Introduction

Despite numerous attempts over the last decade to increase student participation in science, technology, engineering and mathematics (STEM), the proportion of students commencing in STEM disciplines in Australia remains around 10 per cent (UA, 2012).This issue is not unique to Australia, the United States and the United Kingdom also report decreasing numbers of students taking STEM courses at secondary and tertiary levels (Tytler et al., 2008, Dept Employment and Learning, UK, 2009, Wang, 2013). This stagnation can be attributed in part to a disconnect between actual and intended curriculum and the lack of relevance and connection of science to student interests and life experiences (Ainley et al., 2008; Goodrum et al., 2001).

It is estimated that in the coming years, 75 per cent of the fastest growing occupations will require STEM skills (AIG, 2015). Australia must meet this challenge by preparing a workforce that is able to adapt to a rapidly changing global economic environment. The Australian Government has identified a need to lift the overall scientific literacy of the population and to draw more students into senior secondary school studies in STEM and encourage them to continue into tertiary study. There is good correlation between the nations with dynamic economies and the nations with the strongest performing education and/or research science systems. (Australian Council of Learned Academies, 2013)

Australian universities play crucial roles in attracting young people to STEM fields, training them in STEM skills, and influencing their career directions. The Australian Industry Group (2012) supports the National Office of the Chief Scientist strategy to promote greater STEM awareness, to improve high quality teaching in mathematics and science and national initiatives to set new benchmarks for raising the engagement of school students. They propose a major re-think in Australian education leading to transformation in how STEM is taught to increase participation in STEM-related education and training.

When developing strategies to increase the STEM pipeline, it is important to ignite enthusiasm for STEM disciplines and build awareness about how the disciplines translate to STEM careers, as early as primary school. Student's perceptions of mathematics and science are set by the time they reach high school, so positive primary school experiences in these subjects is a predictor of future passion for the STEM subjects (Sullivan et.al, 2004). The most common barriers, which dissuade students from considering STEM, include limited knowledge of career pathways, lack of interest in STEM and perception that STEM subjects and careers are too difficult. Data regarding pathways to STEM degrees indicate that a critical transition point is closely related to participating in targeted outreach and recruitment initiatives. To overcome these barriers, timing of engagement activities has an impact on influencing the decision making of students.

An online survey of incoming first-year domestic students studying STEM-related fields in 2015 at Queensland University of Technology was conducted. The survey provided an opportunity to investigate the factors influencing students' decisions in selecting their course and to understand the right time to offer engagement activities that might influence their choice.

Choosing STEM

There have been a number of studies aimed at understanding why students study STEM courses at secondary and tertiary levels; and identifying who are their major influences in choosing these subjects and career paths. The Choosing Science study conducted in 2010 focused on understanding the influences on Year 10 students' decisions about taking science subjects in Year 11 (Lyons and Quinn, 2010). They found that declines in the proportions of students taking science subjects are part of a broader phenomenon with similar falls in many traditional subject areas, including economics, geography, history and advanced mathematics. The principal factor appears to be the greater array of subject choices available in Year 11, resulting in lower enrolments and increased competition for students within disciplines.

In 2011, the Interests and Recruitment in Science (IRIS) study surveyed 3500 first year students in STEM courses from 30 Australian universities (SiMERR National Research Centre, 2012). The students contributed their views on the relative importance of various school and non-school influences on their decisions, as well as insights into their experiences of university STEM courses so far. They found that young people are attracted to STEM courses primarily by personal interest, passion, enjoyment and practical application. Interestingly career prospects, salaries or the advice of others rated low in decision making. In terms of influencers teachers were rated as most important followed by parents and peers, whereas careers advisors were rated by students as the least important persons in decisions to take university STEM courses. Previous studies (Anlezark, Lim, Semo & Nguyen, 2008; Lyons & Quinn, 2010, Universities Australia, 2012 and Harris Interactive, 2011) have highlighted similar reasons students made decisions to study STEM and found the major influencers to be teachers, parents, family and peers.

A study in West Michigan college students on what factors influenced their choice of major established the number one factor driving choice was the students perceived natural talent and academic interest in science and maths (Center for Social Research, 2009). They also asked non-STEM majors what discouraged them from taking STEM majors. Students cited the difficulty of STEM subjects and that they found them uninteresting. Similarly Wang's 2013 study on why recent secondary school graduates choose STEM majors in the United States found that STEM major choice at college is directly influenced by intent to major in STEM at university; high school math achievement; and initial postsecondary experiences, such as academic interaction and socio-economic status.

To address many of these identified views/factors, universities are seen to play an important role in addressing the declining rates of participation STEM subjects in schools and meet the demands of a future STEM-based workforce through fostering partnerships with schools. University engagement and outreach programs have been shown to provide an opportunity for relationship building and partnerships across school and tertiary education levels (Dolan & Bell, 2008, Dawes and Rasmussen, 2007). These programs have aimed to engage and enthuse students in STEM disciplines, increase student awareness of careers in these fields, as well as providing a valued resource to teachers and schools through provision of curriculum-aligned in-school programs and recruiting the next generation of STEM professionals.

University outreach programs and subsequent engagement can take various forms. Thompson and Lyons (2009) identify two basic implementation models for outreach – (1) the Exposition Model in which ambassadors do presentations in many locations, and (2) the Classroom Immersion Model in which ambassadors work directly with a small number of teachers and their students over an extended period of time. The exposition model includes inquiry-based classroom activities and workshops programs such as those presented by Carberry et al. (2007), Dawes and Rasmussen (2007), Dubetz and Wilson (2013), and Thompson and Lyons (2009). The classroom immersion model includes intensive classroom and extracurricular activities such as science camps as described by Beck et al. (2006) and Moskal and Skokan (2011).

Engagement with secondary school students can range from brief, one-off experiences that provide an awareness of and interest in STEM to ongoing engagement. For example, science ambassadors or academic staff visiting classrooms to co-teach science on a regular basis. There is much debate around whether one-off activities are useful or continual interventions over a number of years are more beneficial to students in career aspiration and selection.

This paper analyses data from a 2015 survey focussing on student decision making in choosing to study STEM courses, timing of these decisions and identifies the major influencers on secondary school students' selection of STEM-related career choices at universities.

Methods

First-year domestic students studying STEM-related fields in 2015 within the Science and Engineering Faculty at Queensland University of Technology were surveyed using the online tool Survey Monkey™. The Queensland University of Technology (QUT), Science and Engineering Faculty offer degrees in science, information technology, engineering, mathematics, games and interactive entertainment, and urban development.

Of the domestic students commencing in 2015, 28% responded to the survey (n=649). The number of male respondents (72%) outweighed the number of female respondents (28%). This is consistent with previous findings of gender disparities in certain STEM fields such as engineering, technology, and specific areas of science (Office of Chief Scientist, 2014). The respondents were spread across all STEM disciplines, with the highest number of respondents studying engineering (33.1%, n=215) and the smallest number studying mathematics (1.7%, n=11). This ratio of study areas is mirrored in the total number of enrolments in each study area within the Science and Engineering Faculty at QUT, and can be inferred as an accurate representative of the total first year student population. Some respondents were also noted to be studying two courses (double degree), some courses both within the Science and Engineering Faculty or one course within the Science and Engineering Faculty and one course in a different faculty. However, the number of double degree respondents were small (<10%) and were not determined to create confounding variables in the data.

The survey consisted of 25 questions about the respondent's demography, academic performance, inspirations, aspirations, and views of tertiary education. The answers were either open-ended or multiple choice answers, and the survey took roughly 30 minutes to complete. Although the survey was not grounded in methodology from existing literature in STEM strategy, the survey content is relevant to themes consistent in literature. One important theme emphasises the focus of STEM recruitment efforts on education attainment.

This paper focuses on the following questions from the survey that contributed to the findings of this study;

- Thinking back to your decision to study for an undergraduate degree, when did you make each of the following decisions? What school year, and when during the year?
    - You decided on a broad area of study.
    - You chose a specific course/degree.
    - You chose a university.
- Who had the most influence on your decision to pursue a STEM degree?
- Before university what got you interested in STEM?

Data Analyses

The software package used for statistical analysis in this research was SPSS 22. Three questions from the survey were used for the descriptive analyses. The year level in which respondents made decisions regarding aspects of university trajectories, when within these year levels they made decisions, who they select as being influential and what was influential in selecting a STEM degree were of interest to this paper. Categorical variables are presented in terms of frequencies.

Results and Discussion

Table 1 presents the descriptive statistics for year level decisions regarding university trajectories take place. Results suggest high school students are likely to make decisions regarding their broad area of study before Year 10 (60%). Decisions regarding more specific aspects, however, were likely to occur in Year 12. In particular, 60.6% (*n* = 339) of participants indicated they chose their specific course/degree in Year 12 and 73% (*n* = 408) chose their university in Year 12. This has a number of implications for timing of engagement activities and influencing the decision making of students. High school students often chose their year 11 and 12 subjects based on the reputation and popularity of the teachers (UA, 2012) and what subjects their peers choose. This finding is supported by researchers from University of Newcastle who collected data on career aspirations of 3500 year 4, 6, 8 and 10 students and found that 40% of year 10 students were tentative or undecided about a particular career (Gore et al., 2015).

Table 1: Decision making regarding university trajectories by year

	Year 8 or below		Year 9		Year 10		Year 11		Year 12	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
You decided on a broad area of study	105	18.82	77	13.80	153	27.42	109	19.53	114	20.43
You chose a specific course/degree	8	1.43	9	1.61	66	11.81	137	24.51	339	60.64
You chose a university	9	1.61	10	1.79	38	6.8	94	16.82	408	72.99

Table 2 and 3 illustrates the timing of decisions regarding university trajectories within particular year levels. With most students selecting their broad area of study in Year 10, it is of interest 49.7% (*n* = 75) make this decision mid-way in the year. For students who selected their specific course/degree in Year 12, 42.3% (*n* = 141) made this choice mid-way through the year, and 40.2% (*n* = 134) made their decision at the end of the year. For students selecting their choice of university in Year 12, 45.9% (*n* = 184) made this decision at the end of the year and 40% (*n* = 161) made this decision mid-way.

Table 2: Timing of decision making for broad area of study and specific course/degree

	You decided on a broad area of study						You chose a specific course/degree					
	Start of		Mid-Way		End of		Start of		Mid-Way		End of	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Year 8 or before	80	78.4	18	17.6	4	3.9	6	85.7	1	14.3	0	0
Year 9	30	40.5	29	39.2	15	20.3	5	55.6	3	33.3	1	11.1
Year 10	40	26.5	75	49.7	36	23.8	17	26.2	30	46.2	18	27.7
Year 11	26	24.3	52	48.6	29	27.1	35	25.9	64	47.4	36	26.7
Year 12	22	19.6	43	38.4	47	42	58	17.4	141	42.3	134	40.2

Table 3: Timing of decision making for choice of university

	You chose a university					
	Start of		Mid-Way		End of	
	n	%	*n*	%	*n*	%
Year 8 or before	8	88.9	0	0	1	11.1
Year 9	5	50	4	40	1	10
Year 10	16	42.1	15	39.5	7	18.4
Year 11	31	34.1	36	39.6	24	26.4
Year 12	56	14	161	40.1	184	45.9

The higher numbers (> 40%) at the end of Year 12 for choosing a specific degree and university has implications for potentially influencing the student's decision making. For many students, the choice of STEM subjects in higher education does not automatically follow from their choices and successes in science and mathematics subjects in high school (van Langen and Dekkers, 2005). Students often hold stereotyping beliefs when it came to particular fields, and that this was often informed by media portrayals of particular industries. Scientists, for instance, are generalised as 'nerds'; highly intelligent but uncool.

Results from the survey, presented in Table 4, suggest parents were very influential in decisions to select STEM degrees (28.41%; *n* = 173). Teachers were also identified as being influential, with 22.82% (*n* = 139) of participants indicating teachers had the most influence on their decision to pursue a STEM degree. Even so, 42.69% (*n* = 260) of participants stated no one influenced their decision. This is an interesting finding and needs to be explored further to determine whether this is a generational response or because of their passion and motivation to study STEM overwhelmed whether someone influenced or encouraged them.

Table 4: Who had the most influence on your decision to pursue a STEM degree?

Choices	*n*	%
Parent	173	28.41
Teacher or guidance counsellor	139	22.82
Friend	85	13.96
Sibling	27	4.43
Famous person	56	9.20
Mentor	48	7.88
Grandparent	16	2.63
Other relative	27	4.43
No one	260	42.69

Having a good teacher that was liked had the effect of raising the interest and enjoyment of subjects and subsequently increasing the likelihood that a similar area of study would be pursued at university. In the 2012 Universities Australia study respondents consistently identified teachers with both passion and subject knowledge as important contributors to their career aspirations and choice of university subjects. They made a recommendation that secondary school students need to be made aware of the career opportunities at an earlier age, rather than in just years 11 and 12.

In a focus group of Deakin and University of Sydney STEM and non-STEM undergraduate students the major issues relating to parental influence were found to be (UA, 2102):

- Direct encouragement/pressure to pursue these careers
- Feeling as though pursuing a career in the science fields would please their parents.

Participants were asked to identify what prior to university got them interested in STEM. Results, presented in Table 5, indicate 36.29% (*n* = 221) of participants identified teachers as influential in this area. Thirty-two percent (*n* = 199) indicated TV, movies or books were influential, and least influential were science fairs/contests (7.22%; *n* = 44). This correlates well with a Microsoft study of STEM college students where 57% said that, before going to college, a teacher or class got them interested in STEM (Harris Interactive, 2012).

Across Australia the quality of science and mathematics teaching is constantly being debated and it is likely that the students themselves as well as the major influencers will question their decision making as a result. Students have often been discouraged from pursuing STEM studies at university due to experiencing a poor standard of STEM teaching in high school, as well as lacking an understanding of where tertiary STEM studies could lead them after university.

University visits by school classes especially in the STEM area are becoming more commonplace and are part of many universities marketing and recruitment strategies. In this study 27% developed their interest in STEM by visiting a university campus.

Table 5: Before University, what got you interested in STEM?

Choices	*n*	%
A teacher in class	221	36.29
TV, movies or books	199	32.68
Games or toys	186	30.54
A parent or relative	142	23.32
Visiting University	166	27.26
Clubs or activities	73	11.99
Work/Internship	56	9.20
A mentor	41	6.73
A famous person in the field	65	10.67
Science fairs/contests	44	7.22
Other	75	12.32

Limitations

The study's findings should be considered in conjunction with several important limitations.

Not all students responded to all questions.

- 609 students responded to table 4 and 5 (n=649)
- 565 students responded to tables 1-3 (n=649)
- All respondents to this survey were studying STEM at university (What about the ones that aren't studying STEM? Did they attend STEM engagement activities?)
- Although a small sample size, Double degrees may be a confounding variable when one of the degrees is in an unrelated STEM field.

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Conclusion

Many researchers agree that one of the best ways to influence student decision making in choosing STEM courses and ultimately increase STEM participation is to make school mathematics and science more relevant to daily life, present it on a personal level and make it more relevant. The analysed survey data indicates it is important to have many STEM-related touch points throughout schooling to ensure that students choose senior STEM subjects leading to a university STEM major and pursue a career using their transferable skills. Engagement needs to provide early exposure to students to build awareness about STEM-related disciplines and how they translate to careers; and also to erase STEM stereotypes. To guide students to make an informed choice of STEM career, timing of engagement activities that spark interest in STEM should be targeted in year 7,8,9 or earlier; and strategies to retain interested students, should be targeted across year 10, 11 and 12 as this is when they select their course and university. There are numerous opportunities for promoting STEM outside the school environment, including programs run by Museums, Libraries and Science Clubs. In the current climate it is important that universities play a role in strengthening partnerships with schools, teachers and informal settings so STEM careers are seen to be valuable and viable career options.

The study conducted included first year undergraduate students already on the pathway to STEM careers. The study outcomes will be strengthened by administering to a non-STEM cohort to allow comparison and benchmarking in the next iteration. As in previous studies teachers and parents are seen as the major influencers on secondary school students' selection of STEM-related career choices at universities. The finding that 43% of students stated "no one influenced their decision to pursue a STEM degree" is interesting as the current generation are avid consumers of technology but they are not increasing their ambitions to be the creators and innovators of tomorrow.

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