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2019

### Engineering Students at Day Zero: Selection and Concerns by Gender

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## Engineering Students at Day Zero: Selection and Concerns by Gender

### Abstract

The importance of attracting students to STEM disciplines such as engineering is well understood. Many developed countries are trying to grow numbers in the field by attracting a greater proportion of females than currently exists. This study explores student engineering selection decisions and initial concerns by gender prior to official commencement of classes within common first year engineering.

### Disciplines

Engineering | Science and Technology Studies

### Publication Details

S. Nikolic, T. Suesse & T. Goldfinch, "Engineering Students at Day Zero: Selection and Concerns by Gender," in Proceedings of 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering, TALE 2018, 2019, pp. 1096-1100.

# Engineering Students at Day Zero: Selection and Concerns by Gender

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**Abstract**—The importance of attracting students to STEM disciplines such as engineering is well understood. Many developed countries are trying to grow numbers in the field by attracting a greater proportion of females than currently exists. This study explores student engineering selection decisions and initial concerns by gender prior to official commencement of classes within common first year engineering.

**Keywords**—*first-year engineering, gender, recruitment, STEM*

## I. INTRODUCTION

The importance of Science, Technology, Engineering and Mathematics (STEM) education is recognised across the globe as important for each country future prosperity and needed to drive innovation forward [1, 2]. This has directed countries and their universities to drive continuous growth in the number of students enrolling and completing STEM degrees. Increasingly, the importance of expanding the demographics of the types of students being attracted to undertake a STEM degree is being realised. Some reasons include providing all students a pathway to fields most likely to dominate future employment, ensuring growth targets can be met, and that innovations will be better targeted and valued by a greater cross section of society [3]. This is driving research to better understand what attracts students to the field, their transition to higher education and their learning experience [4]. In particular, a focus in research has been to develop a better understanding of female and minority group's motivations and experiences to start and continue an education within a STEM discipline [5-8].

This study explores the initial thoughts of first year engineering students before they start their engineering program. The focus of the study is driven by the research question, “*What are the reasons students select an engineering degree and what are their initial concerns?*” with the data analysis conducted at the gender level. Exploring differences in gender can be used to help refine approaches to attract females to engineering and support their transition to university.

## II. RELATED LITERATURE

The relationship between selection choice of a degree and initial concerns is important because having students commence an engineering degree is only the first step. Once in, the desire is to retain them and ensure they complete their

studies. Starting university brings about a lot of uncertainty and is a crucial time for first year students. Ensuring a successful transition to university and understanding initial motivations is very important for the progress a student will make in their first year of study [9, 10].

The success of attempts to encourage students into an engineering discipline, especially female students, are being researched across the world. In Australia, female representation in engineering is at approximately 15% [5] with similar low percentages recorded in many parts of the world [3, 6] highlighting the importance of showcasing engineering as a discipline for all.

Outreach activities at primary and secondary level are a popular method is showcasing opportunities in STEM. A study exploring the success of a STEM Academy with 4<sup>th</sup>-6<sup>th</sup> graders in the USA [11] found that many misconceptions were found to draw students into and out of an engineering profession. Other outreach opportunities include engineering camps for K-12 students [12] showcasing motivation success using hands-on experiences. Providing entertaining, hands-on experiences has also been tried in various forms such as through the use of robots [13] and directly providing hands-on resource kits to school teachers [14]. Attempts to avoid gender stereotypes through animated avatars [8] has also been tried. In order to help students better understand the profession, innovative ways to connect students to practising professionals has also been attempted [15]. With so many activities, events and trials taking place globally, many being replicated in some form locally, the need to reflect has become clear.

## III. METHOD

The study was performed at the University of Wollongong, located in Australia during the years 2015, 2016 and 2017. Five academic staff members from the university provided input to the construction of a survey to identify possible reasons students would select an engineering degree and the possible concerns that they may have commencing the degree. The finalised lists were implemented using Survey Monkey using the checkbox functionality allowing students to select multiple responses and enter in additional considerations if required. The survey was emailed to new first year engineering students one week before the commencement of their studies. The

survey was closed the day before the start of session. The responses received via the 'other' field was used to guide updates to the survey in the following years. The survey was conducted anonymously, and students had the choice to participate. Two questions from this survey formed the focus of this study. The first was, *What made you choose an engineering degree? (Select all that apply)*. The second, *As you are about to start your engineering degree, do you have any of the following major concerns? (Select all that apply)*.

Students undertaking the survey were commencing studies in civil, computer, electrical, environmental, materials, mechanical, mechatronics, mining and telecommunications disciplines, with biomedical added in the 2017 survey. First year engineering at the university is common, meaning that students could identify themselves via a discipline or as flexible, not associated with a discipline. Approximately 450 undergraduate students commence engineering at the university each year. The response rates are shown in Table I.

The statistical analysis in Table I was done with Fisher's exact test to detect whether male and female responses change over years, which was done separately for females and males. The combined analysis taking both genders for each item (comparison of M vs F) was done using logistic regression and based on an Analysis of Deviance Table, similar to an Analysis of Anova Table for normally distributed data. This refers to the main effect of gender and is only significant when the effect of gender times years was not significant. All statistical analysis was done in the statistical open source platform R. Significance was determined at the 5% level

This study was conducted at only one Australian university and responses may be influenced by culture, initiatives and programs conducted within the region. Females represent a low proportion of engineering students. Therefore, the findings are limited in nature and may be different at other institutions or countries.

#### IV. RESULTS & DISCUSSION

The collected data was filtered by gender and is presented in Table I. A statistical analysis was undertaken to test if there had been any significant changes in response across the three years. Responses above 30% were considered to be factors of interest. Across both survey questions males and females shared many similar reasons and concerns. However, female students tended to have a greater number of concerns.

##### A. What made you choose an engineering degree?

One of the most noticeable differences between genders (in terms of both percentage and statistically different) was to the response, *I have always wanted to be an engineer*. Male student more frequently selected this option than female students in all years of the survey. This is an expected finding, as studies within the literature identify gendered perceptions of engineering [1, 8, 11]. From the primary years, it has been found that females less commonly associate with engineering as a career aspiration [11]. This relationship is further

emphasised in the response, *a friend or family member is an engineer* being of greater influence percentage wise to females than males. In particular, previous studies have found links to family role models in that they positively influence females to consider professional degrees such as engineering [3, 9].

Primary school was not seen as influential, but high school was for both genders. This could simply be due to the intense focus many universities place on targeting STEM awareness at the high school level. It also highlights the importance of having good teachers to help students engage with STEM activities, driving initiatives such as the STEM teacher kits [14] trying to enable great STEM classroom experiences. The importance of well informed and capable teachers in STEM [1, 2, 16] is recognised and important to drive interest within the field. This is supported by research that has shown that teaching staff can influence up to 55% of a student's experience [17], helping to setup either positive or negative perceptions of a career in STEM.

Interestingly, attendance at open days and career fairs had little influence in terms of percentages, but it was higher for females and statistically different between the cohorts (career fair only). This may suggest that such events are geared more towards reinforcement of interest in the field for males rather than attracting already uninterested parties. It also suggest if such events are more targeted at females it may help raise more awareness.

*Job prospects* and *changing the world* had positive influence across both genders. Such relationships with career outcomes has been documented elsewhere [10, 18]. Interestingly, while the influence of the media on engineering has been a place of concern in the literature [11, 19], little impact was shown for both genders. The other influencing factors were *opportunities to live and work outside of Australia* and *passion for science and maths* (the only response to have a significant change across years, accelerating in 2017 for females).

##### B. As you are about to start your engineering degree, do you have any of the following major concerns?

In general, both males and females expressed many similar concerns before commencing their engineering degree. However, females did express a number of additional concerns as important. This is consistent with findings in literature that suggest that females can have less self-belief and greater concerns in association with studying engineering [16]. However, only one response item was found to be statistically different across genders.

Both genders expressed nervousness in regard to not knowing what to expect and the difficulty of university. This was further extended by the female's confidence in upcoming challenges and fear in not knowing anybody. This fear in females could possibly be linked to the low gender balance percentage and has been successfully tackled in a study within

TABLE I. SUMMARY OF SURVEY RESPONSES

	Male	Male	Male	Significant		Female	Female	Female	Significant	Significant
Year	2015	2016	2017	Difference		2015	2016	2017	Difference	Difference
Total Responses Received	96	88	75	Males		28	15	16	Females	M vs F
<b>What made you choose an engineering degree? (select all that apply)</b>										
I have always wanted to be an engineer	55%	48%	45%	NO		39%	20%	31%	NO	Yes
A friend or family member is an engineer	21%	19%	9%	NO		18%	33%	31%	NO	NO
Experiences from primary school (K-6)	3%	3%	4%	NO		0%	0%	0%	NO	NO
Experiences from high school (7-12)	52%	47%	36%	NO		61%	47%	44%	NO	NO
Attendance at an open day	13%	11%	12%	NO		18%	20%	13%	NO	NO
Attendance at a career fair	9%	6%	1%	NO		25%	13%	6%	NO	Yes
Job prospects	52%	49%	57%	NO		68%	47%	56%	NO	NO
Starting salary	27%	23%	27%	NO		36%	13%	31%	NO	NO
Interested in changing the world	47%	44%	43%	NO		50%	60%	56%	NO	NO
Newspaper or magazine article	3%	1%	0%	NO		4%	0%	0%	NO	NO
Opportunities to live and work in Australia	20%	28%	29%	NO		14%	7%	25%	NO	NO
Opportunities to live and work outside of Australia	N/A	30%	43%	NO		N/A	27%	56%	NO	NO
Currently working in a related industry	N/A	N/A	7%	N/A		N/A	N/A	0%	N/A	NO
Passion for science and maths	N/A	57%	61%	NO		N/A	53%	94%	Yes	NO
Other (please specify)	15%	9%	4%	NO		18%	7%	6%	NO	NO
<b>As you are about to start your engineering degree, do you have any of the following major concerns? (Select all that apply)</b>										
Nervous as I don't know what to expect	49%	49%	48%	NO		61%	47%	44%	NO	NO
Nervous as I don't know how hard university is	58%	49%	52%	NO		39%	80%	69%	Yes	NO
Nervous as I am not confident in the challenges that await	10%	14%	28%	Yes		29%	7%	44%	NO	NO
Scared as I don't know anybody	17%	20%	20%	NO		29%	7%	44%	NO	NO
I am scared that I won't fit in	9%	13%	17%	NO		29%	0%	25%	Yes	NO
I am not looking forward to a common first year across 9 disciplines of engineering	5%	5%	7%	NO		7%	0%	25%	NO	NO
I am not interested in learning skills across all 9 disciplines of engineering	6%	7%	3%	NO		4%	0%	13%	NO	NO
I don't feel comfortable in my ability to pass some subjects	11%	18%	13%	NO		25%	20%	25%	NO	NO
I have no idea how I will adapt to new learning styles such as lectures, tutorials and labs	35%	36%	25%	NO		50%	33%	44%	NO	NO
I am scared that I won't be able to find my classrooms	10%	8%	9%	NO		32%	7%	25%	NO	Yes
I am worried how I will handle the workload	N/A	52%	44%	NO		N/A	67%	50%	NO	NO
Worried as I don't feel confident in maths	16%	13%	15%	NO		36%	0%	19%	NO	NO
Worried as I don't feel confident in my communication skills	17%	13%	9%	NO		21%	0%	13%	NO	NO
I am worried about using technology	4%	8%	4%	NO		4%	0%	13%	NO	NO
I am worried about managing my time	36%	41%	47%	NO		29%	53%	31%	NO	NO
I am worried about selecting tutorial/practical/workshop times	N/A	17%	19%	NO		N/A	13%	31%	NO	NO
Working out what textbook to buy and if I need to buy a textbook	N/A	43%	32%	NO		N/A	27%	38%	NO	NO
Other (please specify)	11%	9%	7%	NO		14%	13%	13%	NO	NO

another Australian university by ensuring females were placed in larger groups, disregarding the need to create diversified groups [4]. As interest, a statistically significant jump occurred in 2017 for males for confidence in upcoming challenges.

Adjusting to learning styles and workloads was common across genders with females also worried about finding classrooms (found to be statistically different across gender). Both genders had concerns about time management, something common across all first year disciplines [8]. This may suggest that early activities before degree commencement that focus on workload and time management may be beneficial. Another concern for both genders was information regarding text books and this suggests that it may be beneficial to clarify such requirements early. However, both genders were somewhat confident in their maths and communication skills required for the degree and this may be related to university entrance requirements.

The university also implemented a common first year structure across engineering in 2015. Responses received suggested that such a structure is not of particular concern to most students.

## V. CONCLUSION

This study explored the reasons students decided to study an engineering degree and some of their initial concerns in the week prior to commencement of first classes. The results support many findings scattered across the literature bringing together a holistic overview. In terms of choosing an engineering degree males and females showed substantial commonality. One of the key differences was that percentage of females that had always wanted to be an engineer and the impact family and friends can have on such a decision. The data suggests that universities can help make a difference by further supporting teaching in earlier education, helping teachers to provide engaging and well delivered STEM material.

Commonality was also shown for most of the responses in regarding concerns starting an engineering degree. Again, the data brought together many findings found in prior research. Females did show a number of extra concerns and such confidence has been found to impact enrolments within engineering degrees. However, many of the concerns could be reduced through the development of targeted workshops before commencement to provide an insight to matters such as university learning, workload/time management and setting up networking opportunities.

This work will be expanded to include a qualitative component based on focus groups to try and extract a deeper understanding of the quantitative data collected. Continued work on this paper is important as a related study has shown how experiences and teaching approaches can be perceived very differently amongst different groups [20].

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