

STEM Intervention Strategies: Sowing the Seeds for More Women in STEM

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SESSION

C4: The role and impact of engineers and the engineering profession in the wider community

CONTEXT

In a new study released by the Office of the Chief Scientist (2016), only 16% of Australians in Science, Technology, Engineering and Mathematics (STEM) professions are women. A better understanding of the motivations of, influences on, and barriers to young girls as they form STEM career aspirations, and the implementation of such knowledge towards targeted strategies, may improve the global gender disparity in STEM disciplines. A healthy and diverse STEM pipeline could lead to new perspectives on innovation, creativity, leadership and success, ultimately impacting the world's performance and productivity.

PURPOSE

The purpose of this research is to identify barriers to girls at secondary school entering STEM careers, to propose recommendations for tackling and removing the perceived barriers and to identify methods to tailor existing outreach activities to better attract more female students.

APPROACH

The opinions of 496 girls aged between 12 and 18 from an independent girls' school were gathered via an online survey. Results were used to inform strategies to improve the gender disparity in STEM disciplines via outreach activities, programs and marketing material.

RESULTS

While gender stereotypes, a lack of female role models and negative imagery associated with STEM are still frequently highlighted in the extensive body of literature as a cause for the underrepresentation of women in STEM fields, less than 10% of students in our context supported these claims. The perceived difficulty of STEM subjects and a lack of information surrounding STEM career pathways were identified as the dominant barriers to the uptake of STEM subjects. Furthermore, parents were clearly identified as the key influencers on children's academic and career trajectories.

CONCLUSIONS

Tailored workshop activities and outreach materials that clearly highlight stimulating and diverse STEM career opportunities that are available through the pursuit of highly achievable STEM subjects, in addition to accompanying workshop materials designed for family members, could be key to improving the global gender disparity in STEM disciplines. Future studies with students from more diverse types and demographics of schools should be performed to ascertain if these results are anomalous or signal a wider change in student perceptions of STEM from the wider literature.

KEYWORDS

Women in STEM, STEM Intervention Strategies

Introduction

In a new study released by the Office of the Chief Scientist (2016), only 16% of Australians in Science, Technology, Engineering and Mathematics (STEM) professions are women. A better understanding of the motivations of, influences on, and barriers to young girls as they form STEM career aspirations, and the implementation of such knowledge towards targeted strategies, may improve the global gender disparity in STEM disciplines. A healthy and diverse STEM pipeline could lead to new perspectives on innovation, creativity, leadership and success, ultimately impacting the world's performance and productivity.

The purpose of this research is to identify barriers to girls studying for and moving into STEM careers, to propose recommendations for tackling and removing the perceived barriers and to identify methods to tailor existing outreach activities to better attract more female students. A literature review was performed to gain insight into the current landscape of work that has been conducted within this area. Major barriers to the uptake of STEM subjects comprised of the following:

Masculine stereotypes and negative imagery: There is a vast amount of literature on the perception that STEM subjects and careers are commonly aligned with masculinity, which is negatively correlated with the self-concept of girls. New research conducted by Accenture (2015), who sought the views of more than 1,500 girls aged between 11 and 18 in conjunction with more than 2,500 young women aged between 19 and 23, affirms that gender stereotypes still strongly persist. Similarly, individuals who pursue studies in STEM are often associated with the 'geek' or 'nerd' identity, negative imagery that is often reinforced by the media and by popular culture.

Perception of difficulty: The Institution of Engineering and Technology (2008) traces the current barriers associated with the uptake of STEM subjects, through a literature review of approximately 300 articles. The presumed greater difficulty of achieving higher grades in STEM subjects than in non-STEM subjects profoundly decreased students' self efficacy and interest levels in the subjects.

Parental and teacher influence: In the same study conducted by Accenture (2015), parents were identified as key influencers on children's academic and career trajectories, however a lack of encouragement and uninformed decision making, can inhibit the likelihood of cultivating an interest in these fields. Positive interpersonal relationships with teachers, in conjunction with high quality teaching, have been associated with superior motivation towards the uptake of STEM subjects (The Institution of Engineering and Technology, 2008).

Unclear career pathway: Through Adecco Group's (2015) analysis of the opinions of more than 1000 students aged between 14 and 16, 70% of girls revealed a desire to pursue studies in STEM, however, lacked an understanding regarding potential careers in the sector.

Socioeconomic status: Parents of higher socioeconomic status are more likely to provide greater learning opportunities and better quality educational interactions at home, than parents of lower socioeconomic status. These provisions are necessary for positive STEM trajectories (Wang and Degol, 2017).

Teaching methods: The teaching of STEM subjects are often perceived as "knowledge transmission of correct answers, without time nor room for creativity", negatively influencing the formation of students' attitudes towards STEM (The Institution of Engineering and Technology, 2008).

Methodology

To support research in this area, the results of a literature review informed the design of a theoretically and empirically sound anonymous, optional, online survey, which consisted of both qualitative and quantitative questions. The participants in the survey comprised of 496 girls aged between 12 and 18 (12 – 12.5%, 13 – 17.2%, 14 – 13.5%, 15 – 24.7%, 16 – 18%, 17 – 10.8%, 18 – 3.3%), primarily speaking English (64.6%) and Chinese (34.8%), studying at an independent girls' school (day and boarding) located in an eastern suburb of Melbourne, Victoria, Australia. As an alumnus of the school, such selection deemed appropriate. The survey was announced via the school assembly and distributed through Science lessons in the form of a flyer, with permission from the Principal and support from the Head of Science. The flyer contained a link to the survey, in addition to an Explanatory Statement. Time was allocated during Science lessons to participate in the survey. Survey data provided insights into current attitudes towards, influences on, barriers to, and understandings about STEM subjects and STEM careers, in addition to an exploration of methods to increase STEM subject uptake. Survey results were applied towards generating targeted strategies to improve the global gender disparity in STEM disciplines.

Results and Discussion

Students first shared their opinions regarding the 'discouraging features of STEM subjects', as indicated in Figure 1. Students were able to select multiple answers.

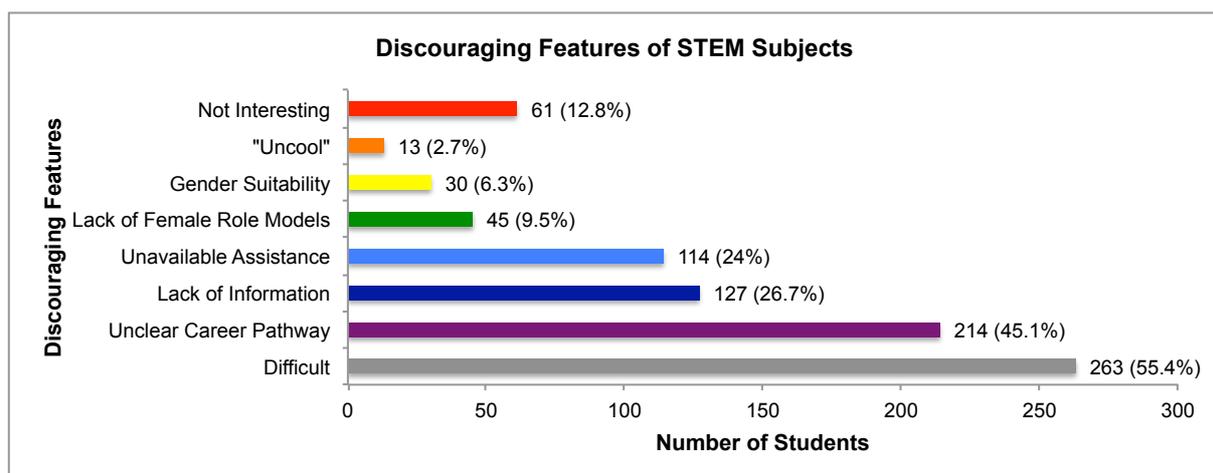


Figure 1: The Discouraging Features of STEM Subjects

Perceived Difficulty of STEM Subjects

The perceived difficulty of STEM subjects was the dominant barrier to students pursuing studies in STEM, with 55.4% of students citing this as a 'discouraging factor'. 76% of students chose subjects based on perceived personal likelihood of achievement, which refers to students' expectations for academic success established from self-efficacy and self-concept (figure not shown). The perceived greater difficulty of achieving high grades in STEM subjects than in non-STEM subjects, in conjunction with the desire to maximize scores to increase tertiary entry opportunities, are key reasons that could contribute to the decline in STEM subject uptake. Interestingly, the notion of 'difficult' is seldom equated with 'challenging', and such concepts are seen as mutually exclusive. This result correlates favorably with the findings of Duffield and Li (2016), in which a distinction between 'challenging' and 'difficult' was formed by students, who wanted to test their abilities on arduous, yet achievable tasks. Furthermore, analysis was performed to determine the

precise age in which students lose interest in pursuing STEM subjects based on perceived difficulty. As highlighted in Figure 2, disengagement peaked in 15 to 16 year old students, where 30% of students believed STEM subjects were too difficult to learn. What makes this figure even more alarming is that these negative attitudes have been embedded into students' psyche prior to the embarkment of VCE studies, the final phase of secondary schooling, which may set the trajectory of their careers.

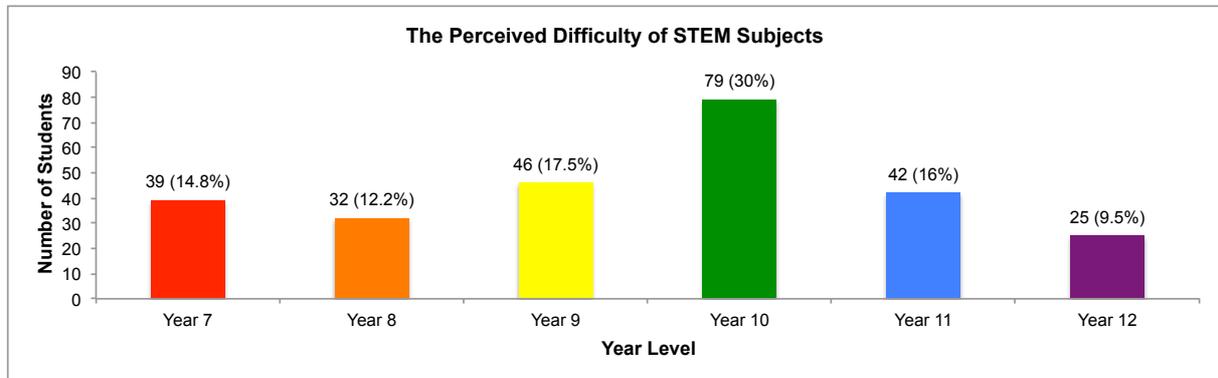


Figure 2: The Perceived Difficulty of STEM Subjects

Lack of Information Around STEM Career Pathways and STEM Subjects

Whilst the perceived difficulty of STEM subjects is the most highly cited discouraging factor, 45.1% and 26.7% of students reveal that a 'lack of information' around STEM career pathways and STEM subjects, respectively, are other major discouraging factors. Perhaps due to insufficient, inaccurate information and misconceptions that occur as a consequence to this, many students fail to see STEM subjects as passports to stimulating, diverse and lucrative careers. Furthermore, as highlighted in Figure 3, despite having access to career advisors, students' understandings about STEM careers are mediocre and fair at best, with only 2% of students possessing excellent insight into what engineering is and what engineers do. However, it is unclear whether career advisors fully understand STEM careers. Additionally, as indicated in Figure 5, only 10.1% of students regard the provision of information, guidance and advice provided by career advisors, as influential.

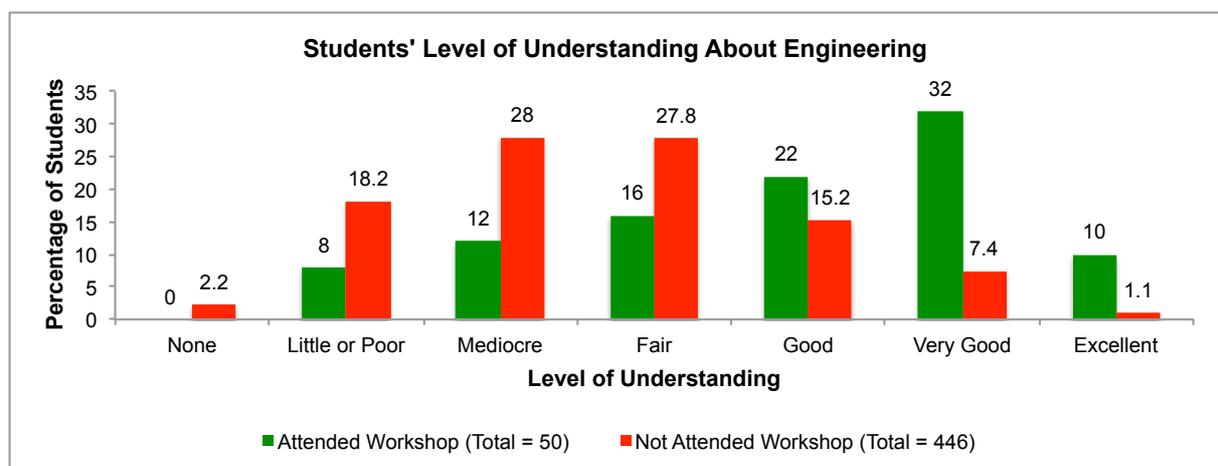


Figure 3: Students' Level of Understanding About Engineering

Quality of Teaching

As a result of the perpetual STEM teacher shortage in schools, STEM is being taught by teachers that have neither a university major nor minor in more than half of schools nationwide (Australian Education Union, 2016). Approximately one quarter of students reported 'unavailable assistance' as a discouraging feature associated with STEM subjects. Such terms were not explicitly defined in the survey. Due to its broad interpretation, a lack of high quality teaching may perhaps be a barrier to the uptake of STEM subjects. Further studies, which remove the ambiguity, will need to be performed to verify such claims.

Gender Stereotypes

While gender stereotypes, a lack of female role models and negative imagery associated with STEM are still frequently highlighted in the extensive body of literature as a cause for the underrepresentation of women in STEM fields, only 6.3%, 9.5% and 2.7% of students surveyed supported such claims, respectively. Gender stereotypic beliefs were explored further through 3 gender-biased questions on a 7-point Likert scale. Students expressed their level of agreement or disagreement to the following questions:

STEM subjects match 'male' careers.

STEM subjects are better suited to boys' brains.

STEM subjects are better suited to boys' personalities and hobbies.

As indicated in Figure 4, students appear to be unaffected by male gender-typed statements. The results suggest that the plethora of gender-targeted STEM strategies to remove gender stereotypes, in addition to the negative portrayal of STEM, may have been successful, at least within this population - girls aged between 12 and 18 studying at a single sex, independent, day and boarding school located in an eastern suburb of Melbourne, Victoria, Australia.

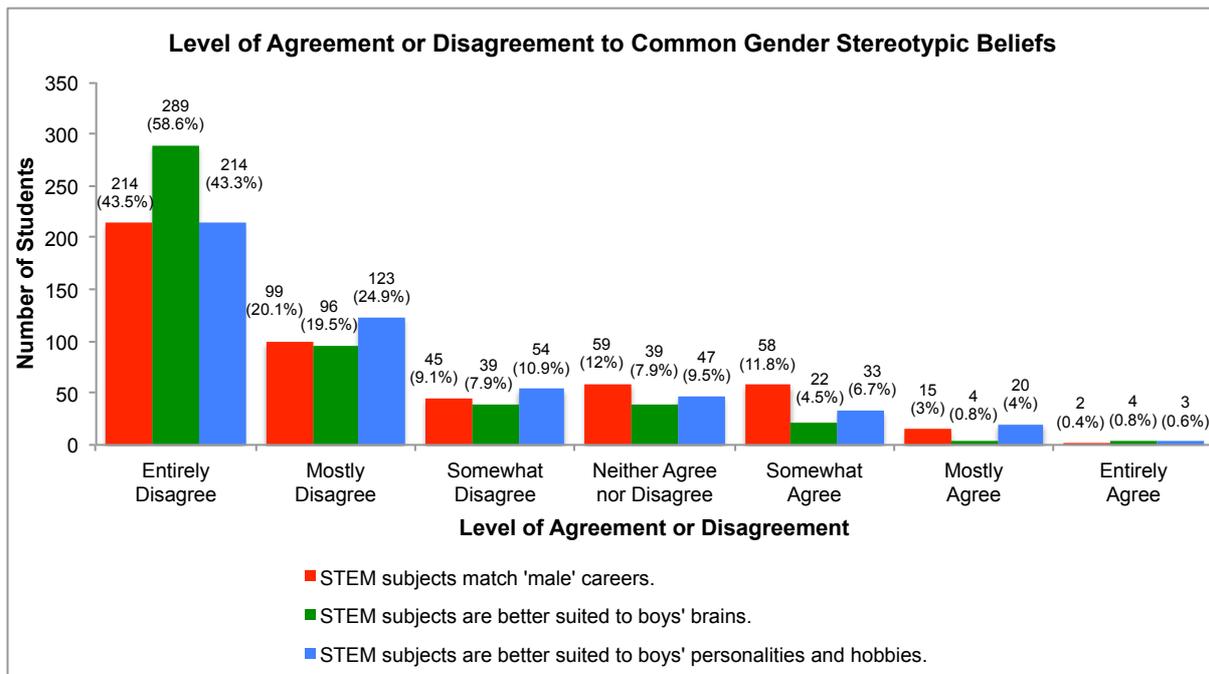


Figure 4: Level of Agreement or Disagreement to Common Gender Stereotypic Beliefs

Influences of Social Contexts

Motivations to pursue certain subjects do not develop in a psychological vacuum, but is evolved under the influences of various ecological contexts, such as family, teachers, friends and society in general (Wang and Degol, 2017). The extent to which these societal factors impact students' uptake of particular subjects was explored through the ranking of students' top 3 selections, as illustrated in Figure 5. Expectedly, 92.9% of students regard parents, family or guardians as influential on subject choice, with 68.4% of students considering such factor as most influential, since the home environments created, the values endorsed and the experiences provided by family members profoundly moulds their academic pursuits. Whilst family holds a dominant role on subject selection, 61.9% of students reveal that educators also play a prominent part in fostering academic motivation, with 36% of students placing teachers as second most influential. This may be attributed to the fact that students spend substantial time in school and are affected by the guidance, encouragement and academic enrichment provided by instructors. The importance of peer relationships during adolescence has been well established throughout the literature where 49.2% of students disclosed that friends exert a major force on their subject choices, with 27.5% of students assigning such factor as third most impactful, rejecting certain subjects to gain social approval by conforming to peer norms. The above results correlate favourably with the findings of Accenture (2015), in which 53%, 52% and 33% of students regarded family, teachers and friends as most influential, respectively.

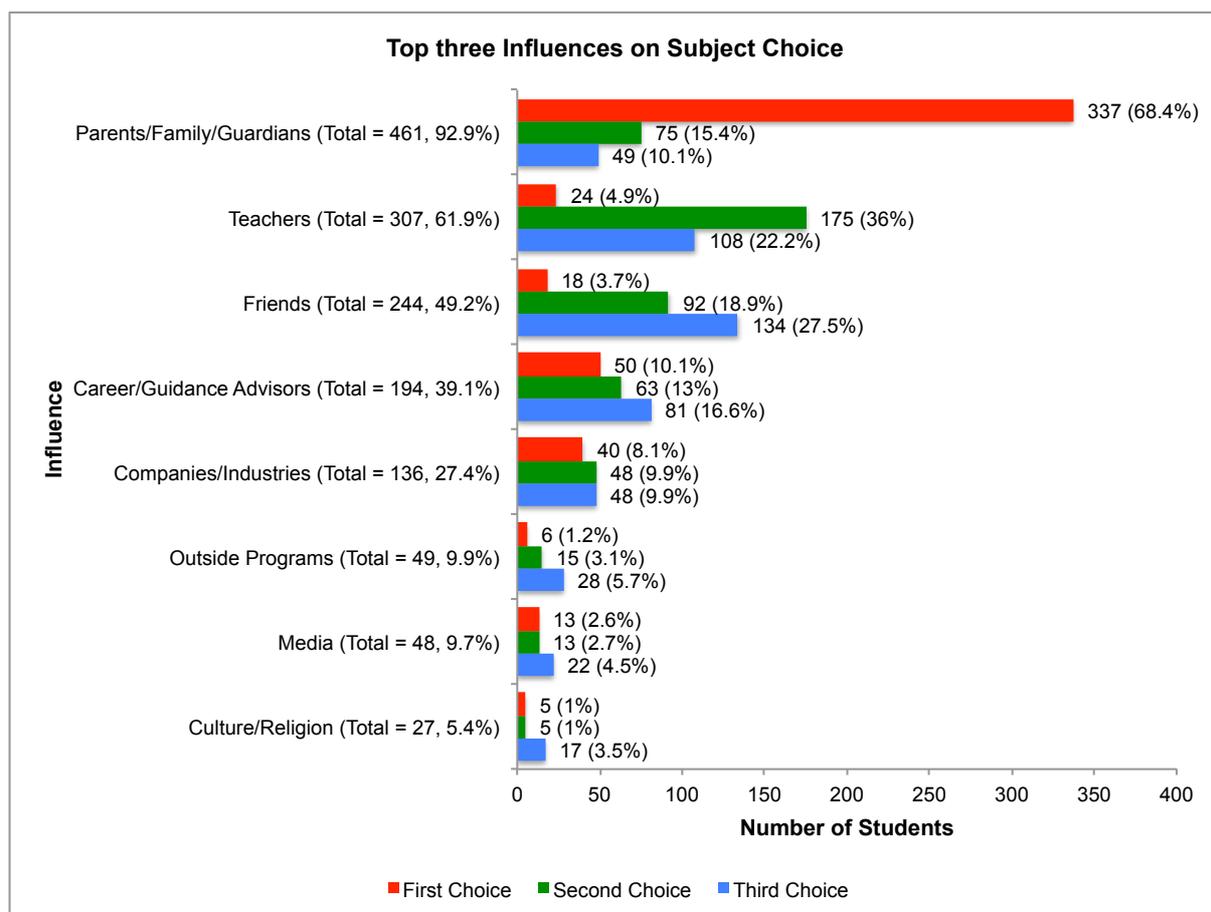


Figure 5: Top three Influences on Subject Choice

Career Aspirations

Students were asked to list the most likely occupations that they would like to choose as a career, with results shown in Figure 6. Whilst 19% of students desire to pursue STEM professions, medicine, nursing and health sciences, were the dominant selections, with 38.1% of students. The perception of the latter is very different from that of STEM, with 54.8% of students associating such profession with great societal value, as compared to only 11.5% for STEM. The objective assessment of the tangible benefits of both careers such as salary and opportunities for career advancement was more preferential towards medicine, nursing and health sciences as opposed to STEM receiving 7.6% and 5.1% responses, respectively. Social and psychological aspects such as family history and personal ability was regarded as least influential on vocational choice but remained superior towards medicine, nursing and health sciences than STEM with 6.4% and 3.8% responses, correspondingly.

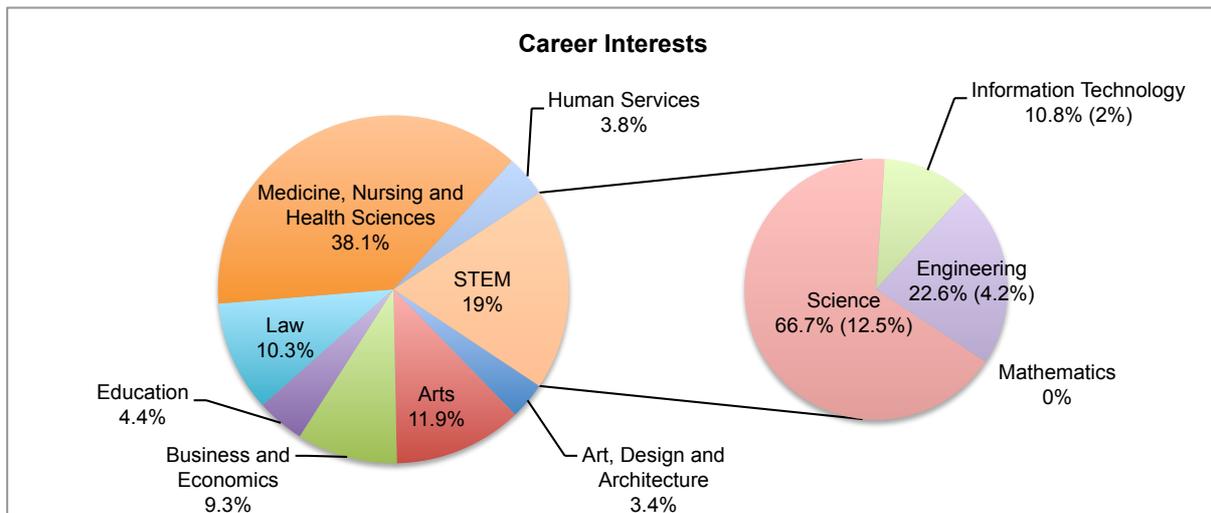


Figure 6: Career Interests

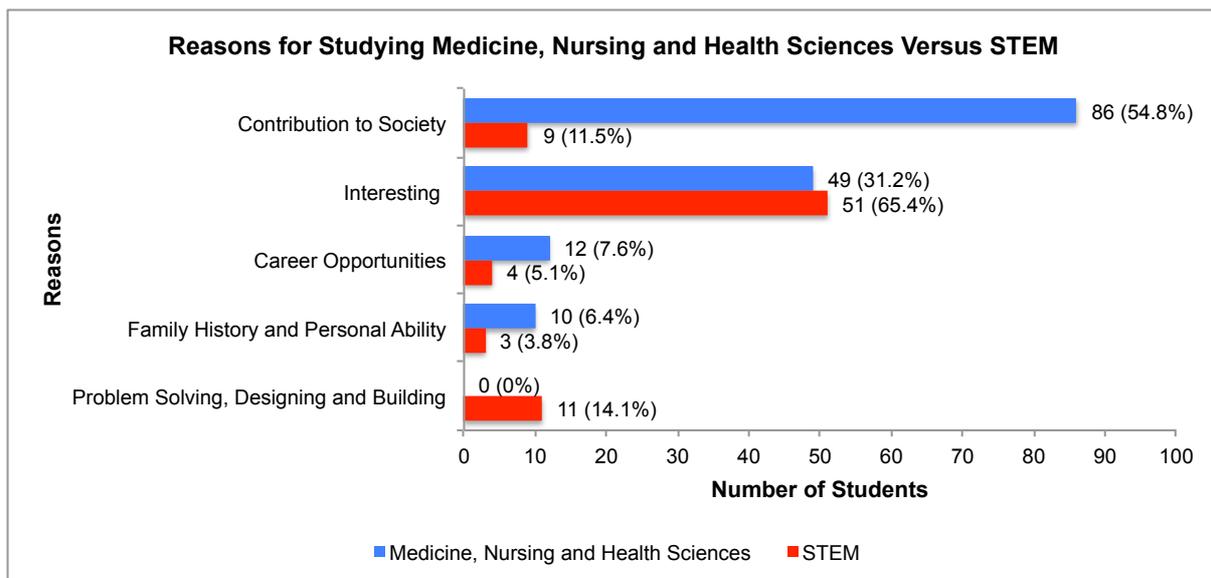


Figure 7: Reasons for Studying Medicine, Nursing and Health Sciences Versus STEM

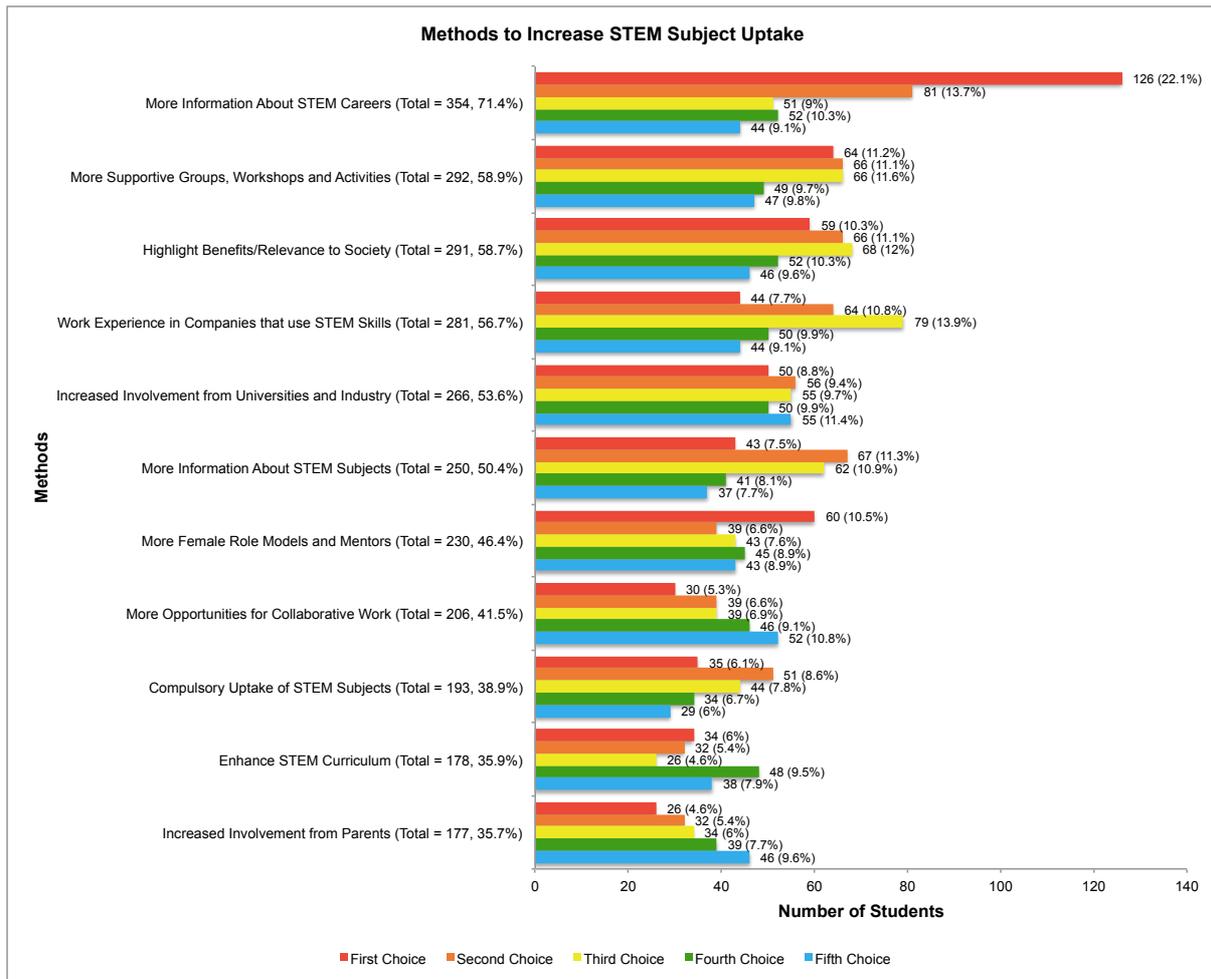


Figure 8: Methods to Increase STEM Subject Uptake

Discussion

The perceived difficulty of STEM subjects and a lack of information about STEM career pathways, remain the dominant barriers to the uptake of STEM subjects, as revealed by 55.4% and 45.1% of students, respectively. Illustrated in Figure 8, 58.9% and 71.4% of students believe that the provision of STEM workshops and information regarding STEM careers, are fundamental to increasing STEM subject uptake, respectively. Given that students who have attended STEM workshops gained approximately 10 times more knowledge about what engineering is and what engineers do, as compared to students who have not attended STEM workshops, future workshop activities may be tailored to highlight the stimulating and diverse career opportunities that are available within the world of STEM, through the pursuit of highly achievable STEM subjects.

Whilst 19% of students desire to pursue STEM professions, medicine, nursing and health sciences, remains the prevailing career aspiration, with 38.1% of students in agreement. The juxtaposition of societal value associated with both careers is confounding, as 54.8% of students associated the latter with great societal value, as compared with a mere 11.5% for STEM. Given that 58.7% of students surveyed identified highlighting the benefits and relevance of STEM careers to society as a method to increase STEM subject uptake, in addition to previous successes in attracting female students through emphasizing just that during STEM workshops (Duffield and Li, 2016), such findings may be applied towards future STEM workshop activities.

92.9% of students regarded family as governing on subject choice. Accompanying workshop materials designed for family members that comprise of information regarding STEM careers and their benefits to society, in addition to upcoming workshop events, may be valuable to support family members and their children to make well-informed career decisions.

Conclusion

While gender stereotypes, a lack of female role models and negative imagery associated with STEM are still frequently highlighted in the extensive body of literature as a cause for the underrepresentation of women in STEM fields, only 6.3%, 9.5% and 2.7% of students supported such claims, respectively. Contrariwise, the perceived difficulty of STEM subjects and a lack of information about STEM career pathways, remain the dominant barriers to the uptake of STEM subjects, as revealed by 55.4% and 45.1% of students, respectively. Societal factors have been established to influence students' uptake of particular subjects, with 92.9% of students regarding family as governing on subject choice. Similarly, due to perceived societal value, medicine, nursing and health sciences remains the prevailing career aspiration, with 38.1% of students in agreement.

The findings from this study suggest that the plethora of gender targeted STEM strategies to remove gender stereotypes and the negative portrayal of STEM, have been successful, at least within this population. However a more thorough exploration into whether such stereotypes and portrayals were ever an issue in the first place, within this population, is required. Furthermore, socioeconomic status and learning methods could be confounding factors in the research. Future studies with students from more diverse types and demographics of schools should be performed to ascertain if these results are anomalous or signal a wider change in student perceptions of STEM from the wider literature.

Perhaps by implementing an amalgamation of the above recommendations we can address the new barriers that surround this complex, multifaceted problem, thereby improving the global gender disparity in STEM disciplines and ultimately, the world's performance and productivity.

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