the most in-demand occupations didn't exist (World Economic Forum, 2016). The rapidity of occupational change is particularly pertinent to STEM graduates given that 75% of the fastest growing occupations in Australia relate to STEM (McCrindle, 2018).

According to the Australian Council of Engineering Deans (ACED), over 111,000 students are enrolled in Australian engineering programs (2018a). Engineering graduates enter a labour market in which rapid global change and advances in digital technology are accelerating and the economic downturn has reduced the availability of both employment and internships (ACED, 2018b). Engineers Australia (EA, 2017) reported that less than 75% of new graduates are able to find full time work, 12% settle for part-time work and 15% are unemployed; subsequently the recruitment and retention of engineering graduates is a significant challenge. Alongside concerns about graduate success is the issue of retaining students, with Bachelors programs experiencing attrition of approximately 25% (Tilli & Trevelyan, 2010).

The attrition of engineering students and graduates suggests that some students embark on engineering studies without understanding the realities of either the degree program or the characteristics of engineering work (Bennett & Male, 2017). Tertiary education has come under increasing pressure to provide students with field-specific training and qualifications to enhance graduate employability and enable their seamless entry into the workforce (Hernández-March, 2009). Despite an increase in employability development initiatives in tertiary education, many students report insufficient career development support in their first year of study (de Hollander et al., 2018) and the perceived value of learning and roles of engineers can emerge as threshold concepts. According to Tomlinson (2008), senior students similarly voice the need for further support in career development, with many students feeling unprepared for their careers post-graduation. This is despite the alignment between learner agency, academic success and explicit career development learning (Wright, Jenkins-Guarnieri, & Murdock, 2013).

There is also an unequal trade-off between learning investments and workforce benefits, which is not strong enough to endorse confidence in undergraduate degrees. Students become concerned about the career opportunities available post-graduation; they question their understanding about what their future work will entail and they doubt that their credentials will be enough to see them into their careers (Tomlinson, 2008).

The interplay between coursework and career goals is another area of concern for undergraduate students (Tomlinson, 2008). Hernández-March (2009) has contended that there is a need to link career relevance with coursework in order to relieve student stress about future career-related goals and opportunities. Indeed, many employers criticise graduate knowledge as being too theoretical, with a sparsity of students graduating with a solid grasp of workforce realities and experience working in industry (Hernández-March, 2009). Duffy (2010) concluded that students with greater personal control are more adaptable and more confident in their abilities to adapt to the world of work. Duffy found that the degree to which students feel in control of their own lives and learning is indicative of their appreciation and willingness to engage in career development learning. One of the drivers of incongruity between education and career development learning is that students are time poor (Richardson, 2019). However, few students have time between graduating and embarking on their careers to solidify course content and to work out what they hope to gain from their newfound credentials (Richardson, 2019).

The study reported here strengthens arguments for employability development in higher education to be more broadly defined than the use of skills or the ability of graduates to find a job. Employability development needs to develop learners' ability to navigate decision making and learning across the career lifespan (van der Heijde, 2013). As such, the study supports a definition of employability as "the ability to find, create and sustain meaningful work across the career lifespan and in multiple contexts" (Bennett, 2019, p. i).

The study

The pilot study reported here sought to answer three research questions:

1. Why do students choose to study engineering?
2. How do engineering students describe a successful engineer?
3. How confident are first-year engineering students in relation to their employability?

The study was grounded in “employABILITY thinking”, which is a strength-based, metacognitive approach to employability development (Bennett, 2019). The approach is grounded in socio-cognitive theory and situates career development learning as a fundamental aspect of higher education learning and teaching (see developingemployability.edu.au). Internal consistency and validity of the employABILITY scale has been established. Each construct within the scale has a Cronbach’s alpha coefficient (Cronbach, 1951) of over 0.70. Composite reliability confirms internal consistency.

EmployABILITY thinking prompts students to understand why they think the way they think; how to critique and learn the unfamiliar; and how their values, beliefs and assumptions can inform and be informed by their learning, lives and careers (Bennett, 2019). The focus of such an approach centres on learners’ ability to create and sustain meaningful work.

The measure was delivered through an online self-reflection tool completed in class. The measure incorporates 153 items, which ask students to report their perceived confidence in relation to six broad facets of employability (see developingemployability.edu.au):

- Self-management and decision-making relative to self and career (Lent et al., 2017);
- Self-esteem (Rosenberg, 1965), self- and academic self-efficacy (Bandura, 1993; Byrne et al., 2014);
- Identity construction relating to academic and future work (Mancini et al., 2015);
- Person-centred self and employability; citizen-self (Coetzee, 2014);
- Emotional intelligence (Brackett & Mayer, 2003); and
- Learner and graduate attributes (Coetzee, 2014; Smith, Ferns, & Russell, 2014).

The measure includes five open questions relating to work history, choice of major, career intentions, feedback on the degree program and their perceptions of a successful graduate outcome. For the purposes of this pilot study, a supplementary question (Q6) was added to address research question 2. Open questions two and six are shown below.

Q2: Why did you choose your major (discipline)?

Q6: How would you describe the characteristics of a successful engineer?

The 251 first-year engineering students were enrolled in a common core (foundation) year and they completed the online self-reflection tool to create personalised career profiles. The online self-reflection took between 15 and 20 minutes to complete. Student profile reports were organised into six sections:

1. Basic literacy: Disciplinary skills, practices and knowledge; communicating and interacting with other people; using digital technologies for work and learning.
2. Rhetorical literacy: Solving problems, making decisions; achieving deadlines.
3. Critical literacy: Confidence in abilities; ability and willingness to learn; putting theory into practice.
4. Emotional literacy: Interacting with people and knowing how relationships function.
5. Occupational literacy: Career exploration and awareness; having a ‘Plan B’.
6. Ethical literacy: Ethically, culturally and socially acceptable behaviours and values.

Analysis of the open data began with complete readings of each case. Inductive coding revealed new themes and the initial codebook was modified in line with each new case; both researchers coded all cases independently and then compared coding until agreement was reached. Students’ perceptions of their strengths and weaknesses were explored through the L4L measure and analysed using SPSS version 16.

Ethical approvals were secured before the study and students’ responses were anonymised prior to analysis. Although students were required to complete the tool as part of their foundation unit, they chose whether or not to include their response in the dataset. In this sample, all students chose to include their responses. Student quotes are coded with a respondent (R) number.

Findings and discussion

Why do students choose to study engineering?

Students were asked, “Why did you choose your major (discipline)?” Where two or more reasons were given, these were coded separately and weighted equally. We note that 80 of the 251 students (31.9%) gave no reason for their choice of major; this was a low response rate and merits further attention. Shown at Figure 1, responses indicate that the students chose engineering as their major because it was an area of interest, a STEM subject in which they were successful at school, or because they saw engineering as challenge-based work.

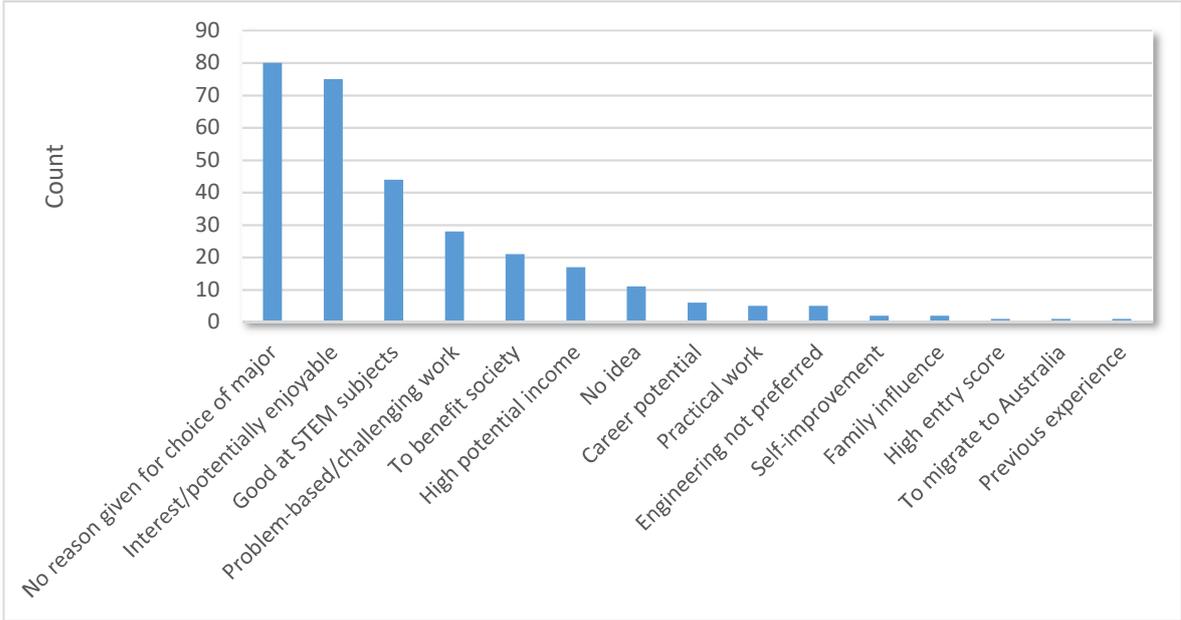


Figure 1. Why do students choose to study engineering? (open question, count).

Among our cohort, intrinsic motivation (i.e. interest and enjoyment) was a dominant driver of career choice. The influence of other people such as family featured very little in students’ responses. One student response epitomised each of these themes:

I hate theory. I like the physics and maths of everything. I like to solve real world problems. It also pays well. Because I had the [university entrance] score, and was unsure what engineering was like so I thought I would try it out to see. (R153)

As seen in the following student quotations, however, many students were uncertain that they would become engineers and others were motivated by the perception that engineering would provide high social status and a stable income.

So that once I have completed one degree I can complete another without repeating all the units. It [engineering] also seems more work oriented than studying science, which, even though I might prefer, would likely present less income. (R166)

I like solving practical problems, not theoretical problems. I'd do medical but I hate blood. (R154)

I didn't get my first preference, engineering was my second. (R167)

Will always have a future and will most likely help me achieve the goal of always being able to increase my level of importance. (R151)

I like the idea of comfortable living and the high salary of engineering would provide this. (R166)

How do engineering students describe a successful engineer?

Students were asked to describe the characteristics of a successful engineer. This was an open question and the student responses, shown at Figure 2, varied from technical- or talent-based descriptions ("High IQ"; "Design skills; technical knowledge; maths") through to more comprehensive definitions such as the two shown below.

Grit, spit and a whole lot of experience. (R98)

Confidence, good communication skills, teamwork, good problem solving, creativity. (R67)

Success was mostly defined in terms of the potential to have a positive impact on society. Only one student described a successful engineer as someone with a "high salary".

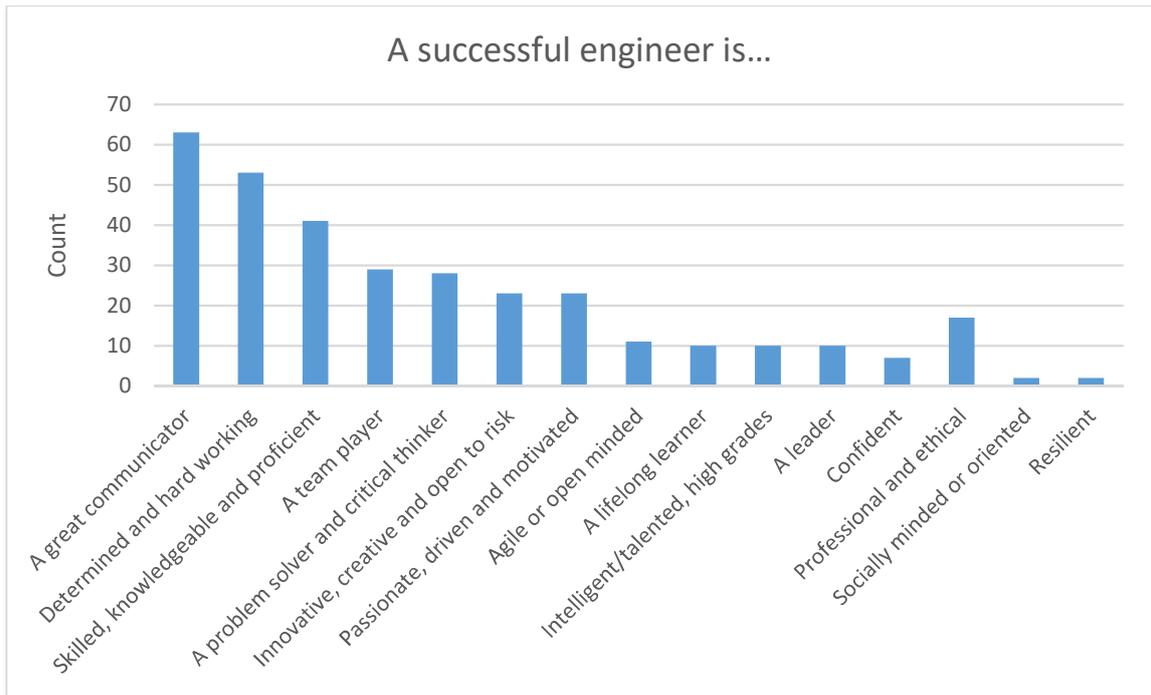


Figure 2. Student perceptions of “a successful engineer” (open question).

How confident are first-year engineering students in relation to their employability?

Confidence levels were assessed using the L4L measure. Initial analysis calculated aggregated means for each of the six literacies within the measure, shown at Figure 3.

The first-year students expressed more confidence in their occupational and emotional literacies and less confidence in their basic, rhetorical, critical and ethical literacies. They were aware that their engineering knowledge, skills and practices (their basic literacy) were at the novice level and they reported that they were relatively aware of engineering practice and their career options (occupational literacy).

The students expressed less confidence in their ability to solve problems or to achieve goals, tasks and deadlines (rhetorical literacy), which is insightful because they emphasised the importance of these capabilities when describing a successful engineer. Of interest, students reported that they did not always uphold ethically, culturally and socially acceptable behaviours and values (ethical literacy). This might relate to students not yet understanding how ethical practice is realised within the context of engineering.

There was no significant difference in students’ reported confidence (literacy scores) when correlated with age or gender in any of the six literacies. There was marginal significance in terms of gender ($p = 0.078$) in rhetorical literacy, with male students expressing slightly more confidence than females; and in emotional literacy ($p = 0.032$) the female students expressed slightly more confidence than males. Similarly, there was no difference by age ($r^2 = 0.01$). We note that the sample was dominated by students aged between 18 and 21 and a larger range of ages would be required to determine the impact of age on literary confidence. Of interest, the analysis showed no significant difference between work status and history (whether students had or had not previously worked) and their level of confidence in any of the six literacies.

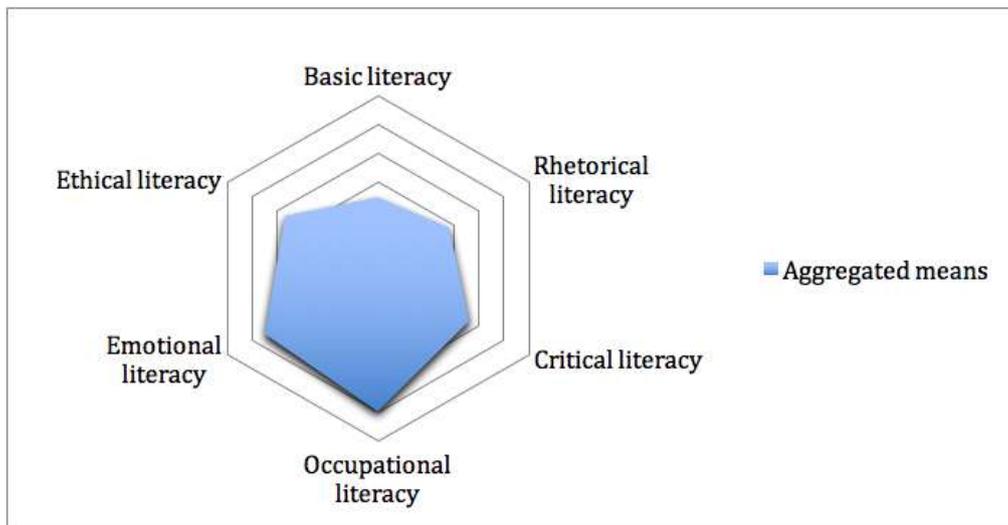


Figure 3: Confidence levels of the first-year engineers.

Conclusion

This paper reported on a pilot study with first-year engineering students at a single institution. Future studies might seek to report on students’ developmental thinking longitudinally and in relation to their academic success, career development learning and engagement in industry placements. The addition of cohorts from other institutions and STEM disciplines would help to determine whether the self-efficacy and career thinking of STEM students differs according to context, discipline and educational background.

Key findings showed that the pilot cohort of engineering students chose an engineering major as a result of their proven STEM abilities, interest in STEM subjects, and a desire for challenged-based work. The respondents demonstrated a basic understanding of the team- and project-based nature of engineering work. They understood the importance of communication, problem-solving and team-work capabilities to engineering practice, but they did not express confidence in these areas. Given the alignment of academic self-efficacy and learner engagement, further discussion and development of learner confidence is vital.

The findings suggest that there might be educational benefits to adopting a strength-based approach to learner development with a focus on learners’ abilities and career awareness. A metacognitive approach to career development learning in engineering would also enhance learner agency, which as noted earlier is aligned with academic success (Duffy, 2010; Wright, Jenkins-Guarnieri, & Murdock, 2013). A metacognitive approach to employability is needed throughout the career lifespan as workers strive to “learn” or “think” their living (Van der Heijden, 2014). A metacognitive view of self, career and society is also in line with the design thinking that underpins much engineering work. Engineering education might therefore seek to engage learners in broader challenges such as how to apply their work in broad social settings.

Further research is needed with STEM cohorts in each year of their degree programs, enabling the development of data which reveal students’ employABILITY thinking by cohort, individual student and program.

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Links and resources

- EmployABILITY tools and resources are free of charge for all tertiary students and educators. Please email 2nd author at dawn.bennett@curtin.edu.au.
- Educator site: <https://developingemployability.edu.au/>
- Student site: <https://student.developingemployability.edu.au/>
- LinkedIn Community of Practice: <https://www.linkedin.com/groups/13553226>

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