Why do students choose engineering: Intrinsic or Extrinsic Motivation?

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Introduction

Student motivation is an important factor in student performance and retention at university in engineering (French et al, 2013) and other university degrees (Rizkallah et al., 2017) as higher levels of motivation are predictive of higher engagement and greater effort. French et al (2013) found that higher levels of motivation were also associated with higher achievement.

Intrinsic motivation is personally driven, and is often due to interest in the discipline. Intrinsic motivation is supported by a perception of autonomous control and competence in the field, leading to feelings of confidence, excitement and fulfilment (Ryan & Deci, 2000). Intrinsic motivation is usually associated with deeper approaches to learning (Lin et al., 2003) and with internal regulation (Ryan & Deci, 2000).

Extrinsic motivation refers to reasons for undertaking an activity where the goal is separate from the activity itself, for example taking a degree for the job prospects at the end (Ryan & Deci, 2000). Extrinsic motivation has been associated with more surface approaches to learning, while intrinsic motivation is associated with deeper approaches to learning (Biggs, 1999). Students taking a surface approach to their study are aiming for a grade (which may be a high grade) while students taking a deep approach are aiming to understand the material. Hence intrinsic motivation is generally considered more desirable by educators.

Studies of engineering students' motivations have identified gender differences in men's and women's reasons for enrolling in engineering. Kolmos et al (2013) found that men were more influenced by the social status attached to engineering, as well as the prospect of a well-paying job – both extrinsic reasons. However, they also found that men were more likely than women to have intrinsic reasons for taking engineering. In contrast, Australian study by Gill et al (2008) showed that success in maths and physics was an important factor for women in pursuing engineering at university, hence an interest in and aptitude for engineering – intrinsic motivators – are important for women.

Students' motivations also change with time. This occurs for several reasons – typical undergraduates are young, recent school-leavers. They are going through a time of transition from adolescence to adulthood, and so it is natural that among the many changes, motivations also change. As they progress through the degree, and applying for jobs goes from a distant prospect to a looming reality it is natural that they become more extrinsically motivated – as has been observed by Alpay et al (2008). Their experience of the degree itself will also influence their motivation. In contrast, mature age students may already have a well-established career path, but lack academic skills (Sitnikova & Duff, 2009).

This study looks at two very different cohorts of engineering students: those enrolled at UNSW Canberra and those enrolled at the Australian National University (ANU). UNSW Canberra is located at the Australian Defence Force Academy and provides tertiary education to Australian Defence Force personnel, primarily newly recruited trainee officers. UNSW is a "Group of Eight" research intensive university, and the degrees offered at the Canberra campus are of the same standard as the main Sydney campus. The ANU is also a "Group of Eight" university, strongly research intensive and considered a destination of choice for elite students.

At UNSW Canberra the majority of the engineering students are young, male, Australian-born trainee defence force officers. There are also a small number of female trainee officers (typically 15% of the cohort), mature age students of both genders but mostly male (typically around 10% of the cohort), and a small number of civilian students (typically less than 10%). The cohort is almost entirely Australian born. The UNSW Canberra students come from all states and territories in Australia, and include a larger fraction of students from rural and regional areas, and first in family to attend university. Almost all of the mature age students at UNSW Canberra are serving defence force officers, who are returning to study after some years in their services. Some are already officers, others are undertaking study as an adjunct to being commissioned. The degree is often part of career progression for these students. The ANU draws students from across Australia also, but has a much larger fraction of its cohort coming from the surrounding region and overseas than UNSW Canberra does. The ANU cohort has slightly more women than the UNSW Canberra cohort (20%) and equally a smaller fraction of mature age students (around 10%). The ANU cohort is, like most universities, almost, if not entirely, composed of civilian students.

The ANU is also known for its postgraduate programs, and was originally founded in 1946 as a research institution providing post graduate and post-doctoral training (Foster and Varghese, 2009). Undergraduate programs were added in 1960, and the university still has a high transition rate from undergraduate to post graduate study. Hence the ANU can be considered a destination of choice for students interested in pursuing post graduate study.

So in some ways the institutions are similar: both are high ranking and research intensive, with engineering degrees considered difficult to gain entry to based on the required entry scores. But their student cohorts are very different. Hence we expect the motivation towards engineering for the two cohorts to be different. This difference in turn will affect their approaches to study and their aspirations.

Method

For the last three years we have been surveying the incoming Bachelor of Engineering (BE) students in their first semester at UNSW Canberra (Wilson and Wilson, 2018). This year the survey was also run at the ANU with students in their first year of a Bachelor of Engineering (BE). In this survey, we ask a range of questions, including demographic questions about gender and degree as well as why they choose to study engineering. These questions were followed by a set of Likert scale questions asking about their motivation and feelings towards their studies, which were then repeated each week of semester.

The surveys are anonymous, but students are asked to write a unique code on their surveys, and it is suggested that they use the first two letters of their mother's first name followed by the first two letters of their father's name and the number of the month in which they were born. For example, if your parents are Jane and Bert and you were born in August, your code would be JABE8.

In 2019 At UNSW Canberra, 95 engineering students completed the first survey and answered the question about their motivation for studying engineering. This is approximately 2/3 of the total engineering cohort. At ANU, a total of 100 BE students and BE flexible double degree students completed the survey, approximately 80% of the cohort.

The students' responses to the question about their reason for choosing engineering were categorised independently by three researchers into Extrinsic motivation (mostly to do with job, or being told to take engineering by the ADF), Intrinsic (to do with interest or enjoyment), Mixed (elements of both) and Other (not clearly intrinsic or extrinsic). The categorisations were then checked for consistency, and where there was disagreement the majority categorisation was used.

Examples of answers categorised as Extrinsic include "It will assist me in my career path in the air force" (UNSW Canberra) and "my family told me to" (ANU). Intrinsic motivations

included “to contribute towards the advancement of our global civilisation, and I enjoy solving problems” (UNSW Canberra) and “I've always found engineering interesting” (ANU). Answers categorised as Other included “None of your business” (ANU) and “dunno” (ANU).

We compared the frequency of the different types of motivation for taking engineering across the two institutions, and within the two cohorts by gender.

For the UNSW cohort we also looked at mature age status and whether grade aspirations differed depending on motivation type. The mature age group were not considered for the ANU cohort due to the small number of students identifying as such.

Results

When we compare the two cohorts, as shown in Figure 1, we see that they are very different in terms of their motivations. The ANU students are far more likely to be intrinsically motivated – choosing to study engineering out of interest. Two thirds of the ANU cohort (66%) gave a reason categorised as solely Intrinsic, and combined with those giving answers classified as Mixed (containing elements of both), the total fraction of students who are intrinsically motivated is 74% - approximately three quarters of the cohort.

In contrast, only 28% of UNSW Canberra students were intrinsically motivated only, and when combined with the Mixed group the total fraction of students who were intrinsically motivated was only 45% - less than half the cohort.

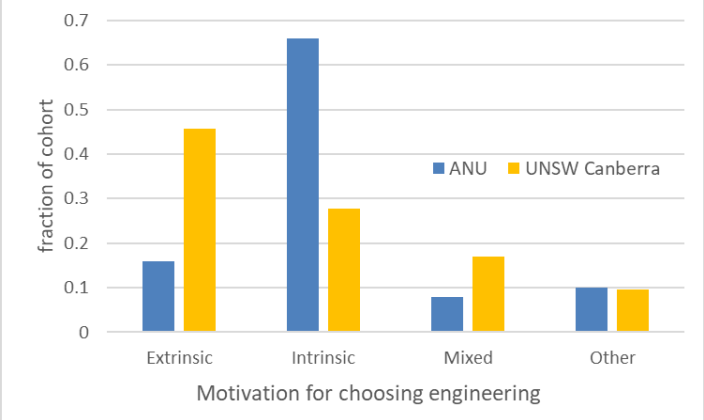

Figure 1: Comparison of ANU and UNSW Canberra cohorts’ motivations for taking engineering

Gender

When we look at motivation by gender, we also see a difference in the two cohorts. As can be seen in Figure 2, there is no difference between the motivations of male and female students at the ANU – both groups are primarily intrinsically motivated. However at UNSW Canberra, the female students are twice as likely to be intrinsically motivated as the male students. While the numbers of students are small in this cohort, only 16 females and 79 males, this pattern is consistent with data from UNSW Canberra for previous years, so we are confident that this difference is genuine. However we do not know *why* we see this pattern. It may be that women who have joined the defence force, and hence are already bucking societal expectations of gender roles, may be more likely to follow their own interests in other ways also, choosing degrees that are generally viewed as more masculine. Further research is needed to understand why we see this gender difference in motivation.

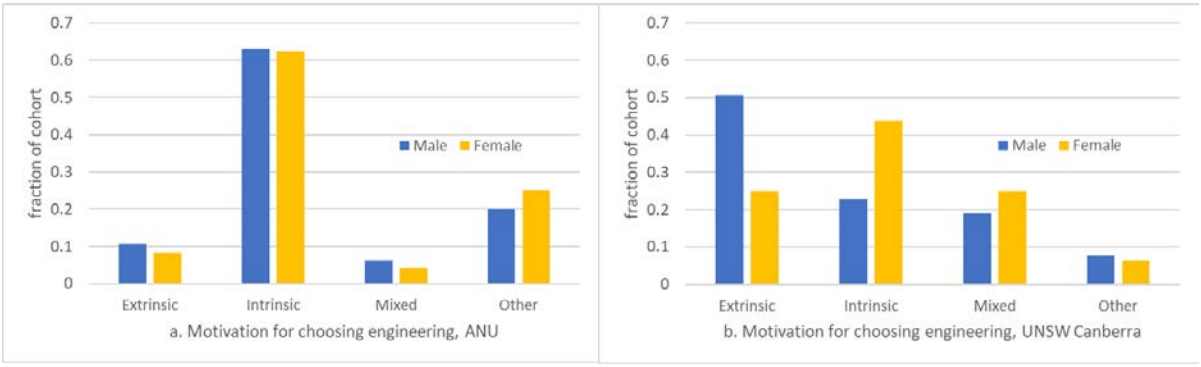

Figure 2: Comparison of male and female students' motivations for taking engineering at a. ANU and b. UNSW Canberra

Mature age vs school leaver status

Only five students in the ANU cohort identified as mature age, so we cannot draw any conclusions as to whether their motivation is different from school leavers. A larger data set is required, or one which includes more mature students. We do note that of the five, three were taking engineering out of interest, one for career progression and one "because it is useful".

In the UNSW Canberra cohort there were 23 mature age students, three quarters of whom were serving officers, and the remainder were trainee officers. Figure 3 shows a comparison of these students' motivations for taking engineering with the remainder of the cohort who are school leavers (within 2 years of finishing secondary school). The mature age students are more often extrinsically motivated, in particular they are motivated to do the degree for career progression, which in many cases includes their commissioning as an officer. This pattern was also seen in previous years' data from UNSW Canberra.

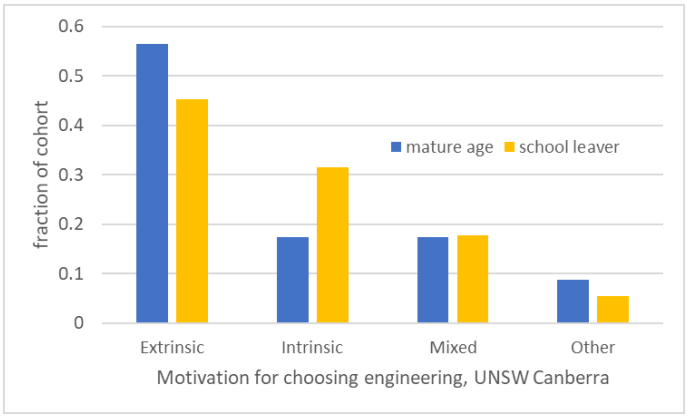

Figure 3: Comparison of mature age students and school leavers motivations for taking engineering at UNSW Canberra

Motivation type and grade aspirations and achievements

We find that students who are intrinsically motivated have slightly higher grade-aspirations than those who are extrinsically motivated, for the UNSW Canberra cohort: they are more likely to be aiming for a high distinction than their extrinsically motivated peers. Those with mixed motivations – both intrinsic and extrinsic – fall between those who showed only one

type of motivation (Figure 4a). While the differences are not large, they are consistent over the last three years, with intrinsically motivated students generally aiming higher.

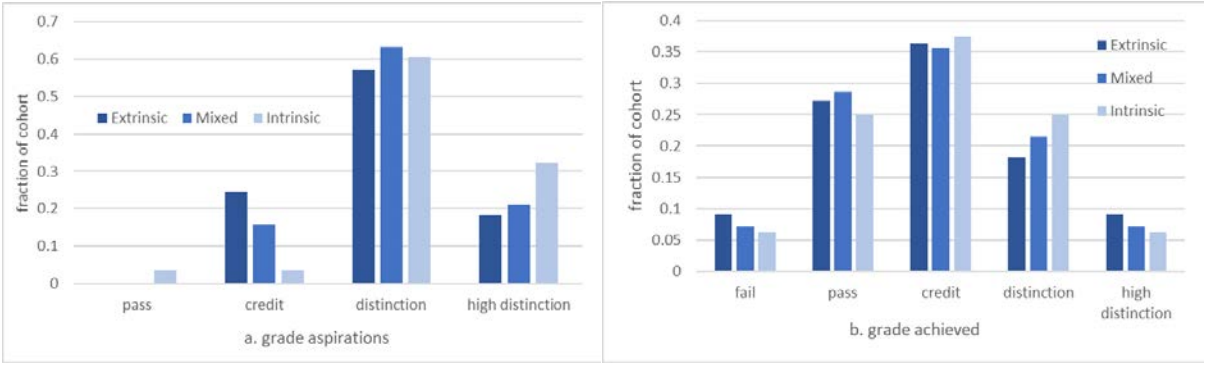

Figure 4: Comparison of a. grade aspirations at start of semester and b. self-reported achievement at the end of semester for students with different motivation types at UNSW Canberra

In the last week of semester we asked the students, via the surveys, what their approximate average grade so far was. The results are shown in Figure 4 b. We note that the response rate was not high for this survey, and not all students who answered other questions responded to the question about their average grade. We also note that this data was collected before the end of semester examinations, so the grades students are reporting do not include at least one third (typically) of their final grade, and these grades are self-reported so may not be accurate. However, based on the data that we do have, it does not appear that there was any difference in their achievement. In previous years we have also not seen any difference in self-reported achievement between the extrinsically motivated and intrinsically motivated students at UNSW Canberra.

Discussion and Implications

The ANU and UNSW Canberra are likely to be extremes amongst institutions in terms of the fraction of students who are intrinsically motivated. ANU, an elite institution with a focus on research and a high rate of retention into post graduate study, is likely to attract students who are passionate about the discipline they have chosen to study. Yet even at the ANU, a quarter of the incoming engineering students do not indicate that they are intrinsically motivated towards engineering.

At UNSW Canberra, where more than 90% of the cohort are either recently recruited into the Australian Defence Force (ADF), or are serving officers, it is not surprising that the majority are extrinsically motivated. The choice to join the ADF is a significant one. There is a lengthy recruitment process including physical and psychological testing. The commitment is significant; trainee officers move away from their families to live on campus, have limited leave off campus and may not return home for many months. They have a return of service obligation following completion of their degree, which may include posting overseas to dangerous destinations. So when they enroll in engineering at UNSW Canberra, they have first committed to the ADF. Hence it is not surprising that their motivations are primarily extrinsic and related to their future career in defence. Hence the fraction of intrinsically motivated students, at 45% (Intrinsic plus Mixed) is likely to be a lower bound for any engineering degree in Australia. This is also true for the mature age students at UNSW Canberra, for whom the degree is a recognised path to promotion, and comes with an additional return of service obligation (additional years enlisted in their service).

Hence in any engineering program in Australia, and probably in culturally similar countries, there are likely to be between one quarter and one half of the students who are *not* intrinsically motivated. These students are choosing to take engineering for the job at the end, or due to parental pressure (because their parents want them to get a good job at the end). While these motivations may be different to the motivations that drove their lecturers when they were students, it does not mean they are any less valid. It is not unreasonable to want a secure and well-paying job, particularly in times of financial uncertainty. Nor would it be good for society if every engineering graduate wanted to become an academic. So we need to respect the motivations of these students and 'teach to' all of our students, not just those who are more 'like we were'.

As these students are motivated by the end goal of a job, teaching that is clearly linked to that end goal is likely to engage them more than teaching that is not. For example, including current, practical applications of theory, guest lecturers from industry and opportunities to build skills that will support them in getting a job will benefit all students, and motivate those focused on a job. This is supported by the findings of Alpay et al (2010) who report that students' motivations tend to shift away from intrinsic and towards job focused as their degree progresses.

This is by no means to say that interest in engineering for its own sake is not to be encouraged. Clearly love of the subject should be welcomed and fostered. Research suggests that novel teaching techniques including the use of gamification (Banfield and Wilkerson, 2014) may increase intrinsic motivation.

The lack of gender difference we observed at the ANU is inconsistent with previous research (Gill et al, 2008; Kolmos et al 2013), however we did observe a difference with the UNSW Canberra group where the men were more driven by external factors, in particular employment. The difference between the two cohorts is likely due to the association with the ADF. More data is needed to understand this difference, and it would also be very interesting to extend this study to other cohorts to see if the gender patterns are different elsewhere.

Intrinsic motivation has been associated with a drive towards deeper learning, and so we might expect intrinsically motivated students to outperform those who are extrinsically motivated. We do see that the intrinsically motived students have (slightly) higher grade aspirations than the extrinsically motivated students. However, we do not see a difference in their achievement – at least as far as can be judged from their self-reported grades near the end of semester. Ryan and Deci (2000) have noted that the division of motivation into extrinsic and intrinsic is a somewhat simplistic one, and theorised that regulation is also important. While intrinsic motivation is associated with internal regulation, extrinsic motivation may be associated with either internal or external regulation. Careful design of assessment using the principles of constructive alignment (Biggs, 1996) can drive deep learning for extrinsically motivated students by providing the required external regulation.

Hence while we may not be able to give our students the love of engineering we might wish them to have, we can at least ensure that they achieve the level of understanding we want. But to do so may require us to move away from traditional approaches to teaching that assume inherent interest in the topic, and consider the wider range of motivations that our students hold.

Conclusions

Based on our findings, engineering cohorts generally are likely to have between one quarter and one half of students primarily or exclusively extrinsically motivated, and many more with mixed motivations. So engineering lecturers need to be aware that many of their students are not interested in engineering for its own sake. Teaching strategies that rely on existing interest in the subject are unlikely to motivate this part of the cohort. However, strategies that foster intrinsic motivation may support these students' learning, and increase their engagement. Teaching of content and skills that will be used in (or to gain) future

employment is important for all students, particularly as students tend to shift towards a job focus as their degree progresses. Both intrinsic and extrinsic motivation can contribute towards deep learning (Biggs, 2011). Lecturers need to adopt teaching strategies, including assessment strategies, which foster both kinds of motivation rather than simply assuming that students are imbued with an intrinsic passion for engineering.

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