Empowering self-reflection to stimulate optimum outcomes in first year engineering

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INTRODUCTION

Active learning is a proven method to maximise student interaction, retention of desired course material and outcome attainment. McCallum et al. (2016) described how they applied Atkinson's tenets (Atkinson, 2012), utilising design, construction and testing of an earthen retaining wall, to best embed geotechnical engineering concepts, and Bloom et al. (1971) and others (Biggs and Tang (2007), Jaksa (2012) etc.) have further evidenced the positive impact that active learning or 'doing' can have on student outcomes. However, active learning is only valuable as a pedagogical tool if its use instils knowledge and skills aligned with students' preferred discipline inclination.

Many, if not most institutions globally, now address this uncertainty by designing a 'common' or 'flexible' first year engineering program, that prepares students for further study down their preferred discipline-pathway (civil, mechanical, electrical, mechatronic etc.) from their second year. This structure exposes students to fundamental aspects of engineering across numerous disciplines, ostensibly to better provide them with experiences upon which to found a decision about their preferred discipline, entering their second year.

However, the age at which students typically enter a university program is often a formative time of their lives (Mahanta and Kannan, 2015) and valuable as it is, a 'common' first year may provide insufficient opportunity for appropriate self-reflection by students, and additional stimuli to drive career/life introspection is valuable; thus, one reason why gap years have become prevalent as a driver of 'personal growth' prior to students entering structured tertiary education (Coetzee & Bester, 2015).

Thalluri (2016) states that "early engagement enhances student satisfaction and success." In this paper, we examine the preparation, delivery and outcomes of a dynamic first year introductory engineering course, that was specifically designed to increase student engagement and self-esteem, by empowering them to critically question their academic inclination, early in their tertiary engineering education journey, in an effort to produce optimal outcomes for the student, institution and employers.

Approach

Foundations of Engineering (ENG101) at the University of the Sunshine Coast (USC) is a fundamental introduction to engineering course, compulsory for all first year students at USC. Historically, the course has comprised examination of many facets typical of a professional engineers' role such as ethics, sustainability, design, project management and the role of engineers in society. However, student satisfaction with the course was decreasing and a 're-imagination' of the course was desired, with the primary outcome of the course, to retain students by engaging them via active-learning methods.

Theoretical underpinnings

Wide-ranging preliminary internal discussions, including with student representatives, identified many facets desirable of inclusion within such an introductory course; these included:

- Provide an engaging hands-on experience,
- Introduce students to the fields of civil, mechanical/mechatronic, and electrical engineering through, for instance, three modules linked to hands-on activities, assessment, and a related field trip;
- Explicitly establish the principles and framework for engineering design and problem solving;
- Cover fundamental engineering skills such as working with numbers, spreadsheets, measurements, instruments, drawings;
- Purposefully and explicitly establish horizontal links to the skills/content of other first year engineering courses, and vertical links to skills/ content in second year courses;
- Explicitly establish the principles and methods of effective group work, through activities that also assist cohort building;
- Introduce students to the profession of engineering more broadly, the role of engineers in organisations, and their relationship to Engineers Australia;
- Introduce the concept of ethics, moral dilemmas, and the criteria against which ethical practice would be evaluated;
- Attend to the transition of students from secondary school and mature students back to University;
- Follow a structured and activity-based format that motivates students to attend;
- Avoid the use of exams, although small quizzes may be appropriate;
- Ensure that the links between the tasks and the technologies is clear and purposeful;
- Produce and curate pre-recorded video content to facilitate multi-campus delivery in 2020 – that is, adopt a partially flipped approach;
- Draw on the larger engineering team to assist in content production and possible delivery, once the overall structure is established;
- Consider how the Engineering Advisory Committee can be involved either through guest lectures, site visits, authentic assessment tasks, or other activities; and
- Consider previous student feedback on the course and involve students as partners in the redevelopment.

Discrete incorporation of each of these elements was neither desirable nor possible within the single reimagined course, however, course structure, content and activities were designed to amalgamate as many of these attributes as possible.

Practical implementation

Three primary themes were devised for the course. These were impressed upon students weekly:

1. the solving of problems,
2. working in groups, and
3. communicating their findings (via written or oral means).

These themes were addressed throughout the 13-week semester by 'clumping' activities into three main modules, focusing on problem-solving, engineering disciplines and communication, with two major field trips designed to expose students to 'real-world' engineering problems (which they subsequently had to address). Weekly field-trips / site-visits were scheduled across the 'disciplines' module to expose students to 'real-world' engineering personnel, companies and activities. After an initial introductory lecture, a 'flipped' classroom was adopted and group and individual oral communication activities were initiated weekly from Week 1, in an attempt to make all students more comfortable with communicating within a group environment.

Desired Outcomes

Although this describes the practical structure of the course, the primary aims for the course were to:

1. provide a weekly learning environment where students felt comfortable,
2. provide a weekly learning environment where students were both supported and challenged,
3. prompt students to actively assess their personal career motivations, and
4. enable communication and discussion of those motivations within a closed and 'safe', small-group tutorial environment.

The point of this was for students to repeatedly be accommodated within an environment that put them at ease and provided them with both the opportunity and impetus to examine their career/discipline 'drivers'. Weekly pre-tutorial questions were open-ended and were designed to stimulate inquiry, not just of engineering, but of the student's motivation to be initiating engineering studies in the first place; for example:

1. What do you want to be when you grow up?
2. Where specifically do you see yourself in five years' time (professionally, not necessarily geographically)?
3. What discipline of engineering do you think you should study to enable that role?

Lunchtime barbeques were provided at the completion of each fieldtrip to further stimulate class cohesion and increase opportunities for casual discussion, and 'vacant' tutorial sessions were also programmed throughout the course to give students additional opportunities to informally discuss their career preferences/motivators with course staff.

Outcomes and Discussion

Because it has only been run once, limited data exist to support the success or otherwise of this revised first-year introductory course; success defined here as increased student retention and student adoption of an aligned engineering discipline. However, some useful data are available. eValu8 questions asked in 2019 and scores obtained (n=19) are shown:

- The learning outcomes were clear to me (3.4/4),
- The learning experiences and materials used helped me to achieve the learning outcomes (3.6/4),
- Feedback on my work helped me to learn (3.4/4),
- The assessment tasks helped me to achieve the learning outcomes (3.5/4),
- The teaching actively engaged me in learning (3.8/4), and
- The quality of the teaching helped me to achieve the learning outcomes (3.6/4).

Average eValu8 scores for 2019 (3.5/4) compare favourably with previous offerings (2018 (2.5/4)). However, it is more difficult to ascertain whether the self-reflection practises employed throughout the course were effective in empowering students sufficiently to better consider their preferred tertiary education journey, be that intra or inter-disciplinary.

One positive quantitative indicator is that the number of students retained in the revised course has increased (Table 1).

Table 1: Number of students retained in the first-year introductory engineering course is increasing

Year	% students retained
2017	88.5
2018	89.3
2019	91.1

These data compare favorably with the 2014 average institutional retention rate for full-time male commencing engineering students of 87.8 %, and for female full-time commencing engineering students of 90.7 % (Australian Council of Engineering Deans, 2017).

Preliminary qualitative feedback suggests that the course is achieving desired outcomes. The majority of respondents (n=19) agreed that "The teaching actively engaged me in learning" (3.8/4.0) and specific feedback noted the "fun and curiosity" within the course and the personally engaging activities that aimed to "get the best out of every student"; also: "I really like how this course is structured and how the teaching makes the student actually think deeper about the concepts being presented to them."

Establishing a 'comfortable' environment within the course, where students feel that they belong, is key to enabling valuable self-reflection (Morrow and Ackerman, 2012) and preliminary feedback supports this as an outcome: "made it easy to get to know and even make friendship with your peers." These findings align with those presented by Knight et al. (2003), who in examining the impact of a hands-on, team- and project-based course, concluded that retention improved because students developed a peer support network. Marra et al. (2012) also cited that ‘lack of belonging’ is an important factor in poor first year engineering student retention.

Ideally, a limited longitudinal study would be implemented to track student enrolment progression post-ENG101, however, such a study is beyond the scope of this preliminary assessment.

Conclusion

Although this re-imagined first year introductory engineering course has only been running for one year, initial results are promising. Feedback is positive, engagement is increasing, and retention is decreasing. Analysis of subsequent years' data will be necessary to further confirm these trends. Additionally, a quantitative means of assessing changes in student self-confidence over the progression of the course would be valuable, perhaps by utilising a pre and post-course survey.

Bennett et al. (2015) caution that transitional differences exist between domestic and international students, so as USC's engineering cohort continues to diversify (in 2019, 9% were international), so must the nature of our empowering activities, to ensure equal success across a cohort.

However, the initial implementation of this course appears to be stimulating and enabling students to better reflect upon their preferred professional journey, thereby assisting them to make better-founded educational decisions in their first year of university.

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