To what extent does the professional practicum develop or change an engineering student's identity?

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Structured abstract

BACKGROUND
Educational institutions provide the learning foundation upon which competence for a professional engineering career is established. Therefore it is important that the educational institution provides the graduate with the generic attributes and competencies required to lead a successful career. Graduates, however, often feel unprepared to meet the demands of the engineering profession, and it could be argued that the majority of engineering programs do not adequately prepare students for the socio-technical aspect of engineering (Trevelyan, 2011).

PURPOSE
This project addresses the development of an engineering students' identity and its influence on career development upon completion of the professional practicum program. The guiding research question used in this study was:

To what extent are students' identities and self-perceptions of their competencies developed through exposure to engineering practice in completion of the professional practicum?

DESIGN/METHOD
The research design consisted of four stages of data collection: survey of competencies, interviews, analysis of practicum reports, and a focus group to validate findings. This paper focuses on findings from the survey component. Each phase of data collection utilised the 'possible selves' theory (Marcus and Nurius, 1986) to identify participants' projections about what they hoped to become, what they expected to become, and what they feared becoming (Freer and Bennett, 2012).

RESULTS
It was anticipated that findings would identify the elements of identity that were acquired, realised or developed during, or as a result of, the professional practicum. In particular the study hoped to uncover how students experienced the practicum and how their identities changed as a result. It was anticipated that the study would reveal the effectiveness of the professional practicum, as experienced and described by the participants, and that this would increase our understanding of the extent to which the professional practicum developed or changed students' emerging professional identities.

CONCLUSIONS
Preliminary analysis indicated that both students who had completed the professional practicum and those who had not, viewed effective communication and ability to work in a team (socio-technical skills) as important generic attributes to be a successful engineer in the industry. However, students who had not completed the professional practicum acknowledged the importance of technical skills at a higher level than did those who had completed the professional practicum. This suggests the students' perception of the relative importance of technical competence dropped during the professional practicum. The results also indicate the need for future research, with a focus on identity formation, to assist engineering educators to examine the efficacy and adequacy of industry engagement currently offered to engineering students.

KEYWORDS
Engineering education, professional practicum, possible selves

Introduction

Higher education institutions provide the learning foundation upon which competence is established to lead a professional career. In Australia, the 'Engineers Australia Policy on Accreditation of Professional Engineering Programs' (Bradley, 2010) provides guidance to educational institutions about the generic attributes and competencies needed to practice as a professional engineer. The generic attributes support graduates from an accredited program to be adequately prepared to enter and continue to practice engineering (Bradley, 2010). It has been argued, however, that the current engineering program does not prepare students for the socio-technical aspects of engineering such as communication and working in teams (Trevelyan, 2011). Previous educational research has suggested that there is an overwhelming representation of engineering technology and science researchers, who do not have substantial industry experience, teaching in educational institutions (Cameron and Reidsema, 2011). Consequently, there is a possibility of engineering educators misleading students about engineering practice as they may find it difficult to prepare students with the practical skill set required for those who choose the commercial work setting upon graduation (Trevelyan, 2011). As a result, many engineering graduates are often left feeling unprepared for the workplace and dissatisfied with the development of their engineering identity.

With a focus on the role of the professional practicum in forming professional identity, this honours study is part of an overarching project titled 'Enhancing Industry Engagement in Engineering Degrees'. The project, led by the Australian Council of Engineering Deans (ACED), seeks to examine how more effective engagement with industry can improve student retention and success in engineering degrees and improve graduates' employability (Academic Resource Network for Engineering and ICT Australia, 2013).

For most engineering students, the professional practicum is the greatest exposure a student will receive into an engineering organisation in a commercial setting. Given its orientation towards preparing students for their future careers as engineers, the professional practicum is likely to influence students' career identity. This is the definition people have of themselves in terms of work or career (Meijers, 1998). These are 'possible selves': namely, how students see themselves, what they hope to become and what they fear becoming. For this reason the study adopted 'possible selves' (Markus and Nurius, 1986) as its theoretical frame.

This paper begins by outlining the theoretical frame for the study and then moves on to describe the study approach and design of the research undertaken. Using the theoretical framework, the study then addresses the proposed research question.

Theoretical framework

As we planned to investigate the development of students' identities through their professional practicum experience, the study adopted the theoretical frame of 'possible selves' (Markus and Nurius, 1986), which is a forward-orientated approach towards identifying both desired and feared conceptions of self (Freer and Bennet, 2012). The theory was first developed by Markus and Nurius (1986) to provide a link between cognition and motivation and is important because possible selves function as incentives for future behaviour (selves to be approached or avoided) and because they provide an evaluative and interpretive context for the current view of self (Markus and Nurius, 1986). The theory has been used successfully within the higher education context: for example, a recent study conducted in Australia and the USA explored identity development among university music students who were found to be often at odds with their musical and educational identities. The study revealed that the three recognised modes of possible selves were all present within the student sample (Freer and Bennet, 2012, p 8):

- *positive possible selves that are achievable with effort (hopeful);*
- *likely selves that will probably occur (confident); and*
- *disconcerting futures (feared selves) that are to be avoided.*

These modes of possible selves link self-efficacy to identity. In addition to becoming aware of a possible future self, a student needs confidence this is achievable. We apply this thinking to engineering. Specifically the students' development of identity is linked to awareness of possible roles, perception of competencies required in these roles, confidence in having or achieving these competencies, and consistency between competencies important to the engineering industry and those important to the student.

In London, Spinks, Silburn and Birchall (2007) conducted research to understand the industry's view on educating engineers for the 21st Century. From this research they developed a visual depiction of the domain of the engineering graduate of the future, and this visual depiction has been modified to suit the purpose of the project reported in this paper. Whilst Spinks, Silburn and Birchall (2007) did not consider possible selves as such in their study of UK engineers, their findings illustrate that the success of undergraduate engineering education is as dependent on the engineering industry as that industry is dependent upon engineering education. According to Spinks, Silburn and Birchall (2007, p 60), industry looks for at least one of the following identities in graduate engineers:

- *The engineer as specialist recognises the continued need for engineers who are technical experts of world-class standing;*
- *The engineer as integrator reflects the need for engineers who can operate and manage across boundaries, be they technical or organisational in a complex business environment;*
- *The engineer as change agent highlights the critical role engineers must play in providing the creativity, innovation and leadership to shape the industry in an uncertain future.*

Figure 1 centres on the Engineers Australia's generic attributes (Bradley, 2010) as all graduates from an accredited program should be able to demonstrate these core competences. Figure 1 indicates how all three of the above engineering identities are possible only with a foundation of generic attributes. In addition to the generic attributes, each type of engineer will require strengths in these additional attributes:

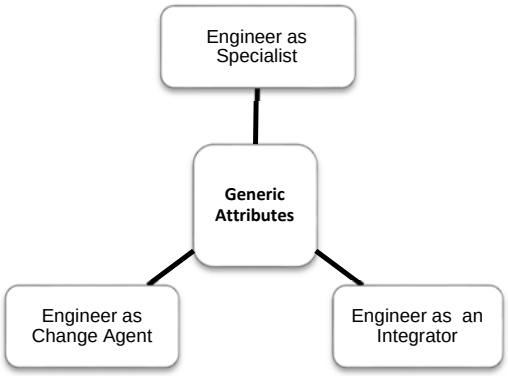

Figure 1: Modified visual depiction of various engineering identities, adapted from Spinks, Silburn and Birchall (2007)

This project addressed the development of the engineering students' identity and its influence on career development upon completion of the professional practicum program. The guiding research question used in this study was:

> *To what extent are students' identities and self-perceptions of their competencies developed through exposure to engineering practice in completion of the professional practicum?*

From the data collected, we aimed to identify:

- The various possible selves adopted before and after completion of the professional practicum program;
- The important features of the program that influenced or impacted the students' identity development and self-perception of their competency development; and

- Consequently, the extent to which the educational institution in which the study was conducted, the University of Western Australia (UWA), helped students to develop their identities.

The context of the study

This paper reports findings from a study undertaken at an Australian higher education institution, which currently requires all students who are enrolled in a Bachelor of Engineering to complete twelve weeks of self-arranged, discipline-related, work based placement otherwise known as the professional practicum. Students are not able to graduate until this work experience is completed and both a document certifying the placement and a report of the experience are submitted and assessed as acceptable. This report is given an 'ungraded pass (UP)' or an 'ungraded fail (UF)'. Unsatisfactory reports must be resubmitted until a grade of UP is awarded. Work experience that is deemed to be unsuitable for the discipline will result in a UF. As students submit documentation only after their practicum work, it is possible for an entire practicum to be deemed invalid.

> *The professional practicum experience provides students with the ability to:*
> - *Contact and liaise with employers to organise work experience;*
> - *Develop an understanding of future roles as a professional engineer;*
> - *Reflect on work experience and articulate professional benefits;*
> - *Constructively criticise workplace practices;*
> - *Communicate these ideas concisely and articulate them in the report; and*
> - *Perform satisfactorily as assessed by an employer (University of Western Australia, 2013).*

A purposive sample of 10 students, during the 2013 academic year, was selected. Following Spinks, Silburn and Birchall's (2007) inclusion of participants from a wide range of industries and core engineering disciplines, maximum diversity was sought for increased validity of collected data. The participant demographic included:

- A diverse range from different engineering schools (1 student from Civil , 2 students from Mechanical, 6 students from Electrical and 1 student from Chemical Engineering);
- Students who had completed the professional practicum program (6) including 1 student who completed prior to commencement of engineering studies; students who had completed the program in the 2nd, 3rd, 4th and final year of their studies;
- Students who had not yet completed the professional practicum (4), to explore identity before completion of the professional practicum program;
- Students with a family member or close friend who was an engineer and professional role model (5) and students with no such influences (5);
- Students aged 19-30 years (mean age 23); and mixed gender (7 male and 3 female);
- Varied duration of the professional practicum program (4 students completed the standard 12 weeks required and 2 students completed more than 12 weeks); and
- Range of industries in which the professional practicum program was completed (2 students from Consulting firms, 2 students from the Resource industry, 1 student in Government and 1 student in Construction industry).

The research design consisted of four stages of data collection: survey of competencies, interviews, analysis of practicum reports, and a focus group to validate findings. The four stages are illustrated at Figure 2.

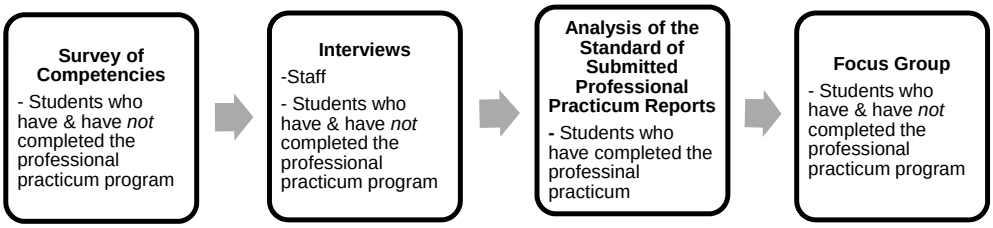

Figure 2: Flow chart of research design process

This paper focuses on the findings of the survey component.

Survey Design

The purpose of the survey of competencies was to collect student perceptions about engineering competencies and self-efficacy to inform the interviews. The survey questions are linked to the following students' possible identities as engineers:

- Whether they picture themselves as certain type of engineer they fear becoming versus their ideal type of engineer;
- Whether they have self-efficacy for achieving a possible future self as an engineer; and
- Whether their perception of the important competencies is consistent with the chosen theoretical framework of 'possible selves' (Markus and Nurius, 1986).

The survey of competencies, requiring approximately 20 minutes to complete, consisted of a demographics table and three Likert-style questions with a list of the generic attributes of a graduate as identified by Engineers Australia (Bradley, 2010). Participants were asked to:

1. "Rate the importance of the use of each generic attribute to engineering industry – measured on a scale of 1 (*not very important)* to 5 (*very important*)";
2. "Rate the importance of each generic attribute to you – measured on a scale of 1 (*not very important*) to 5 (*very important*)"; and
3. "Rate your current level of capability for each generic attribute - measured on a scale of 1 (*poor*) to 4 (*excellent*)".

Only the students who completed the survey of competencies were interviewed as the survey formed the foundation of the interview questions. Ethics approval was obtained via the overarching project 'Enhancing Industry Engagement in Engineering Degrees'. All participants signed a consent form.

Survey Results and Discussion

Due to the small sample size of students used for this study, results indicate a possible scenario of what could happen rather than a generalisable outcome.

Importance of each generic attribute to the industry

Students who completed the professional practicum program rated the following generic attributes more important to the engineering industry than the other student participants:

- *Ability to view problems as part of an overall system; and*
- *Ability to undergo continued learning.*

This high rating suggests that students who have completed their professional practicum are aware of the limitations of their education and the importance of continued learning after graduation. This is consistent with the literature indicated earlier (Trevelyan, 2011) on the possibility of the limitations of the engineering educators' knowledge of engineering practice.

Students who had not completed the professional practicum rated the following generic attributes higher than the other student participants (Figure 3):

- *Ability to apply basic science and engineering knowledge;*
- *Ability to apply technical theory; and*
- *Understanding of the social, cultural, global and environmental responsibilities of an engineer.*

Similarly, a possible reason for these high ratings could be that students who had not completed the practicum were unaware of the engineering competencies required of them by industry. This is also consistent with the literature discussed earlier (Trevelyan, 2011). Another factor could be the identity students adopted when they decided to study engineering. The literature suggests that female and to a smaller extent male engineers who opt to study engineering, often do so due to their sound technical abilities, namely in

mathematics and science (Gill, Sharp, Mills and Franzway, 2008). For this reason, the students may feel that technical competencies rate higher than professional skills.

It is also important to note that all students highlighted the importance of team work as demonstrated in the consistently high importance rating (M, SE = 5.00, 0). These ratings indicate the possible self (the engineer as a team player) that students believe the industry expects of them to embody in order to succeed.

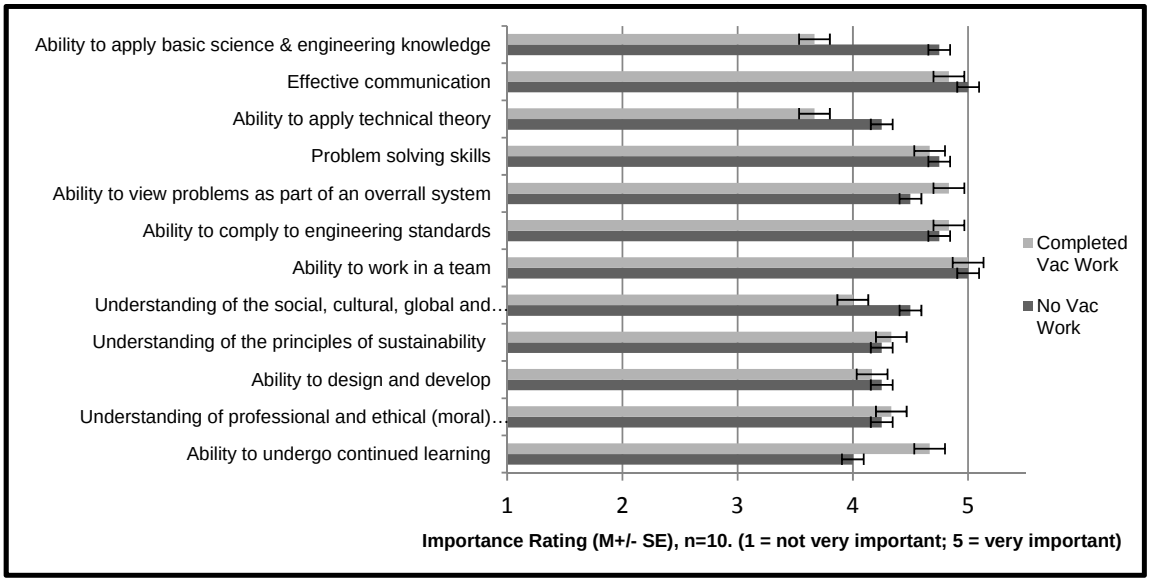

Figure 3: The students' perceived importance rating of each generic attribute to the industry

Importance of each generic attribute to the student

Referring to Figure 4, where students were asked to rate the importance of each generic attribute to themselves, students who completed the professional practicum program rated the following generic attributes higher than other student participants:

- *Ability to undergo continued learning and;*
- *Understanding of professional and ethical (moral) responsibilities.*

The consistently high rating of the generic attribute 'ability to undergo continued learning' emphasises the importance of continued learning to students who have completed industry-related work experience and who understand the limitations and lack of exposure to engineering practices at educational institutions. It shows that these students see themselves as lifelong learners and as part of a profession that will require continuous development.

Students who had not completed the professional practicum rated the following generic attributes more highly than other student participants:

- *Ability to design and develop;*
- *Ability to apply basic science and engineering knowledge; and*
- *Ability to view problems as part of an overall system.*

These ratings are also consistent with the high ratings given to the importance of technical knowledge to the industry. This indicates that students who have not completed the professional practicum program value the importance of technical knowledge to succeed in the engineering industry (M, SE = 4.50, 0.53).

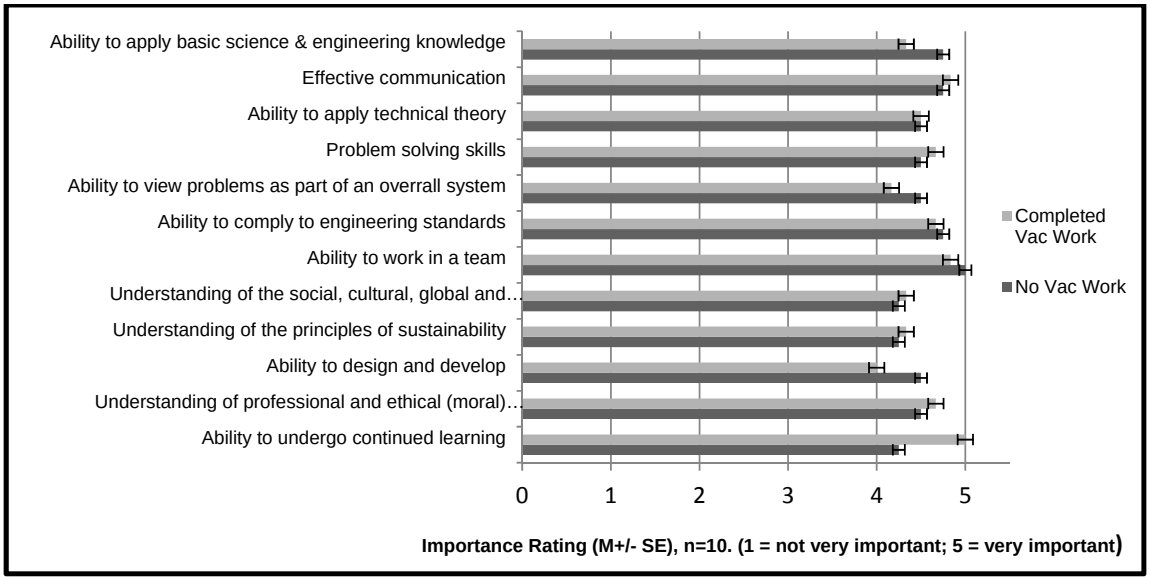

Figure 4: The students' perceived importance rating of each generic attribute to themselves

Current level of capability

Figure 5 illustrates findings of the questions that asked students to rate their current level of capability to each generic attribute. Students who completed the professional practicum program rated the following generic attributes higher than other student participants:

- *Ability to apply basic science and engineering knowledge;*
- *Ability to apply technical theory;*
- *Problem solving skills; and*
- *Ability to undergo continued learning.*

These ratings indicate that despite any curriculum limitations, the students who have completed the professional practicum program are confident in the sufficiency of their technical knowledge to succeed in the engineering industry.

Students who had not completed the professional practicum rated the following generic attributes significantly higher than the post-practicum cohort:

- *Effective communication;*
- *Ability to work in a team;*
- *Understanding of the social, cultural and environmental responsibilities of an engineer; and*
- *Understanding of the principles of sustainability.*

These ratings indicate that the students lacked confidence in their technical abilities despite rating them as important generic attributes to succeed in the industry. However, the students were confident in their ability to work in teams and to communicate effectively.

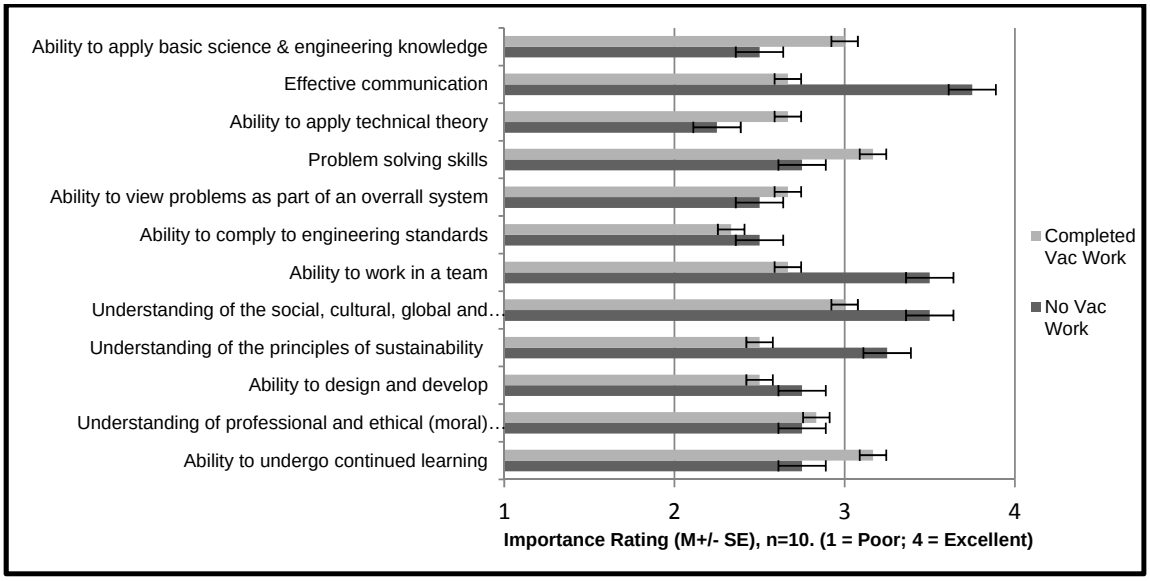

Figure 5: The students' perceived rating of their current level of capability

The survey results highlight the possible selves adopted by the students. The students who had completed the professional practicum had the perception that in order to be successful, they must be competent in their ability to undergo continued education as well as connecting with a sound technical foundation. However, students who had not completed the professional practicum considered being technically competent important to succeeding in the engineering industry.

The proposed model shown at Figure 6 is based on the survey results. The model progresses from the initial competencies that the student sees as important. Then, upon exposure to industry engineering related work, the student realises the various competencies required to succeed. The cogs are representative of the student, so student's confidence and self-efficacy for each competence, which sets the motion for success. This model formed the foundation for the design of the subsequent interviews and focus group. Future studies could explore the applicability and/or adaption of the model in other contexts.

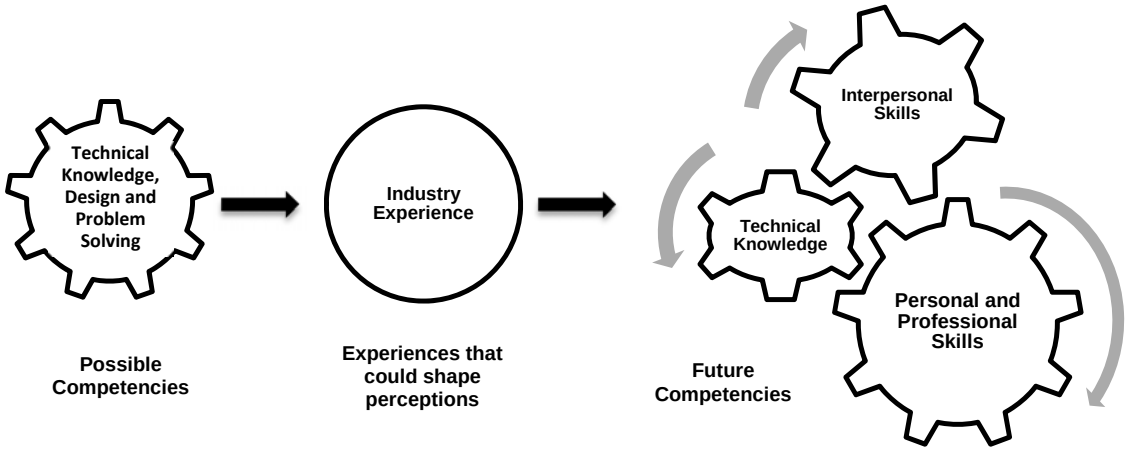

Figure 6: Model of a possible path for the students' identity development

Conclusions

The professional practicum is one of the key strategies utilised by educational institutions to expose students to engineering practice. The results of this small study indicate the need for further research to explore the development and change of students' identities during and

upon completion of the practicum experience. The theoretical framework of possible selves emerges as a useful framework for this exploration, in particular because of its potential to reveal the impact of exposure to engineering practices in various settings before, during and after the practicum.

With a focus on identity formation, future research could assist engineering educators to scrutinise the efficacy and sufficiency of industry engagement currently offered to engineering students. As such it promises to make a useful contribution to the preparation of graduate engineers with the self-efficacy, self-concept and resilience needed to successfully transition to the world of work.

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Acknowledgements

I would like to thank the participants and my supervisors, Sally, Dawn and Nicoleta. I would also like to acknowledge the Australian Government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education which funded the overarching project lead by the Robin King on behalf of the Australian Council of Engineering Deans.

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