Towards an engineering career appraisal tool for secondary school students

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INTRODUCTION

Engineering in Australia has experienced critical skill shortages for the last decade, particularly in the infrastructure and resource sectors. In fact, engineering skills across the trades, technical and professional occupations currently dominate the Department of Education, Employment and Workplace Relations national skills shortage list [1]. In response, industry organisations and engineering schools have been working together to increase the number of graduates from engineering programs. Some initiatives aim to increase the pool of applicants for engineering programs. Others seek to lower attrition rates. This paper addresses both issues.

Entry requirements for some first year engineering programs have changed because of the skill shortages. Consequently, students now come to university with a variety of educational backgrounds and via different entry pathways. Many lack the prerequisite knowledge and skills that underpin the first year engineering curricula [2] [3] which contributes to student attrition [4]. To succeed, these students must first adjust to their new circumstances at university, including the need to become self-directed learners [5].

The attrition rates in first year engineering programs in Australia remain a major concern [6] as first year is crucial for students – it lays the platform for future

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academic success and continued participation in higher education. Universities therefore have a vested interest in identifying those factors that influence academic success, to help students get over the first year hurdle.

Inappropriate discipline choice is also a major cause of student withdrawal [7]. Although career choice and its impact on academic success has gained some attention [8] there is considerable scope to explore this relationship in engineering, particularly as prospective students are often poorly informed about the discipline and the coursework it involves [9].

It is important that those who are exploring career options, particularly secondary schools students, receive more relevant and targeted information about careers in engineering This material should focus on informing prospective students about the types of careers and specialisations available in engineering, their readiness to study engineering, and the courses they will study. The materials should also aim to attract people who are qualified to study engineering but who have never considered engineering as a career. This paper describes the development of an online educational resource designed to achieve these aims.

1 ENGINEERING CAREER APPRAISAL TOOL

The Engineering Career Appraisal Tool (EngCAT) project is funded by the Australian Government Office for Learning and Teaching and aims to:

- Identify the key factors that lead to academic success in engineering degree programs; and
- Develop strategies to better support students academically and ensure that they make informed decisions regarding choice of study major.

The EngCAT project builds on previous research by examining the first year students' knowledge, motivations and interests in studying engineering. The project team members were selected because of their previous work and experiences in the field and to represent the full spectrum of Australian universities, engineering programs, and student cohorts. The team members came from the University of Southern Queensland; the University of Queensland; the University of Technology, Sydney, the University of Newcastle, and the University of New England.

Before team members could develop a prototype model for EngCAT, they had to identify, define and validate the key design criteria. These are explored below.

1.1 Choosing a career

Commencing students who leave institutions or change programs do so for a variety of reasons. Most withdraw because of transitional issues relating to mismatched or ill-formed goals or a sense of feeling isolated, rather than intellectual issues. Many withdraw from courses early to change institutions or enrol in different courses at the same university. This implies poor career decision making before their enrolment, or that they had inadequate or unrealised expectations of the courses they had initially chosen.

Career decision making is the process of making a career choice and is one of life's most important decisions. Career decidedness reflects how certain people are in choosing a career [10]; career decided individuals typically show little uncertainty regarding their career choice. It is assumed that being decided in one's career will result in satisfying careers [11]. In the higher education context, an appropriate measure of students' career satisfaction is satisfaction with one's major field of study [12]. Its equivalency to future satisfaction lays in the premise that students'

majors share characteristics with their future occupational environments. Major satisfaction is therefore defined as the degree to which tertiary students are globally satisfied with their major field of study [12]. Students who are decided about their future career and satisfied with their major field of study tend to be motivated to achieve high academic success [12].

Similarly, students' sense of purpose - the extent to which they believe they are in the right degree program and that their studies will lead to a successful and satisfying career [13] - is fundamental to successful student transition. In fact, sense of purpose is a key predictor of student satisfaction, and a significant predictor of retention and grade point average [13]. It is argued that purposefulness provides a degree of resilience for students, which helps them to persist in the face of perceived barriers or difficulties [13].

1.2 Student transition

The first year at university is crucial for students. Proactive and targeted interventions are essential in getting students on track and feeling able to persist with their studies [14] [15]. Engaging with students well before they arrive on campus, be that physical or virtual engagement, is vital [16]. Students should also have the opportunity to self-assess their competencies to help them formulate their personal skills profile and set goals for the year [17]. Not surprisingly, students were most interested and most motivated to develop skills which they perceived as being relevant to their course or career goals [17].

1.3 EngCAT design criteria

Based on the existing research the project team adopted the following key design criteria for EngCAT:

- EngCAT should help prospective students to make more informed career choices and thereby increase their level of decidedness about their career choice and intended program of study;
- EngCAT should attract those students who are most suited to the engineering discipline, particularly those who have not considered engineering as a career;
- EngCAT should enable students to self-assess their readiness to study engineering;
- EngCAT should support student transition and entry into the engineering profession; and
- EngCAT should better inform engineering schools regarding decisions about entry standards, and alternative entry pathways.

Through this critical review process, EngCAT aims to help students to better transition into and engage with first year engineering studies.

1.4 EngCAT project methodology

The following tasks were considered crucial to the success of the EngCAT project:

1. Identify the key factors that lead to success in first year engineering studies;
2. Develop a questionnaire that will enable students to self-assess their knowledge, interests and skills to determine their suitability and readiness to study engineering;
3. Identify appropriate on campus and online resources and provide students with individual advice to enable them to fill in any gaps in their prerequisite knowledge and skills;
4. Identify online sources of relevant information about engineering careers in Australia and New Zealand; and

5. Identify all of the providers of undergraduate engineering programs in Australia and New Zealand.

The main focus of 2012 was on the research necessary to complete the first three tasks. The next section of the paper describes this work. The focus during 2013 is on validating the research undertaken during 2012, testing EngCAT, and developing the EngCAT website, including links to the information resulting from tasks 4-5.

2 GET SET FOR SUCCESS QUIZZES

To identify the key factors underpinning first year success the project team refined a number of existing quizzes to develop the online Get Set for Success quizzes [2] [3] [18]. These included the key cognitive and non-cognitive measures that individuals require to self-assess their cognitive (e.g., spatial, mathematical, and technical skills) and non-cognitive (e.g., personality traits, career interests and approaches to learning) abilities.

The online Get Set for Success quizzes were administered to the 2012 cohorts of first year engineering students across the five partner universities. Students received immediate individual feedback from the online quizzes. This personalised feedback focuses on empowering the individual to self-reflect on their prior experiences, knowledge, and skills and to better inform them of the pre-requisite skill sets and knowledge that underpin entry into engineering programs.

2.1 The cognitive quizzes

The 52-item Get Set for Success cognitive quiz enabled commencing engineering students to self-test their skills in maths, physics, chemistry, and spatial abilities. Feedback from the cognitive quiz was customised for each partner university to allow students to see at a glance the courses they are well-prepared for and those where they might need additional support. The feedback included links to online sites that contain resources that students can use to address any identified gaps in knowledge.

2.2 The non-cognitive quizzes

The Get Set for Success non-cognitive quiz measured factors such as personality (50 items), learning approaches (52 items), and a newly developed self-report measure of interest and motivation for studying engineering (31 items). This self-report questionnaire also included measures of ambition and self-efficacy. Factor analytic results (unreported) indicated that this new self-report interest and motivation for studying engineering scale comprised seven subscales:

1. Functional/Creative – interest in working with practical problems and designing and planning new things. For example “I like to design and build things”.
2. Idealistic – interest in making a different in the world by making things more environmentally sustainable. For example “I want to adapt systems so that they are more sustainable and have less environmental impact”.
3. Conceptual Engagement – interest in working with mathematical and scientific ideas and problems. For example “I love maths”.
4. Organised – interest in planning and knowing how to make your plans work. For example “I like to focus on details”.
5. Inquisitive – interest in knowing how things work and in generating new ideas. For example “I like to know how things work”.
6. Ambition – interest in setting high study goals. For example “I have high standards for academic work”.
7. Self-efficacy – confidence in ability to achieve academic success. For example “I am confident I can complete my degree”.

This non-cognitive quiz was designed to help students better understand the skills and knowledge required in an engineering degree and to be an engineer. The personalised feedback on personality and approaches to learning helps students reflect on ways they can adapt their study efforts for greater success.

2.3 Student response to the Get Set for Success quizzes

In 2012, 505 first year engineering students completed the online cognitive quiz before they commenced their studies, and 285 of them completed the non-cognitive quiz during the first six weeks of the first semester. The quiz results were combined with the students' academic results and then analysed to identify the key predictors of academic success [19] [20]. The progress of these students is being tracked to identify the key predictors of academic success, as measured by GPA and retention. These analyses are beyond the scope of this paper.

Overall, there was a positive student response to the Get Set for Success quizzes [19]. Initial feedback suggests positive outcomes are likely to arise from students' participation. However, consistent with [17], the first year engineering students were more willing to complete the cognitive quiz than the non-cognitive measures because they recognise these skills as being relevant to a career in engineering. Unless they can be persuaded to accept the relevance of the non-cognitive skills to their studies, they will continue to be resistant or at least reluctant to participate in that aspect of the pre-testing.

The automatic feedback mechanism in the Get Set for Success quizzes provides individual feedback to help students:

- Access support and develop an individual plan to address any gaps in their knowledge and skills;
- Use the results of their self-assessments to enhance and manage their learning; and
- Review and refine their career plan to become an engineer.

2.4 Validation and application of the Get Set for Success quiz results

In 2013, the commencing students at each partner university are undertaking refined versions of the Get Set for Success quizzes. The results will be used to validate the 2012 findings and to refine the EngCAT prototype.

A summary of the cohort data has been provided to Associate Deans and the academics who teach commencing engineering students to better inform them of the skill sets of their commencing cohorts, so they can adjust their teaching accordingly.

3 THE REFINEMENT OF ENGCAT

The goal is to deliver an EngCAT prototype that is intuitive, easy to use, and can be seamlessly integrated into university portal systems. Importantly, EngCAT will be designed to raise awareness in prospective students about the skills and qualities that underpin success in an engineering degree.

The project team used data from the Get Set for Success quizzes to identify the key factors that underpin academic success in first year engineering studies [19]. This data continues to inform the refinement of an EngCAT prototype and strategies to:

1. Attract those students who are most suited to the engineering discipline, and to assist them to make an informed career choice.

2. Better inform engineering schools regarding decisions about entry standards, and alternative entry pathways.
3. Support student transition and entry into the engineering profession.

3.1 Selection of quiz items

The project team is undertaking a risk management process while developing the prototype EngCAT to ensure that the Get Set for Success quiz items are developed free from bias and that the test results are not likely to disadvantage either gender. Further, the team is minimising this potential risk by critically reviewing each test item to determine EngCAT's accessibility and equitability for both male and female students. Statistical techniques have been used to examine for systematic gender differences.

3.2 Individual quiz feedback

The individual feedback provided by EngCAT will help prospective students to be more aware of their individual learning approaches and whether they have the skills and abilities that predispose them to engineering studies. For example, students who are interested in engineering but who lack the identified skill sets will better understand which aptitudes they need to develop. This enhanced self-awareness will help them to seek support where needed and better manage their learning.

Another key consideration is the potential impact of EngCAT test results on students' perceptions about their suitability for engineering, both positive and negative. The personalised advice given to prospective students on the basis of their EngCAT results has focussed on empowering the individual to self-reflect on their prior experiences, knowledge, and skills and to better inform them of the pre-requisite skill sets that underpin entry into engineering programs.

At one end of the continuum, this could narrow the intake to those who indicate a 'good fit' with engineering. However, all students receive personalised feedback on their current skill levels and, where appropriate, are linked to additional resources, including advice on bridging programs, to help them improve their knowledge and skills and enhance their prospects for success. The aim is to widen the pool of prospective students by empowering engineering schools to develop alternative entry pathways to suit their market and geographic location. This will enable students who do not meet the normal entry requirements to upskill and gain entry.

At the other end of the continuum, it may encourage students who have the right skill sets, but have not considered engineering, to make an informed decision and choose engineering as their preferred study option.

4 CONCLUSION

This paper discusses the development and implementation of a cross-sector approach for testing the capabilities of first year students to facilitate entry pathways and progression rates in engineering programs. EngCAT represents an important first step in attracting additional students into engineering programs and in addressing student attrition. It enables first year students to self-assess their knowledge gaps and gain insights into the learning experience at university. The EngCAT project will potentially help career support interventions to become more effective by developing a prototype that can be used as part of careers advice. Prospective students, including high school students and mature age learners, will be able to self-assess their motivational, attitudinal, and cognitive strengths and weaknesses, and better understand factors related to success in studying engineering, potentially helping attract candidates who may not otherwise have

considered engineering. This would potentially increase the pool of eligible candidates and help address the critical skills shortage in the engineering industry. Prospective students interested in engineering can learn how to access further information on the discipline and can use their personalised feedback to inform their career decision making. This may include accessing extra support for study and skills development or seeking careers support to explore the engineering profession.

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