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Metacognition as a graduate attribute: Developing engineering employability with self and career literacy

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CONTEXT

Although engineering employability receives significant attention both nationally and internationally, there is little agreement about how employability should be defined or how it might be developed through an integrated approach. Definitions aside, student engineers need to prepare for careers that are increasingly unstable, mobile and self-directed. In the current climate, employability in engineering can no longer be defined as a job: it does not come with the graduation certificate or with accreditation and it requires constant work throughout the career lifecycle.

PURPOSE

This study positioned employability development as the cognitive and social development of student engineers as capable and informed individuals, professionals and social citizens. The study located employability development within the existing curriculum and sought to engage students as partners in their developmental journeys by creating a better understanding of students' thinking as student engineers.

APPROACH

The study employed a new measure of self and career literacy to develop personalised engineering profiles with 255 first-year engineering students. Students self-assessed their employability development using an online tool. Using the same process, educators will draw on students' self-assessments to rethink the design and delivery of initial engineering education, including composite forms of work-integrated-learning.

RESULTS

Early results indicate the value of a metacognitive approach to employability development. The measure revealed students' perceptions of their development as engineers. The inclusion of 'self' alongside 'career' revealed new insights on 'basic' career literacy, with students emphasising the need for high-level communication skills and a desire for work that has meaning and impact.

CONCLUSIONS

Employability development is a career-long concern in which higher education plays an intensive early role. Involving students in this process from the first year of studies has the potential for students to realise their individual roles as partners in the developmental process. The findings illustrate that the successful integration of engineering theory and practice requires students to become agentic partners in their personal development. For this to occur, educators need to understand students' perceived weaknesses and strengths, and areas in which they might be over-confident. The study reaffirms that it is insufficient for students to know how to think; they need a critical awareness and understanding of their thinking and learning processes. It is imperative, then, that metacognition forms the basis of an integrated engineering education.

KEYWORDS

Work integrated learning, graduate attributes, metacognition, employability

Introduction

This article reports early results from a study that fosters students' developmental agency through the creation and review of formative, personalised engineering profiles. Mindful that engineering graduates transition between roles and need to self-direct at least some of their work and learning, the study adopted a metacognitive view of employability on the basis. Peak body Engineering Australia (2014) agrees that only 62% of engineering graduates work in engineering-related roles and that the recruitment and retention of engineering students and graduates is a critical challenge in Australia (see also Male & Bennett, 2014; Tilli & Trevelyan, 2010). Further, the economic downturn has negatively impacted graduate employment and internship opportunities, with many engineers "forced to switch to other professions or leave the country in order to secure work" (Engineers Australia, 2014, p. 6).

Engineering educators need to prepare student engineers for more unstable, mobile and self-directed work than has traditionally been the case. Engineering is not alone: the number of part-time, casual and multiple job-holding workers has never been higher; neither has the prevalence of boundaryless careers (Arthur & Rousseau, 1996) that involve multiple employers, ignore traditional career progression, and traverse economic sectors.

Not surprisingly, current models of graduate employability often distinguish between job-getting and the ability to create and sustain work over time, including personal satisfaction and the importance of life-wide learning (cf. Yorke, 2006). Scholars are also responding to concerns that graduates lack the attitudes, emotional intelligence, inter- and intra-personal skills and metacognitive capacities to be successful in the labour market (Cumming, 2010).

Boundaryless careers (see Hall, 1976) in various forms are encountered by graduates from both generalist and professional programs and are variously pro-active (voluntary) and reactive (involuntary). In the case of graduate engineers, for example, a pro-active approach might include the adoption of short-term contracts or home-based work in order to meet caring commitments; a reactive approach might be adopted by a graduate who is unable to secure a traditional, full-time role and has to take whatever work is offered.

The implications for engineering education include developing student engineers' nascent personal epistemologies of self, career, learning and practice; self-concept and self-efficacy; and identity development. This requires students to be agentic, active learners and recognises the importance of self-knowledge and identity in learner engagement.

Purpose

The study reported here positioned employability development as the cognitive and social development of student engineers as capable and informed individuals, professionals and social citizens. The study located employability development within the existing curriculum and sought to engage students as partners in their developmental journeys. The team hopes that the initiative will help educators to embed employability thinking across the curriculum, help students to shape their future work and career, and create the datasets needed to understand students' thinking about their studies and their future lives and careers. This paper highlights students' first engagement with the study, at which time they created employability profiles using a trial version of the online tool. The paper describes the tool and its development and then presents and discusses student data derived from their profile development, focusing on students' responses to the concept of basic career literacy.

Approach and theoretical framework

First-year engineering students at a Western Australian university were invited to create a personalised employability profile using an online self-assessment; students were advised that completion of the tool would take 15 to 20 minutes. The 255 participating students received personalised profile reports followed by a workshop titled 'Me as an engineer'.

The study employed the Literacies for Life (L4L) measure (Bennett, in review), which is grounded in social cognitive theory and assesses five broad concepts:

- Self-management and decision-making relative to self and career (Lent et al., 2017), to self- and academic self-efficacy (Bandura, 1993; Byrne, Flood, & Griffin, 2014) and to self-esteem (Rosenberg, 1965);
- Professional identity construction in academic and future work (Mancini et al., 2015);
- Person-centred conceptualisations of self and employability including the citizen-self (Coetzee, 2014);
- Emotional intelligence (Brackett & Mayer, 2003); and
- The self-assessment of learner and graduate skills and attributes (Coetzee, 2014; Smith, Ferns and Russell, 2014).

The measure underpins a metacognitive model of employability in which employability is defined as "the ability to create and sustain meaningful work across the career lifespan" (Bennett, 2016). The model's six inter-related *Literacies for Life* combine to enhance employability and inform personal and professional development. The student version, illustrated at Figure 1, was shared with students as part of their profile and workshop.

Figure 1: Student (plain English) version of the Literacies for Life (L4) model

Students' online self-assessments involved completion of the L4L measure (134 items) and responses to five optional open response questions:

1. What do you think it takes to be a successful engineer? (Optional question)
2. Why did you choose to study engineering? (Optional question)
3. Have you made any career decisions at this point? (Optional question)
4. What do you want to achieve over your career? (Optional question)
5. Do you have any feedback on your degree program? (Optional question)

Items drawn from existing validated measures employed Likert scales ranging from 5- to 10-points. For the purposes of comparison, these were weighted to between 1 (not at all) and 6 (completely). Employability was then assessed by the six literacies in the L4L model. Exploratory factor analysis revealed that the literacies fit the data adequately; however, confirmatory factor analysis was not attempted with such a small number. Statistical analysis and validation of the measure will be undertaken at the end of 2017, with a bigger sample.

The length of open response questions ranged from three-word answers to several sentences. Textual data were coded and analysed for emergent themes, and quasi-quantification was applied as a means of summarising the material. This led to a final codebook and inclusion in the database (SPSS) for future analysis. Content analysis enabled the systematic, replicable compression of text into fewer content (Weber, 1990) and inspection of data for recurrent instances. Frequency counting was used where appropriate.

Results

This article reports results from the trial of the new measure. It focuses on students' perceptions of their basic literacy—their disciplinary skills and knowledge—and draws heavily on their open responses. Shown at Figure 2, basic literacy was the weakest of all the literacies for the first-year cohort. Given that first-year students have yet to build their disciplinary skills and knowledge, this is perhaps a predictable result; however, the L4L model is metacognitive in that it challenges students to 'think about their thinking' and to consider both self and career. Basic literacy incorporates 'disciplinary skills and knowledge' alongside 'communicating and interacting with other people' and 'using technologies for my work and learning', thus it is possible to look at student thinking across all three domains.

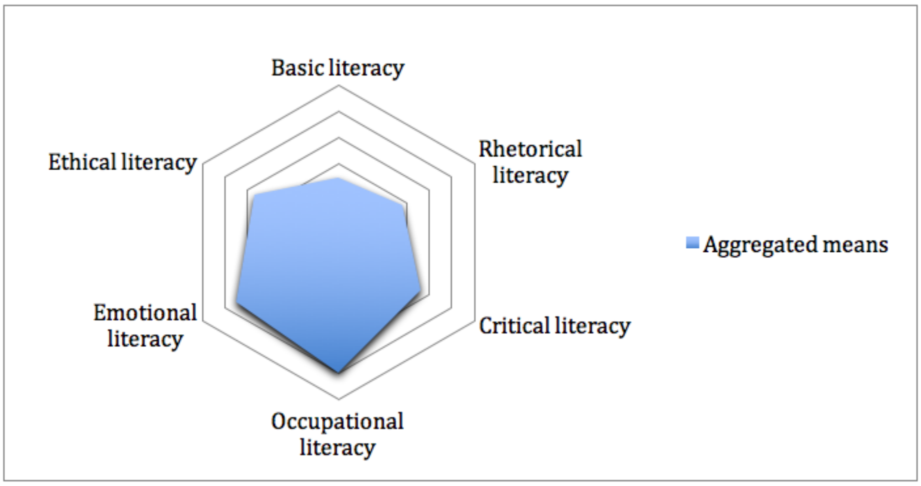

Figure 2: Students' aggregated results across the six L4L literacies

Within basic literacy, the four technology items attracted a mean score of 5.0/6. This indicated that students were fairly confident in their ability to use and learn technologies associated with their work and learning. In contrast, communications items averaged 3.7/6:

- I find it easy to get cooperation and support from others when working in a team. (*M* 3.4)
- I consult others and share my expertise and information. (*M* 3.9)
- I am able to build wide and effective networks of contacts to achieve my goals. (*M* 3.7)

The results indicate that the first-year student engineers were concerned aware of their ability to communicate effectively, which is at odds with the view that students are focused on the scientific or technicist aspects of their engineering education. Indeed, analysis of students' open responses reveals their belief that communication skills are a vital aspect of engineering practice. Responding to the question, "What do you think it takes to be a successful engineer?", 54 students emphasised the social aspects of engineering practice and just four students wrote only of technical or science aspects; only two students wrote exclusively about intelligence and high grades.

Successful engineers must be able to take initiative and think innovatively. They should be able to work well in a team and communicate their ideas effectively. I also believe a successful engineer is one that enjoys what they do.

You should have good communication skills as you will be working in groups and will need to make good first impressions while working with other companies. You should be able to listen to other people's ideas and take criticism while proposing your own ideas. Compromising when needed as a client might disagree with what you have proposed.

It was surprising to see the number of students who defined successful engineering work as personally meaningful, enjoyable, imaginative and/or having a social impact: for example,

To be an engineer is to think like a scientist and work like a tradesman. To be a successful engineer depends on whether you aim for income or self-worth; personally, I don't care about income so long as I have enough to live comfortably and pursue furthering myself and humanity.

To be a successful engineer, you need an open mind that is not influenced by what is, but what things could become - a wide imagination and a head full of ideas with the commitment to learning and passion for the future.

Eighteen students used the terms happiness or fulfilment and 23 students wrote about making a positive societal difference.

I want to have a meaningful career, one that I can look back on and say I made the right choices.

Earn money while being happy with my job.

Gain a well-paying job that I enjoy, one that I can sustain a family with. If I get the opportunity to better the world in some manner or form, that would be a great bonus as well.

I want to become an expert in my field of work, while also upholding my personal interests, values and beliefs. I would also like to be able to provide security, both in a financial and emotional sense, to my family and those close to me. In addition, I believe firmly in making a lasting positive contribution to the community, so I therefore aspire to improve the world in some small way; ensuring environmental sustainability, and addressing matters of social justice and racial and gender equality. If I am only able to make a small change, I can still make a difference.

The lowest mean basic literacy score related to students' self-awareness and their understanding of what they would learn within their program. These three items (listed below) attracted a mean score of only 3.3.

- I can identify personal weaknesses in need of further development. (*M* 3.3)
- I can articulate my personal strengths and how these can be deployed in my career. (*M* 3.4)
- I can identify the knowledge, abilities and transferable skills I will develop in my degree. (*M* 3.2)

The open question, 'Have you made any career decisions at this point?', prompts students to think about the rationale for their study choice and the relevance of that choice to their possible future lives and careers. This thinking is central to students' ability to identify the relevance and value of the knowledge, abilities and transferable skills developed within their degree programs. In this cohort of students, 42 students (16.4%) wrote about their 'career decision' to enrol in engineering. Many students were undecided about which engineering discipline to pursue, whilst other students felt that they were making progress: for example, "I am now choosing between 2 careers rather than 15!"

Among the 31 students who had not made any career decisions were those who had yet to give their future much thought and those who were thinking deeply about possible futures.

Not particularly as none have been qualified by financial or manual measures. The goal is to make enough money as an engineer and learn enough about engineering to start working on the issues our current world and its population face.

For these students, indecision was voiced as a healthy aspect of self- and career exploration, even when indecision was prompted by less positive information.

> *Mining as well as oil and gas are a dying economy.*
>
> *I have accepted the fact that I might not necessarily receive a job in the field that I majored in.*
>
> *Yep, I really dislike maths. I'm going to try to avoid civil engineering.*

As expected, some students were unsure that they had made the right enrolment choice.

> *That if I choose to continue with engineering, which I'm unsure about, that I would want to do Chemical engineering.*
>
> *No, I still do not know which stream of engineering I want to go into, let alone if I'm going to continue doing engineering. I'm still not 100% certain about any of it.*

Students were given the opportunity to give feedback on their degree program, and the perceived relevance of learning featured strongly in their responses. For some students, the relevance was clear.

> *It is very good and gives me an idea on what being an engineer is like.*
>
> *Very well organised and seems to relate thoroughly to life after graduation.*

Other students, however, were struggling.

> *I feel there are several units which have little to no relevancy to what I wish to study in the future and it seems like a waste of resources, time and money.*
>
> *I believe some of the work we do in our degree is almost redundant and there is absolutely no guarantee to a position in the workforce after the completion of a degree.*

Discussion

Attrition among student and graduate engineers has led to concerns that students may enter engineering study without a sense of motivation and commitment, and without understanding the realities of either their degree program or engineering work (Male & Bennett, 2015). The link between relevance and learning is not new: Entwistle and Ramsden, for example, wrote over thirty years ago (1982) about students' tendency to adopt a surface or mechanical rote-learning approach towards material perceived as irrelevant to their future lives. Thus, relevance impacts not only the amount of relevant knowledge retained by students, but the level or depth of understanding they achieve.

More recently, scholars have examined the meaning and use of the term relevance. Writing about science, Stuckey, Hofstein, Mamlok-Naaman and Eilks (2013, p. 8) identified three dimensions with which science education can be seen as 'relevant': relevance for

1. preparing students for potential careers in science and engineering;
2. understanding scientific phenomena and coping with the challenges in a learner's life;
3. students becoming effective future citizens in the society in which they live.

The first of these three dimensions has particular bearing here, particularly because what might be perceived as relevant by curricular designers and educators may not appear so for students. Trevelyan & Tilli's (2008) longitudinal study of engineering practice highlights the stark differences between how students imagine engineering practice and what they experience in placements and as graduate engineers. The authors, for example, highlight that engineers spend only 10% of their time undertaking solitary technical work and around 60% of their time communicating directly with other people.

In the study reported here, first-year students emphasised the importance of communication skills when they responded to an open question about what it takes to be a 'successful' engineer. When completing the self-assessment measure, however, students assessed their personal communication skills as weak. Trevelyan (2011) has long argued that few engineering programs prepare students for the socio-technical aspects of engineering such as communication and working in teams. The fact that students recognised the importance of communication for engineering practice and recognised this weakness in themselves suggests that they would be accept explicit interventions to strengthen their skills. This would be further strengthened if the intervention was based on students' aspirations for the future.

Students were not confident about their ability to identify the knowledge, abilities and transferable skills they would develop through their degree studies. Although graduates go on to work in multiple engineering and non-engineering roles, there are core knowledges, abilities and skills that are transferable – communication being one of these. It would make sense to identify these for students so that regardless of their stage of decision-making or identity development, they can understand the potential relevance of what they are being asked to learn. As such, foundation years might consider positioning student learning more broadly even than the engineering disciplines.

Eighteen students used the terms happiness or fulfilment and 23 wrote about making a difference to the environment or to society. Students' responses indicate that many first-year students have internal and external motivations or drivers that inform their decision-making. These are not apparent when we ask why they chose engineering and hear "because I'm good at chemistry and maths". Following the lead that employability development has to be explicit, we might give students opportunities to discuss their passions, motivations and goals, and try to find links between these and what we ask them to learn.

Conclusion

This article concerned the self- and career thinking of 255 first-year engineering students at a single university; therefore, there is no attempt to generalise the findings. Data were derived from students' responses to an online self-assessment through which they created personalised career profiles. They were the first students to do this and it was too early in the study to make much of the quantitative data. With more participating students, however, it will be possible to identify characteristic trends across engineering disciplines and years of study, and to understand the thinking of students who belong to one or more equity groups.

The study recognised that employability in engineering can no longer be defined as a job and requires constant work. Whilst there is broad acceptance that engineering students need to form themselves for complex work *during* their studies, it is acknowledged that there are multiple challenges to accomplishing this task. Educators in particular can face multiple barriers such as out-dated industry knowledge, over-crowded curricula, modularised delivery models, research-focused career advancement, casualisation of the teaching workforce, and students who prefer their learning to be delivered as neat packages.

The L4L model emphasises a future-oriented epistemology of practice where possible future selves are internalised through effortful engagement with knowledge (including distributed learning) and action (experiential learning). Using the model, learning can be scaffolded so that learners purposefully engage with practice experiences and integrate them with their coursework. Initiatives such as these establish habits and practices that support the on-going development needed to sustain employability in the longer term. Combined, these factors highlight the need for a systematic and integrated approach to embedding effective employability development in engineering education.

References

Arthur, M. B., & Rousseau, D. M. (1996). The boundaryless career: A new employment principle for new organizational era. In M. B. Arthur & D. M. Rousseau (Eds.), *The boundaryless career: A new employment principle for a new organizational era* (pp. 370-382). Oxford University Press.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117-148.

Bennett, D. (2016). Developing employability and professional identity through visual narratives. *Australian Art Education*, *37*(2), 100-115.

Brackett, M. A., & Mayer, J. D. (2003). Convergent, discriminant, and incremental validity of competing measures of emotional intelligence. *Personality and Social Psychology Bulletin*, *29*, 1147–1158.
Byrne, M., Flood, B., & Griffin, J. (2014). Measuring the academic self-efficacy of first-year accounting students. *Accounting Education*, *23*(5), 407-423.
Coetzee, M. (2014). Measuring student graduateness: Reliability and construct validity of the Graduate Skills and Attributes Scale. *Higher Education Research & Development*, *33(*5), 887-902.
Cumming, J. (2010). Contextualised performance: Reframing the skills debate in research education. *Studies in Higher Education*, *1*(15), 405-419.
Engineers Australia. (2014). *The engineering profession: A statistical overview* (11th ed.). Sydney: Institution of Engineers Australia.
Entwistle, N. J., & Ramsden, P. (1982). *Understanding student learning.* London: Social Science Research Council.
Fugate, M., Kinicki, A. J., & Ashforth, B. E. (2004). Employability: A psycho-social construct, its dimensions, and applications. *Journal of Vocational Behavior*, *65*, 14-38.
Hall, D. T. (1976). *Careers in organizations*. Glenview, IL: Scott, Foresman.
Lent, R. W., Ezeofor, I., Morrison, A., Penn, L. T., & Ireland, G. W. Applying the social cognitive model of career self-management to career exploration and decision-making. Journal of Vocational Behavior, 93(2016), 47-57.
Male, S. A., & Bennett, D. (2014). "Don't know what we'll be doing yet!" Enhancing career preview and engagement among undergraduate engineering students. Proceedings of the *Australasian Association of Engineering Education Conference* (n. p), Wellington, December.
Male, S. A., & Bennett, D. (2015). Threshold concepts in undergraduate engineering: Exploring engineering roles and value of learning. *Australasian Journal of Engineering Education*, *20*(1), 59-69.
Mancini, T., Caricati, L., Panari, C., & Tonarelli, A. (2015). Personal and social aspects of professional identity. An extension of Marcia's identity status model applied to a sample of university students. *Journal of Vocational Behavior*, *89*(2015), 140-150.
Rosenberg, M. (1965). Society and the adolescent self-image. Princeton: Princeton University Press.
Smith, C., Ferns, S., & Russell, L. (2014). Conceptualising and measuring 'employability': Lessons from a national OLT project. Proceedings of the ACEN National Conference, Gold Coast 2014.
Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education*, *49*(1), 1-34,
Tilli, S., & Trevelyan, J. (2010). Labour force outcomes for engineering graduates in Australia. *Australasian Journal of Engineering Education*, *16*(2), 101-122.
Trevelyan, J. (2011). *Are we accidentally misleading students about engineering practice?* Paper presented at the Research in Engineering Education Symposium (REES 2011), Spain, October.
Trevelyan, J., & Tilli, S. (2008). Longitudinal study of Australian engineering graduates: Preliminary results. Paper at the *American Society for Engineering Education Conference*, Pittsburgh, June.
Weber, R. P. (1990), *Basic Content Analysis*. California: Newbury Park.
Yorke, M. (2006). Employability in higher education: What it is - what it is not. *Learning and Employability Series One*. UK: Higher Education Academy.

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Links to the research and online resources

For the resources, self-assessment tool and more information, please visit the educator website (http://www.developingemployability.edu.au/). Student resources are hosted at (http://www.student.developingemployability.edu.au/).