“Don’t know what we’ll be doing yet”: Enhancing career preview and engagement among undergraduate engineering students

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Structured Abstract

Recruitment and retention is a key concern for Australian engineering, with indications that 40% of engineering graduates work in other professions rather than in engineering (Tilli & Trevelyan, 2010) and attrition from Australian engineering degrees standing at around 35% (Godfrey & King, 2011). The attrition of students and graduate engineers has led to concerns that students may enter engineering study without understanding the realities of either their degree programs or engineering work. This study contributes to understanding these issues and explores possible approaches to address them.

BACKGROUND

This study built on previous research in which potential threshold concepts in an engineering foundation program were identified by engineering educators and students, and negotiated by engineering educators around Australia, and in New Zealand and Europe (Male, 2012; Male & Baillie, 2011; Parkinson, 2011). The project revealed understanding of ‘roles of engineers’, the ‘value of learning’, and ‘self-directed learning’, as threshold concepts. These concepts were found to be transformative and troublesome for many students and they were likely to be linked (Meyer & Land, 2003). Using an innovative pedagogical design we explored how students might be supported to explore and manage these concepts within the existing curricular structures of undergraduate programs.

PURPOSE

To better understand the three concepts identified above and to determine how teaching staff could support students to negotiate them, the current study drew on research that had successfully enhanced students’ career preview, self-efficacy and identity development in other disciplines (Bennett, 2012) and applied this thinking to engineering.

DESIGN/METHOD

The study combined three theoretical frameworks. We engaged engineering students in workshops in which they investigated roles and attributes of engineers, the purpose of their studies, and their engineering goals. The workshops were designed to provide valuable learning experiences, and they were structured such that we could add to the existing body of research through data collection and analysis.

RESULTS

The findings within each framework are consistent and informed each other; however, each framework provided unique insights into why students experienced the previously identified threshold concepts and each framework gave us different terminology to explain the students’ experiences.

CONCLUSIONS

The three frameworks enriched understanding of the previously identified threshold concepts. The study draws attention to the need and opportunity for engineering educators to help students adopt presage or foundational thinking in relation to their engineering futures.

KEYWORDS

Threshold concepts, possible selves, motivation.

Introduction

Recruitment and retention of engineering students is a key concern for engineering faculties, Australian industries that employ engineers, and the nation, with indications that 40% of engineering graduates work in other professions rather than in engineering (Tilli & Trevelyan, 2010) and attrition from Australian engineering degrees stands at around 35% (Godfrey & King, 2011). The attrition of students and graduate engineers has led to concerns that students may enter engineering study without understanding the realities of either their degree programs or engineering work.

This study built on previous research in which potential threshold concepts in an engineering foundation program were identified by engineering educators and students, and negotiated by engineering educators around Australia, and in New Zealand and Europe (Male, 2012; Male & Baillie, 2011; Parkinson, 2011). The project revealed understanding of ‘roles of engineers’, the ‘value of learning’, and ‘self-directed learning’, as threshold concepts. These concepts were found to be transformative and troublesome for many students and they were likely to be linked (Meyer & Land, 2003).

The study reported here sought to further understand these issues by exploring the thinking of second-year undergraduate engineering students in relation to their future careers. In this study we explored the three threshold concepts, previously identified as experienced by first-year engineering students, within three theoretical frameworks. Using an innovative pedagogical design we explored how students might be supported to consider and manage these concepts within the existing curricular structures of undergraduate programs.

The study was innovative in three aspects. First, the researchers came from distinct disciplines and brought different perspectives to this aspect of engineering education research. Second, the research employed three frameworks in combination. Third, the method combined data collection with delivery of a workshop designed specifically for the benefit of students whilst gauging the efficacy of this approach for addressing career awareness and self-efficacy. This paper focuses all three innovative aspects. The diverse distinct theoretical backgrounds and experience of the researchers led us to tackle the research problem from three different angles, each positioned within a different framework and using one innovative method for data collection.

The overarching goal was to inform strategies for improved student retention and learning, which is a problem without a well-defined framework. The study emerged from work positioned within threshold concept theory, thus to some extent it was positioned within a threshold concept framework. However, to better understand threshold concepts arising from the previous study, in this study we introduced ways to explore the threshold concepts based on the second author’s earlier work on career preview, motivation and identity. The second author introduced a framework focusing on motivation and identity (Amabile et al., 1994) and the theoretical framework of possible selves (Markus & Nurius, 1986).

Entwining three frameworks

We took three approaches to exploring the three threshold concepts. Each approach had a slightly different aim and research questions in order to draw attention to the different assumptions, priorities, possible explanations, and possible solutions surrounding student retention and learning. Despite the different research questions, the three approaches were addressed by collecting data in one student workshop, incorporating important data collection for each framework. Analysis differed for each framework as described below.

We next introduce the three frameworks and describe the study focusing on how the frameworks influenced each element of the study: aims and research questions; method; analysis; findings; and conclusions. Finally we discuss the contribution to the research problem of combining three frameworks.

The theoretical frameworks

Threshold concepts

Threshold concept theory is a framework in which specific, transformative concepts form thresholds to learning within a discipline. By identifying these threshold concepts it is possible to focus a curriculum such that students are supported in overcoming the most critical and troublesome concepts (Cousin, 2006). These concepts can be the focus of class time. However, it is first necessary to identify the threshold concepts and understand how they are troublesome for students. An advantage of using a threshold concept framework to renew engineering curricula is the potential to identify concepts that are critical to students' learning but not necessarily explicitly identified in traditional engineering syllabi and might be overlooked in curriculum development. These include the three concepts investigated here. By using the threshold concept framework curriculum developers can draw their attention to concepts experienced as transformative rather than experts' ideas of critical concepts.

Being transformative, threshold concepts are usually experienced as initially troublesome. The state of a student before a concept comes into view is known as 'pre-liminal'. Once a student experiences the concept as troublesome, he or she is said to be in the 'liminal space'; the 'post-liminal' state occurs once a student is comfortable with the concept.

Possible selves

The theoretical frame for the research is located in the possible selves construct, developed by Markus and Nurius and first published in 1986. Described as "an evaluative and interpretive context for the current view of self" (1986, p. 962), possible selves are people's projections about what they hope to become, what they expect to become, and what they fear becoming. The construct is closely related to Marcia's (1966) identity status framework, which relates the formation of identity to levels of crisis and commitment. Marcia's work differs from Erikson's work in 'ego identity' by contextualising identity development within a variety of life domains including cultural and social contexts. Both Erikson and Marcia advocate that adolescents are more likely to engage in learning when it is perceived as being relevant to their future. Determining 'relevance to future' provides the trigger for encouraging students to think creatively about their future lives and careers, and yet we have realised that few students are accustomed to such open-ended, boundaryless thinking.

Motivation and identity

Amabile, Hill, Hennessey, and Tighe (1994) note that willingness to engage, task commitment and length of commitment are contingent on motivational orientation (for example intrinsic or inward versus extrinsic or outward motivators) and by social and environmental factors. The authors (p. 965) predict that students who score highly on intrinsic motivation should be more likely to:

> *voluntarily undertake challenging courses and course assignments; enroll in courses that will allow them autonomy; choose professions that will allow them active, self-reliant involvement in their work; continue their education (formally or informally) beyond college; become more deeply involved in the activities they undertake; perform more creatively in their work after college; evidence more curiosity toward new or unusual things; and express higher levels of positive affect when engaged in complex, challenging activities.*

The motivation to learn also corresponds with students' conceptualisation of their strengths, interests and goals, which combine to form salient identities (Stryker & Burke, 2000). These give "form, direction and self-relevant meaning to one's logical reasoning ability" (Cross & Markus, 1994, p. 434). In terms of higher education this means that students who believe they have skills in a particular domain perform better, have higher expectations for their future lives and careers, pay greater attention, and are more likely to focus. These factors underpin the extended effort required to develop complex knowledge and skills.

Aims and research questions

Although the overarching aim was the same, the aims and research questions differed by framework. Research questions were designed for the three frameworks and many questions contributed to all three approaches; however, several questions were specific to one framework. Overarching research questions were:

1. To what extent do students understand the relevance of their learning in relation to their development as engineers? (value of learning leading to self-directed learning)
2. What do students see as the roles of an engineer? (roles of engineers)
3. How do students characterise engineering practice? (roles of engineers)

Threshold concepts

In this study we explored the three threshold concepts to better understand how they were troublesome and transformative, and how engineering students might be supported to engage with them.

Relating to the threshold concepts 'roles of engineers','value of learning', and 'self-directed learning', we also posed the following research questions (Male & Bennett, accepted):

4. Is there evidence of these concepts being transformative for students?
5. Is there evidence of these concepts being troublesome for students?
6. Is there evidence of conflict between students' self-concept and their perceived characteristics of an engineer (being an expected source of troublesomeness)?
7. What are students' concerns after considering perceptions of engineers and their desirable selves as engineers (representing any other form of troublesomeness)?
8. For each concept is there evidence of students being in a pre-liminal, liminal or post-liminal state?

Possible selves

Within the possible selves framework the study aimed to highlight strategies with which educators could encourage students' development of presage thinking in relation to their future careers in engineering. There were two specific questions in this element (Bennett & Male, under review):

9. What do students want to achieve as engineers? (self-concept, self-directed learning)
10. After considering their perceptions of engineering practice, what fears do students hold about their ability to achieve their career aspirations? (self-concept, self-directed learning)

Motivation and identity

Finally, the motivation and identity aspect aimed to develop understanding of engineering students' identities and motivation to learn in relation to their perceptions of and attitudes towards possible future roles as engineers. In this element we explored one question:

11. What differences do students perceive between self and engineer? (self-concept, self-efficacy, self-directed learning);

Method

We engaged engineering students in workshops in which they investigated roles and attributes of engineers, the purpose of their studies, and their engineering goals. The workshops were designed to provide valuable learning experiences, and they were structured such that we could add to the existing body of research through data collection and analysis.

In a large Australian university, 49 undergraduate engineering students attended one of two, two-hour workshops conducted at the start of a foundation unit on motion. A further 54 students attended a workshop the following semester.

Each interactive workshop incorporated multiple activities lasting 20 minutes or less. These included whole-class discussion, reflection, group work within and outside of discipline groups and a two-minute paper. The workshop was developed specifically for this study, drawing from and refining a-priori measures that have accepted reliability for research purposes (Bennett, 2012). The structure of each workshop was as follows:

Activity 1: Whole-class activity
- What do you love to do? (personal)
- Why are you here, taking this course/unit? (value of learning)
- In what ways might it be useful in the future? (as above)

Activity 2: Individual activity with a focus on aspirations, followed with discussion.
- Write down the one thing you want to be remembered for/to achieve as an engineer.

Activity 3: Individual self-reflection to establish career preview and relevance to self and study; discussion with students in the same engineering discipline; collaborative work on the characteristics of an engineer followed by class discussion.
- What does an _____ engineer look like? (career preview. Students inserted their discipline.)
- What differences are there (if any) between the above characteristics and you as a person?
- (preview, self-concept, self-efficacy))
- What do you see as the roles of an engineer? (roles of engineers)
- What will your personal role be? (aspirational, career preview)
- How will the learning in this unit contribute to your development as an engineer? (value of
- learning)
- Imagine yourself in 15 years' time. What will you be doing? (personal, aspirational, career
- preview)
- In a sentence, describe what you dream you will have achieved as an engineer over this time.
- (aspirational, self and career)

Activity 4: Creating a high-achieving group
- Team-related analysis and discussion of strengths and weaknesses, loves and hates

Activity 5: Adapted two-minute paper (individual reflection) designed to determine whether students experienced threshold concepts during the session. The paper asked:
- Have you learnt anything transformative in this session? (Y/N) If so, what?
- Do you feel a need to think further about anything raised in this session? If so, what and why?

Activities 1 and 3 were relevant to all three frameworks. Activity 2 was related to motivation and identity. Activity 4 was designed to help prepare the students for group work in the course (unit) and to help them reflect in order to take responsibility for their learning. Activity 5, the adapted to two-minute paper, was included for the analysis in the threshold concepts framework. The second question in Activity 5 was analysed for evidence of students finding concepts troublesome.

Analysis

This was a transcendental phenomenological study (Creswell, 2007) involving analytical procedures as described by (Moustakas, 1994). This approach emphasises belief in the data as reported by participants and begins with identifying key statements and clustering them into themes and meaningful units. If any of the theoretical frameworks had been inconsistent with this it would not have been possible to combine the frameworks as we did. Researchers not otherwise involved with the study coded the responses to remove identifiable data, after which the lead researchers independently coded the data. Coding was compared before final refinements were made to the codebook, which incorporated all three theoretical frameworks. NVivo qualitative analysis software was used for the coding and analysis of emergent themes. Within each framework the analysis of the themes sought to answer the research questions posed within that framework. The analysis of progression of responses by each student was also important in the threshold concepts framework.

Findings

Combining the three frameworks of possible selves, threshold concepts, and identity-based motivation, was a new approach for us. Using all three frameworks enabled us to frame complementary research questions, to engage students in complementary learning activities, and to analyse the data through complementary lenses.

Possible selves

Students' engagement in peer- and tutor- discussion about possible selves prompted them to reorient their relationship with the learning that was discussed: for example, *"*What I have learnt in this lesson redefined what an engineer is". The findings confirmed Oyserman's assertion (2007, p. 1029) that "subtle shifts in contexts including shifts resulting from small interventions can have big effects on outcomes when they instantiate identity-behavior links". In particular, students began to consider how enhanced knowledge of teamwork, communication, and design and leadership, developed during their program, might contribute to their development as engineers. This aligns with the threshold concepts 'roles of engineers' and 'value of learning' and suggests that the students may have entered the liminal space in relation to these concepts.

Threshold concepts

The threshold concept of 'roles of engineers' was troublesome for students because many knew very little about engineering roles that they could aspire to. The concept of roles of engineers was also troublesome if students' perceptions of roles of engineers were inconsistent with personal values and with self-efficacy. This was especially the case if student perceived limitations ability to develop the attributes they perceived they would need as engineers.

Troublesome features of 'value of learning' and 'self-directed learning' included lack of awareness by students about the relevance to their futures of the learning in units on which they were embarking, and students' vague and distant concepts of their engineering futures. For example, one student thought that a foundation unit called 'Motion', featuring free body diagrams, was a broadening unit because she planned to study civil engineering.

Several students were in the pre-liminal space with respect to these concepts at the start of the project, referring to the benefit from a unit being credit points. During the workshop they moved into the liminal space as they started to think about benefits of the unit to their futures. This was evidence of the transformative feature of the threshold concept 'value of learning', consistent with the concept 'value of learning' opening possibilities for 'self-directed learning'.

Motivation and identity

As outlined earlier, the attrition of students 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. The findings highlighted students' motivational drivers, some of whom made explicit links between engineering and interests in other areas such as Formula 1 racing, climate change or social justice: *"*To have made a positive, long term impact on society*".* Students also reported extrinsic drivers such as high salaries and building reputation: "[I hope to have] earned a lot of money, travelled to many different countries*".* Other students demonstrated an unexplored, diffuse identity (Marcia, 1966) that made it hard for them to understand the relevance of their learning to future selves and careers: for example, "I have no idea at this point in time"; "I have no idea considering I am currently not in the workforce".

Significance of Combining Three Frameworks

The findings within each framework are consistent and informed each other; however, each framework provided unique insights into why students experienced the previously identified threshold concepts and each framework gave us different terminology to explain the students' experiences. The findings complement each other by adding alternative explanations and terminology but the main finding is similar across the frameworks. This is similar to triangulation but not quite the same. Triangulation involves collecting data from multiple source and/or methods in order to confirm findings in studies where one truth is sought (Merriam, 2009, p. 215). In our study we used multiple theoretical frameworks and designed questions to investigate one or more of the frameworks. We also employed a different analytical technique for each type of data. Consequently we reached different explanations for the consistent finding that the engineering students in the study needed to better understand the relevance of their units and to have better awareness of engineering practice.

Following is an example of how the combined frameworks supported each other in the study. The threshold concepts framework drew attention to how and why students experienced concepts as transformative or troublesome. The possible selves framework revealed that students had little awareness of possible future roles they could have as engineers and why this was the case. The motivation and identity framework revealed that students experienced conflict between their own identities and their perceptions of engineers; this explained the troublesome feature of the threshold concept 'roles of engineers'

Conclusions

The threshold concepts framework drew attention to how and why students experienced concepts as transformative or troublesome. This is valuable because it helps curriculum developers design curricula that help students overcome the troublesome features of threshold concepts. The other frameworks helped provide explanations and insights for the troublesomeness and they informed it might be overcome.

Within possible selves, making explicit links between students' intrinsic motivations and engineering study and practice emerges as a crucial concern for educators. This entails giving students the space and opportunity to explore possible futures without boundaries, both within the workplace and within the confines of the university. This exploration must attend to the connections between possible engineering roles and individual intrinsic interests.

In the motivation and identity framework, establishing relevance emerged as key to "seeing the relevance of concepts, resituating the concepts and integrating new knowledge" (Fischer, Boreham & Nyham 2004, p. 286). Moreover, it cannot be assumed. Establishing relevance enables students to make vital connections between self, learning and engineering practice, and the students in this study needed guidance and examples in order to understand the relevance of even foundational learning.

The three frameworks enriched understanding of the previously identified threshold concepts. The study draws attention to the need and opportunity for engineering educators to help students adopt presage or foundational thinking in relation to their engineering futures.

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Acknowledgements

We gratefully acknowledge the students who participated in this study and the unit coordinators and tutors who welcomed us into the classes.

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