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Why Students study STEM: Disciplinary and gender motivations

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ABSTRACT

CONTEXT

As globalisation and technological advances continue to impact the nature of work, skills in science, technology, engineering, and mathematics (STEM) are becoming increasingly critical to the national economy. However, attracting students to tertiary study in the STEM disciplines remains a challenge, especially for historically marginalised groups such as women. Understanding what motivates students to study their chosen disciplines can inform strategies to attract more and diverse students to STEM degrees.

PURPOSE

Building on earlier work (Dawes et al., 2015; Long et al., 2022), this study seeks to explore the motivations underpinning student decisions to pursue STEM degrees at a large metropolitan university in Australia. The research question is: "*How do student motivations for choosing their university degree vary by discipline and gender?*"

METHOD

First-year students enrolled in selected degrees at the Queensland University of Technology were surveyed between 2016 to 2023. This study focuses on a question asking students to identify their reasons for choosing their degree – *good salary, job potential, good grades, intellectual stimulation, make a difference,* and *passion*. Students were assigned into discipline groupings of (1) engineering or (2) science, technology, or mathematics (STM). Statistical testing was used to assess the association between each motivation, and discipline grouping and gender respectively.

OUTCOMES

There was strong statistical evidence of discipline grouping difference for four degree selection reasons. In order of significance, these were *good salary*, *intellectually stimulating*, *make a difference*, and *job potential*. In each case, STM students were less likely to select the reason compared to engineering students. There was strong statistical evidence of gender difference for *good salary*, *passion*, and *make a difference*. Male students had a stronger motivation to select *good salary* and *passion* compared to their female counterparts. In contrast, female students were more likely to select *make a difference* as a reason for studying their chosen STEM degree.

CONCLUSIONS

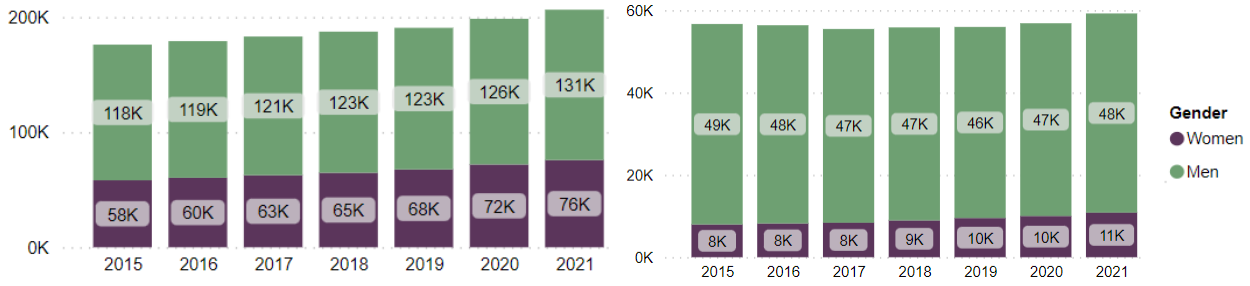
Ensuring that STEM degrees attract a diverse range of students is vital to ensuring that those participating in the field are representative of the wider community. The findings of this study highlight differences in motivations between engineering and STM students, as well as between male and female students. This suggests that engineering degrees could be marketed in different ways to STM degrees to target specific motivating factors. Similarly, specific strategies may be introduced to make STEM engagement more attractive to women.

KEYWORDS

STEM, motivation, discipline, gender, degree

Introduction

As globalisation and technological advances continue to impact the nature of work, skills in science, technology, engineering, and mathematics (STEM) are becoming increasingly critical to the national economy (Office of the Chief Scientist, 2020). Consequently, there is increasing pressure to develop STEM skills throughout the education system (Department of Education, 2022). However, attracting students to university study in STEM disciplines remains a challenge, especially for historically marginalised groups such as women. Despite increasing initiatives designed to increase the number and gender diversity of students choosing to study STEM, there has been only modest improvements in student enrolments (see Figure 1). According to the Department of Education (2023), between 2015 and 2021 there was a 18% increase in overall STEM student enrolment numbers, with the proportion of women increasing from 33% to 37% of the cohort (Figure 1a). When isolating the engineering discipline, an increase of only 3.5% in overall student enrolments was recorded over the same period, with the proportion of women increasing from 14% to 17% (Figure 1b).



(a) STEM enrolments

(b) Engineering enrolments

Figure 1 – Undergraduate student enrolments within Australian universities over time by gender for (a) STEM and (b) engineering (Department of Education, 2023)

The literature shows that a range of sources inform students' degree decision-making. For example, some students make selections based on prior exposure to a discipline area, success in related coursework, or alignment of a field to their long-term career aspirations (Painter et al., 2017). Personal interests and passions can also play a role, as some students may be drawn to a field due to the perceived intellectual stimulation associated with the subject matter or a desire to contribute to addressing a specific societal issue, such as climate change (Canney & Bielefeldt, 2015). The capacity to generate income as a graduate has also been shown to contribute to students' study decisions (Alexan, 2022).

With regard to engineering, Godwin et al. (2016) states that the discipline has often been defined by a narrow framing of who engineers are and what they do. This plays into the stereotypes that students hold for the profession, which are frequently informed by media portrayals of careers (Corsbie-Massay & Wheatly, 2022). A lack of direct engineering experience within the high school curriculum also makes the choice of an engineering career more difficult than for other STEM disciplines, such as mathematics or science, which offer at least some explicit experiences for students in high school. For example in Queensland in 2022, only 91 schools offered engineering as a senior subject (Queensland Curriculum and Assessment Authority, 2023b), compared to 427 schools that offered mathematical methods (Queensland Curriculum and Assessment Authority, 2023c) and 416 that offered chemistry (Queensland Curriculum and Assessment Authority, 2023a).

A substantial body of research has explored how motivations for selecting a degree vary by gender (Bielefeldt & Canney, 2016; Capobianco & Yu, 2014). A growing body of research has more recently begun to explore how motivations for studying STEM can vary by the individual constituent disciplines (Long et al., 2022; Naukkarinen & Bairoh, 2020). Understanding these variations that drive students' degree choices is vital for educational institutions in developing approaches to increase STEM engagement for students from diverse backgrounds.

This study builds on earlier work (Dawes et al., 2015; Long et al., 2022) that has focused on understanding the motivations and influences on degree selection for commencing students at a large metropolitan university in Australia. This study explores the reasons students provide for choosing their degree, leading to the research question: "*How do student motivations for choosing their university degree vary by discipline and gender?*"

Method

Setting

The setting for the study was the Queensland University of Technology, located in metropolitan Brisbane, Australia. The university is composed of several faculties covering science, engineering, business, law, creative industries, and education. At the undergraduate level, students can choose to study STEM degrees across science (including majors of biology, chemistry, earth, environmental, and physics), information technology (including majors in computer science and information systems), engineering (including majors in civil, electrical, environmental, mechanical, mechatronics, medical, chemical process, and software), and mathematics (including majors in applied, operations research, and statistics).

Data Collection

Given the interest in students' degree decision-making, first-year domestic students were invited to participate in the research by responding to a survey. The research was approved by the Human Ethics Research Committee (approval 5205). Initially from 2015, only students from the Science and Engineering Faculty were targeted. However, in 2022, the survey was extended to include those enrolled in the Faculty of Health and the Faculty of Business and Law. In 2023, the survey was extended to include students from all faculties. The survey was estimated to take 20 minutes to complete and used open-ended, multiple-choice, and five-point Likert scale question formats. The survey included questions about participants' demographic backgrounds, academic performance, motivations, aspirations, and perceptions of university. Survey questions were chosen to understand why students chose a particular degree and inform recruitment and marketing to future students. The response rate by year is summarised in Table 1. Overall, a response rate of 22% was achieved.

Table 1 – Summary of survey responses by year for participants in all disciplines

Year	Participants	Response Rate
2015	649	28%
2016	639	23%
2017	889	38%
2018	764	38%
2019	661	21%
2020	451	18%
2021	553	18%
2022	967	19%
2023	874	14%
Total	**6447**	**22%**

The present study considers responses across all years of the survey but focuses only on the subset of STEM students (who have been consistently included). We acknowledge that gender is not binary, however, only students who identified as men and women were considered in the analysis due to the small sample size associated with other gender responses. Applying these exclusion criteria produced a sample size of 4464 for analysis.

The study focuses on a question regarding students' motivations for choosing their degree. When the survey only targeted STEM students, the question was phrased as "What was your reason for

choosing a STEM (Science, Technology, Engineering, Maths) degree?". This was generalised to "What was your reason for choosing your degree?" when the survey cohort was widened beyond STEM. Students were invited to select all options that applied to them from a list. For this research we focus on six of the most frequently reported reasons:

- **Good Salary**: "Good salary and earning potential out of university"
- **Job Potential**: "The job potential"
- **Good Grades**: "I received good grades in this subject at School"
- **Intellectually Stimulating**: "It's intellectually stimulating/challenging"
- **Make a Difference**: "To make a difference and positively impact society"
- **Passion**: "I'm passionate about STEM"

Analysis

Due to the longitudinal nature of the dataset analysed, data collected across different years was stored in separate files. This required consolidation into a single spreadsheet for analysis. Due to the evolution of the study, the format of data varied between years, requiring a unique mapping process to be developed in Microsoft Excel. The mapping process was undertaken by two members of research team using Excel functions, including *CONCAT* and *COUNTIF*, to pull response values from raw datasets into cleaned spreadsheets for each year. Developing individual cleaned spreadsheets for each year prior to consolidation allowed for a greater level of traceability throughout the verification process. The cleaned datasets were consolidated into a single spreadsheet for use in statistical analysis software using Excel cell references. Assumptions were noted regarding the alignment of questions due to the variation of wording and response options between years. These small changes that occurred over the years represent a limitation.

The study expands upon earlier research which examined how selected factors (gender, perceived mathematics ability, influencers, decision timing) varied by discipline groupings (Long et al., 2022). This paper focuses on investigating how students' motivations for choosing their degree vary by their discipline and gender. The discipline groupings are defined as (1) engineering, and (2) science, technology, or mathematics (STM). For the purposes of defining STM, environmental science and data science were included. However, the following were excluded from the STM grouping as they were deemed to be more health-focused: medical laboratory science, behavioural science, paramedic science, exercise and sports science, nutrition science, vision science. Education students majoring in a STEM area, as well as those studying urban development, property economics, architecture, and design were also excluded from STM. Students who studied engineering as part of a double degree (even if the second degree was in STM) were allocated to the engineering grouping. Between 2015 and 2023, there were 2236 students in the engineering discipline grouping and 2228 students in the STM discipline grouping. Thus, this discipline grouping split provided relatively even numbers between the two groups, making for more meaningful comparisons.

SPSS Statistics 29 was used for the data analysis. To test the association between discipline group and each reason for degree selection, Pearson's Chi-square test was applied (Field, 2017). This is a well-accepted approach to investigating the relationship between categorical variables, and has been widely used in engineering education research (e.g. Naukkarinen and Bairoh (2020); Verdín and Godwin (2015)). Assumptions were validated for each test (Field, 2017). The odds ratio was calculated as a measure of effect size, including its 95% confidence interval.

Results

Relationship between Degree Selection Motivation and Discipline Grouping

Figure 2 shows the reasons that motivated students to choose their degree by discipline grouping. Outcomes of the statistical testing assessing the association between the reasons and discipline grouping are shown in Table 2.

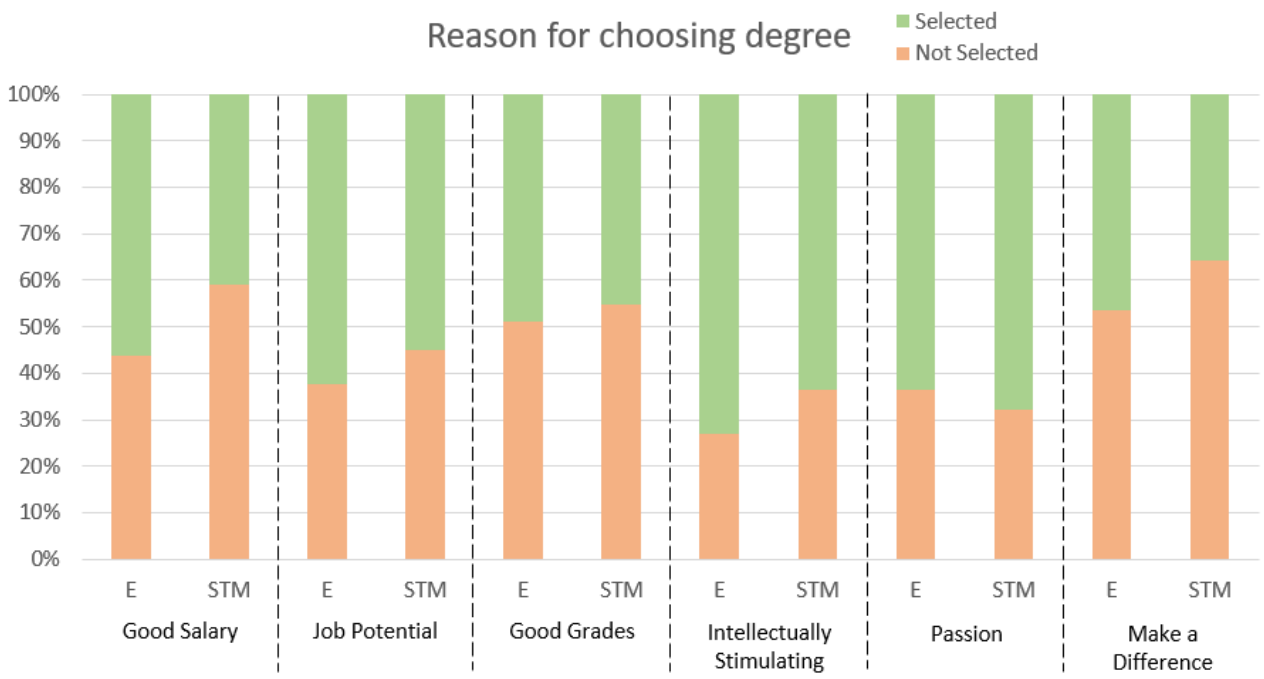


Figure 2 – Reasons students selected for choosing their degree by discipline group; E=engineering, STM=science, technology and mathematics

Table 2 – Outcomes of statistical testing assessing the association between reason for choosing degree and discipline group

Reason for Choosing Degree	Discipline Group	Count Not Selected	Count Selected	χ^2	p-value	Odds Ratio (E/STM)	Lower 95% CI	Upper 95% CI
Good Salary	E	978	1258	106.816	<0.001	0.536	0.476	0.603
	STM	1319	909					
Job Potential	E	844	1392	24.035	<0.001	0.742	0.658	0.836
	STM	1002	1226					
Good Grades	E	1144	1092	5.789	0.016	0.866	0.770	0.974
	STM	1220	1008					
Intellectually Simulating	E	600	1636	47.248	<.001	0.641	0.564	0.728
	STM	811	1417					
Passion	E	815	1421	9.406	0.002	1.214	1.072	1.374
	STM	715	1513					
Make a Difference	E	1197	1039	51.821	<.001	0.644	0.571	0.726
	STM	1429	799					

Focusing on the p-values in Table 2 indicates evidence of association between discipline grouping and all motivating reasons for degree selection. The odds ratios and the associated confidence intervals support that there is a strong effect of discipline grouping for the reasons of *good salary*, *job potential*, *intellectual stimulation*, and *make a difference*. However, the upper confidence interval bound for *good grades* and the lower confidence interval bound for *passion* are relatively close to 1. Thus, there is limited evidence for the effect of discipline grouping for these two degree selection reasons.

Relationship between Degree Selection Motivation and Gender

Figure 3 shows the reasons that motivated students choose their STEM degree by gender. Outcomes of the statistical testing assessing the association are shown in Table 3.

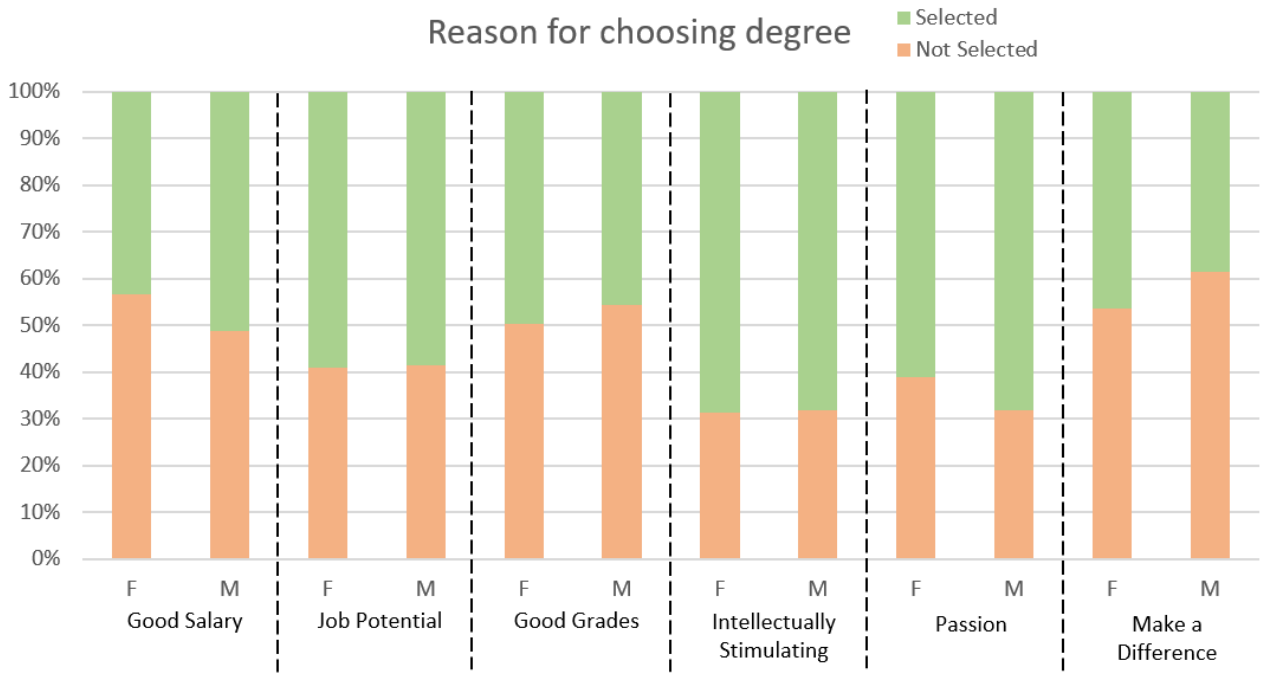


Figure 3 – Reasons students selected for choosing their degree by gender; F=female, M=male

Table 3 – Outcomes of statistical testing assessing the association between reason for choosing degree and gender; F=female, M=male

Reason for Choosing Degree	Gender	Count Not Selected	Count Selected	χ^2	p value	Odds Ratio (F/M)	Lower 95% CI	Upper 95% CI
Good Salary	F	867	661	25.976	<0.001	1.381	1.220	1.564
	M	1430	1506					
Job Potential	F	627	901	0.097	0.755			
	M	1219	1717					
Good Grades	F	770	758	6.132	0.013	0.855	0.756	0.968
	M	1594	1342					
Intellectually Simulating	F	478	1050	0.114	0.736			
	M	933	2003					
Passion	F	596	932	23.084	<.001	1.371	1.205	1.559
	M	934	2002					
Make a Difference	F	820	708	25.551	<.001	0.725	0.639	0.821
	M	1806	1130					

Interpreting the p-values shows that there is insufficient evidence of a gender difference for the degree selection reasons of *job potential* and *intellectual stimulation*. Inspecting odds ratios and the associated confidence intervals for the remaining degree selection reasons shows that there is limited evidence of a gender difference for *good grades*, given the upper bound of the confidence

interval is close to 1. In contrast, the odds ratios for *good salary*, *passion*, and *make a difference* imply that there is a gender effect. Each of these degree selection reasons had a similar level of statistical evidence for the gender effect.

Discussion

There was strong statistical evidence of discipline grouping difference for four degree selection reasons. In order of significance, these were *good salary*, *intellectually stimulating*, *make a difference*, and *job potential*. In each case, STM students were less likely to select the reason compared to engineering students. There was strong statistical evidence of gender difference for *good salary*, *passion*, and *make a difference*. Male students had a stronger motivation to select *good salary* and *passion* compared to their female counterparts. In contrast, female students were more likely to select *make a difference* as a reason for studying their chosen STEM degree.

Good salary was one of two degree selection reasons to show a difference across both discipline grouping and gender. Through the odds ratio, it can be observed that STM students were approximately half as likely to select good salary compared to engineering students. This is consistent with the literature – for example, Alexan (2022) found that the most significant factor impacting the major selection of engineering students was financial reasons. Alexan (2022) reported that the influence of mentors, intrinsic motives, and social good were secondary factors. Male students were 1.381 times more likely to select good salary as a reason for choosing their STEM degree. Although earning money can be a motivation for choosing to study a STEM degree, the reasons behind wanting to earn money can vary (Matusovich et al., 2010).

Desire to *make a difference* was the second degree selection reason to have a difference across both the discipline groupings and gender. STM students were 0.644 times less likely to select this reason compared to engineering students, while male students were 0.725 less likely to select this reason compared to female students. This mirrors trends shown in the literature where the gender ratio for student enrolments is closer to parity for disciplines that have a more clear connection to human-centred values such as humanitarian and biomedical engineering (MacMaster, 2022; Stoakley & Brown, 2018). Canney and Bielefeldt (2015) found that women studying in selected engineering majors demonstrated higher levels of social responsibility compared to men. Moreover, this was most pronounced in students majoring in environmental engineering, compared to the other two disciplines of civil and mechanical. This highlights the need to ensure that engineering is framed in an accessible and inclusive way (Capobianco & Yu, 2014).

Three other reasons were identified as significant but did not differ across both discipline grouping and gender. *Intellectually stimulating* and *job potential* showed a difference between discipline grouping, with STM students 0.641 and 0.742 times less likely to select these reasons compared to engineering students respectively. *Passion* only differed by gender, with male students 1.371 times more likely to select this compared to female students.

Limitations

It is important to acknowledge that a limitation of this study is that it only focuses on students from one large metropolitan university, so findings may not extend across other cohorts. We only analysed responses from those whose gender identity was male or female, due to the small sample size associated with other responses. There is the potential to further divide the engineering and STM groupings to assess differences at a lower level (such as within majors). Finally, the survey used in this research has been conducted annually since 2015, and thus offers further opportunities to analyse trends over time and the influence of other demographic factors like age. However, changes in the survey design through this period (such as updated question wording), may have impacted how students responded, and thus poses a limitation in the strength of the analysis that can be undertaken.

Concluding Remarks

This study has explored the motivations underpinning student decisions to pursue STEM degrees at a large metropolitan university in Australia, with the differences by discipline grouping and gender probed. It was found that, engineering students were more likely to select *good salary*, *intellectually stimulating*, *make a difference*, and *job potential* as reasons for choosing their degree when compared with STM students. Female students were more likely to choose their STEM degree to *make a difference*. In contrast, male students were more motivated by *good salary* and *passion* compared to their female counterparts. Future research could include unpacking the demographics in more detail.

Ensuring that STEM degrees attract a diverse range of students is vital to ensuring that those participating in the field are representative of the wider community. Motivations for studying STEM interact with the messages that potential students receive about who STEM is for, and the person that students become as they engage in STEM degrees and begin to develop their professional identify. Broadening participation requires the diverse potential student pipeline to view STEM study as being in alignment with their intrinsic and extrinsic motivations. The findings of this study highlight differences in these motivations between engineering and STM students, as well as between male and female students. This suggests that engineering degrees could be marketed in different ways to STM degrees to target specific motivating factors. Similarly, specific strategies may be introduced to make STEM engagement more attractive to women.

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