International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Parental Influences on Those Seeking a Career in STEM: The Primacy of Gender

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ABSTRACT
In many areas of Science, Technology, Engineering, and Mathematics (STEM), and despite attempts by governments and other agencies to address the issue, females remain significantly underrepresented. Research has shown that parents play a significant role in shaping the aspirations of children with regard to higher education. However, there is a paucity of research exploring the particular influence of parents on the aspirations of children towards STEM. Drawing on data from a four-year mixed-method longitudinal study conducted with students (N = 6,492) in Years 3 to 12 from the Australian state of New South Wales, we examine parent data (survey and focus groups) for those students who expressed an interest in pursuing STEM studies and careers. Students who expressed an interest in STEM were typically high achieving and just over 90% of their parents had aspirations for them to attend university—although this was proportionally higher for sons than for daughters. Even when parents created a supportive environment, there was little evidence indicating that girls were encouraged to pursue STEM. This analysis highlights the complexity and importance of parental influences on student aspirations. When exploring strategies aimed at encouraging students to consider pathways into STEM, we argue that educational institutions should consider ways of actively involving parents in order to counter stereotypical gendered views of STEM and to expand the range of possibilities considered by both girls and boys.

KEYWORDS
parental influences; STEM; gender; Australia; career choice; student aspirations

INTRODUCTION

As the twenty-first century progresses and society becomes ever more dependent on Science, Technology, Engineering, and Mathematics (STEM) industries, it is imperative that educational institutions attract and train students to meet the evolving needs of these fields. Internationally there has been growing concern about a potential "crisis" in industries that require a STEM-trained workforce (Wilson & Mack, 2014), whereby the availability of a suitably trained, diverse workforce will fail to meet demand. In 2016, only 16% of STEM-qualified people in Australia were female (Office of the Chief Scientist, 2016), and in many areas of STEM education there has been a disparity in the representation of female students, particularly at the tertiary level (Beede et al., 2011; Broadley, 2015).

In recent years, various studies have identified multiple factors associated with the educational and occupational aspirations of students, including parental expectations (Gemici, Bednarz, Karmel & Lim, 2014); cultural background (Ainley & Ainley, 2011; Bodovski, 2010; Riegle-Crumb, Moore & Ramos-Wada, 2011); gender (Wang & Degol, 2013; Watt et al., 2012); the media (Archer, DeWitt & Wong, 2014; Steinke et al., 2007); social media (Wohn, Ellison, Khan, Fewins-Bliss & Gray, 2013); as well as socioeconomic status and prior achievement (Gore, Holmes, Smith, Southgate & Albright, 2015). However, as Harackiewicz, Rozek, Hulleman and Hyde (2012) have suggested, as a result of their STEM intervention programs with parents and adolescents, "parents are an untapped resource" (p. 899). Given that parents play a pivotal role in creating a child's home environment, as well as significantly influencing their lifestyle behaviors (Lloyd, Lubans, Plotnikoff, Collins & Morgan, 2014), self-efficacy (van Tuijl & van der Molen, 2016), school achievement (Spera, 2005), and career aspirations (Kniveton, 2004), elucidating the influence of parents is critical to understanding how children's aspirations are formed.

Given the well-documented, persistent disparity in the proportion of males and females with STEM aspirations, a key feature of much of the research exploring STEM aspirations has been gender (Archer et al., 2014; Broadley, 2015; Sadler, Sonnert, Hazari & Tai, 2012; Watt et al., 2012). Researchers have found, for instance, that male adolescents are more likely to aspire to math-related careers (Watt, 2008) compared to female adolescents, who often aspire to careers that involve social interaction (Wigfield & Eccles, 2002) or in which they are able to help and care for others (Hemsley-Brown & Foskett, 1999; Jirwe & Rudman, 2012). Entrenched gendered pathways and careers have been identified. They are problematic for a number of reasons, including the potential impact on wage disparity (Hegewisch & Hartmann, 2014), reducing choice for both males and females, and failing to optimize economic growth (Kabeer & Natali, 2013). It has been suggested that a more gender-balanced STEM pathway and workforce will make STEM fields more productive, relevant, and innovative (Marginson, Tytler, Freeman & Roberts, 2013).

Despite an increase in recent years of outreach activities, the low participation of women in non-traditional fields persists (Gale et al., 2013; Naylor, Baik & James, 2013). The reasons for this ongoing disparity in female participation are both

multifaceted and complex. A recent review conducted by van Tuijl and van der Molen (2016) highlighted the importance of female and male STEM role models for children. Indeed, having a parent or carer who already works in a STEM career has been found to positively influence children's aspirations towards a STEM career (Holmes, Gore, Smith & Lloyd, 2017), and their decision to enroll in a particular university degree, such as engineering (Bonaldi & Silva, 2014). Other factors that are believed to contribute to the ongoing underrepresentation of women in STEM include irrelevant science curricula (Braund & Reiss, 2006); cultural workforce and occupational stereotypes (Cheryan, Master & Meltzoff, 2015); choice of which mathematics courses to take in high school (Watt et al., 2012); as well as gendered socialization practices in schools, at home, and among peers (Eccles, 2011).

Researchers have also explored the role of prior achievements in STEM aspirations (both formation and maintenance). Although mathematics achievement has been described as a critical filter for STEM careers (Shapka, Domene & Keating, 2006), female and male adolescents have previously shown similar levels of achievement in mathematics (Hyde, Lindberg, Linn, Ellis & Williams, 2008). However, when students have been given the choice to opt out of mathematics-related subjects in the later years of high school (Meece, 2006), the gendered cultural norms and other influences previously mentioned were often realized. This has been highlighted in the Australian context, where gender differences have been evident in senior high school mathematics participation rates (Watt, 2008; Wilson & Mack, 2014).

Families, and in particular parents, have been identified as providing an important context within which young people form their educational and occupational aspirations (Archer et al., 2012). Researchers have found that positive parental involvement in their children's education is related to better outcomes, including academic achievement (Anderson & Minke, 2007; Banerjee, Harrell & Johnson, 2011), and lower dropout rates (Jimerson, Egeland, Sroufe & Carlson, 2000). Parents and carers have also been found to provide support for, and/or encouragement of, educational achievement and aspirations (Archer et al., 2012; Bodovski, 2010) with parents' educational expectations and involvement in their children's education being positively correlated with students' educational aspirations (Nichols, Kotchick, Barry & Haskins, 2010). Ethnicity, gender, and social class have also been identified as important considerations when seeking to understand the behavior of parents and their role in the educational experience of children (Bodovski, 2010). For example, in their extensive literature review using Expectancy-Value Theory as a guiding framework, Wang and Degol (2013) identified some research to suggest "differential parental beliefs, expectations and treatment of sons and daughters may promote a gender divide in math and science motivational beliefs" (p. 318).

While parents have long been acknowledged as influencing student aspirations in general, few studies have examined parental influences on STEM aspirations in particular. Hence, the aim of this study is to build on our earlier analysis of school students' aspirations towards STEM careers (Holmes et al., 2017) to understand the critical influence of parents on the STEM career aspirations of their children, and to

ascertain if this influence varied according to the child's gender. Using matched student-parent data, we investigated the links between students' aspirations towards STEM careers and a range of parent variables in order to tease out any implications for the role of educational institutions and workplaces. In doing so, we address the key question: Does parental influence in relation to STEM career aspirations vary by student gender?

METHODS

We draw on data from the four-year (2012–2015) mixed-method longitudinal study *Educational and Career Aspirations in the Middle Years of Schooling: Understanding Complexity for Increased Equity* (Gore et al., 2015), conducted in 64 government schools located in New South Wales, Australia. The study involved 6,492 students across the full range of Year 3 to Year 12 in annual surveys, and 553 students in focus groups. In Australia, students usually attend school from ages 5 to 18. Students in Year 3 are typically between 8 and 9 years of age, and turn 18 in Year 12. Government schools are public sector schools, and this category does not include Catholic, private, or independent schools. Parents (N = 1,362) completed online surveys and participated in focus groups (n = 60).

Survey

In the survey, students were asked open-ended questions about their future career aspirations. Specifically, they were asked: "What work would you like to do when you grow up?" (primary students); or "What kind of work would you like to be doing when you are 25 years old?" (secondary students). Students were also asked to indicate the level of education they planned to complete and to provide reasons for their occupational choice in an open-ended survey question. Responses were systematically coded based on the reasons provided.

For this study, we examined the views of students who signaled an interest in pursuing STEM careers and focused on professions that typically require a university degree, categorizing jobs as either STEM or non-STEM. There does not appear to be a universally accepted definition of STEM, with definitions varying between countries, governments, and institutions (Breiner, Johnson, Harkness & Koehler, 2012; Marginson et al., 2013). In Australia, STEM has been defined by the Chief Scientist as the enabling disciplines in the natural and physical sciences, which rely on "causal relationships, characterised by systematic observation, critical experimentation, hypothesis formation and falsification" (Office of the Chief Scientist, 2013, p. 24). Thus, guided by this definition, and consistent with our earlier analysis (Holmes et al., 2017), occupations requiring a university qualification in STEM were included. STEM professions included engineers, life scientists, computer professionals, mathematicians, and other science professionals. The Australian and New Zealand Standard Classification of Occupations (ANZSCO) was used to categorize student responses.

An analysis of the full student data set has been published elsewhere (Holmes et al., 2017). For this paper, we considered the subsample of students whose data could be matched to a parent's survey data (n = 1,076). Demographic information for this subsample was used to determine the proportion of students who were

Indigenous/non-Indigenous, male/female, and whether from metropolitan or provincial locations. In addition, information on school year level at the time of survey completion, the level of parental education, parental employment status, language background, and socioeconomic status (SES) was gathered. Student SES was calculated by combining the highest parental education and occupation levels into an equally weighted proxy, using an approach consistent with that taken by Marjoribanks (2003) and Khattab (2015). Full data for the relevant school sector was used as a normative backdrop to separate SES scores into quartiles for our analysis.

In the parent survey, parents were asked about their expectations for their child's educational attainment. Specifically, they were asked "As things stand now, how far in education do you think your child might go?" (senior high school, Technical And Further Education [TAFE] or other training provider, university). Parents were also asked if they had aspirations for their child to attend university, and to describe their child's work at school (well above average, above average, average, below average, well below average). The student and parent survey data were matched and analyzed using IBM SPSS Statistics for Windows, Version 22.0 (2010 SPSS Inc., IBM Company Armonk, NY). For this study, the analysis of the matched student-parent survey data was descriptive.

Focus Groups

Using purposive sampling, each school was provided with a list of students who had completed the survey and were to be invited to participate in a focus group. These students represented a diverse mix of SES backgrounds, aspirations, and year levels. Where possible, focus groups involved students from the same year level or stage (across a two-year band), and the majority included both male and female students. Focus groups for parents and students were held separately. In order to understand the influence of parents on student aspirations towards STEM careers, an analysis of parent and student focus group data was undertaken. This analysis focused on parents who had participated in a focus group and had a child who indicated an interest in STEM (n = 15). Students (n = 16) who had indicated an interest in STEM, had participated in a focus group, and had a parent who had taken part in a focus group were also included in the qualitative analysis. NVivo version 11 (QSR International, 2015) was used to assist in thematic coding of focus group interviews, using inductive and deductive reasoning (Creswell, 2013). A process of coding and recoding parent and student responses was utilized and themes were expanded or reduced as necessary (Creswell, 2013).

RESULTS

Quantitative Findings

Of the 1,442 parent surveys completed, 1,076 could be matched to a student survey, with 63.7% of the matched data from primary students and the remaining 36.3% from secondary students. Of the matched student data, 50.3% were males, whereas in the matched parent sample, 83% of the parents and carers who completed the survey were female. Indigenous students comprised 4.5% of the sample and almost 9% were students from a Language Background Other Than

English (LBOTE). The sample was skewed towards high SES with just over 45% being in Quartile 4 (the highest SES quartile) and almost 15% being in Quartile 1 (the lowest SES quartile). Just over 62% of the sample were from a metropolitan school and 37.7% from a provincial school.

From the student survey 61% of the students had aspirations to attend university. Mothers and female carers had slightly lower expectations and aspirations (64.6% and 76.4% respectively) for their child to attend university compared to fathers and male carers (73.0% and 83.3% respectively). The matched student-parent survey data (n = 1,076) came from 980 unique students. A small number of families had both a mother and father complete the survey in the same year (n = 3), and on a few occasions a parent survey was completed from the same family in different years. The majority of parents only completed one survey during the four years of the study, effectively prohibiting any longitudinal analysis of the parent survey data.

One hundred and fifty of the matched student-parent surveys were comprised of students who had expressed an interest in STEM and 81.2% of these students had aspirations to attend university. Within this subsample of students interested in STEM occupations, more than half (52.3%) of the parents who completed the survey had a university degree compared to 43.1% in the full sample. There were no Indigenous students who expressed an interest in STEM in this subsample, while a greater proportion of fathers were from a LBOTE (20.7%) and employed full-time (67%) compared to mothers (LBOTE 9.6% and 30.4% in full-time employment). Just over 90% of parents of students interested in STEM had university aspirations for their child, with parents of male students proportionally more likely to have university aspirations for their child (91.7%) compared to parents of female students (86.4%). However, parents of female students were more likely to rate their child's ability as well above average. Consistent with the analysis of the whole student sample (Holmes et al., 2017), males in this sample were significantly more likely to aspire to a STEM career than females. Fathers and male carers (83.9%) had a slightly lower expectation than mothers and female carers (85.7%) of their child going to university and, similarly for aspirations, 90.3% of mothers and female carers compared to 87.1% of fathers and male carers had aspirations for their child to attend university.

Gender breakdown within a selection of career interests

As noted above, males were more likely than females to aspire to a STEM career. Figure 1, based on all student survey responses, further illustrates this gender disparity in STEM, but also presents the proportion of male and female students aspiring to other career areas. In Figure 1, Engineering and Science are presented separately in order to demonstrate the relative difference in the proportion of females interested in these subfields of STEM.

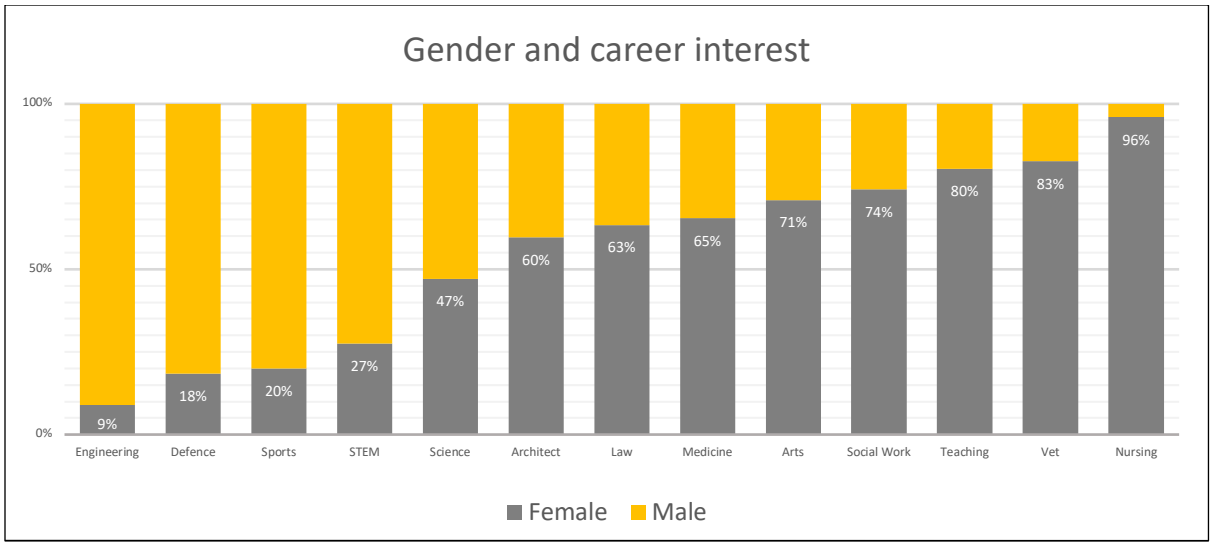

Figure 1: Gender breakdown for specific career categories (Gore, 2016)

Type of STEM careers

In this study, we were particularly interested in what type of STEM careers male and female students were aspiring to. Previously we have reported, based on an analysis of the full student data set, that males are generally more likely to aspire to STEM overall (Holmes et al., 2017). However, when comparing which STEM careers are most popular by gender, there are clear differences. Of those students who aspired to a STEM career and for whom we had matched parent data, over 45% of the male survey responses indicated aspirations towards engineering, compared to only 19.5% of the female survey responses. As presented in Table 1, the most popular STEM aspiration for female students (41.5%) was life scientist (including marine biology), which was also popular among male students (13%). Other natural and physical science professions (e.g., meteorologist, environmental scientist, geologist) were the second most popular career category for both male and female students. Although technology (software and applications programmers), as a category, came fourth for females, only one female student (2.4%) indicated an interest in these careers compared to ten male students (8.1%) who also aspired to technology careers (ICT and computer network professionals). There was also a greater range of STEM careers expressed by male students compared to female students. "Other" careers that were of interest to males, but not listed in Table 1, included technology-based (software and applications programmers) and mathematics-based careers (actuaries, mathematicians, and statisticians).

Table 1: Top 4 STEM careers to which male and female students aspired

Male	***n***	**%[a]**	**Female**	***n***	**%[b]**
Engineering	56	45.5	Life Scientists	17	41.5
Other Natural and Physical Science Professionals	31	25.2	Other Natural and Physical Science Professionals	15	36.6
Life Scientists	16	13.0	Engineering	8	19.5
ICT and Computer Network Professionals	10	8.1	Software and Applications Programmers	1	2.4
Other	10	8.1	Other	0	0
Total (*N*)	123	100		41	100

[a] Percentage of males
[b] Percentage of females
Note: Some students may have reported more than one STEM career.

Students' reasons for interest in STEM careers
The reasons given by students for their interest in STEM careers were varied. The ten reasons that were cited most frequently by the students with STEM aspirations who had matched parent survey data are presented in Figure 2.

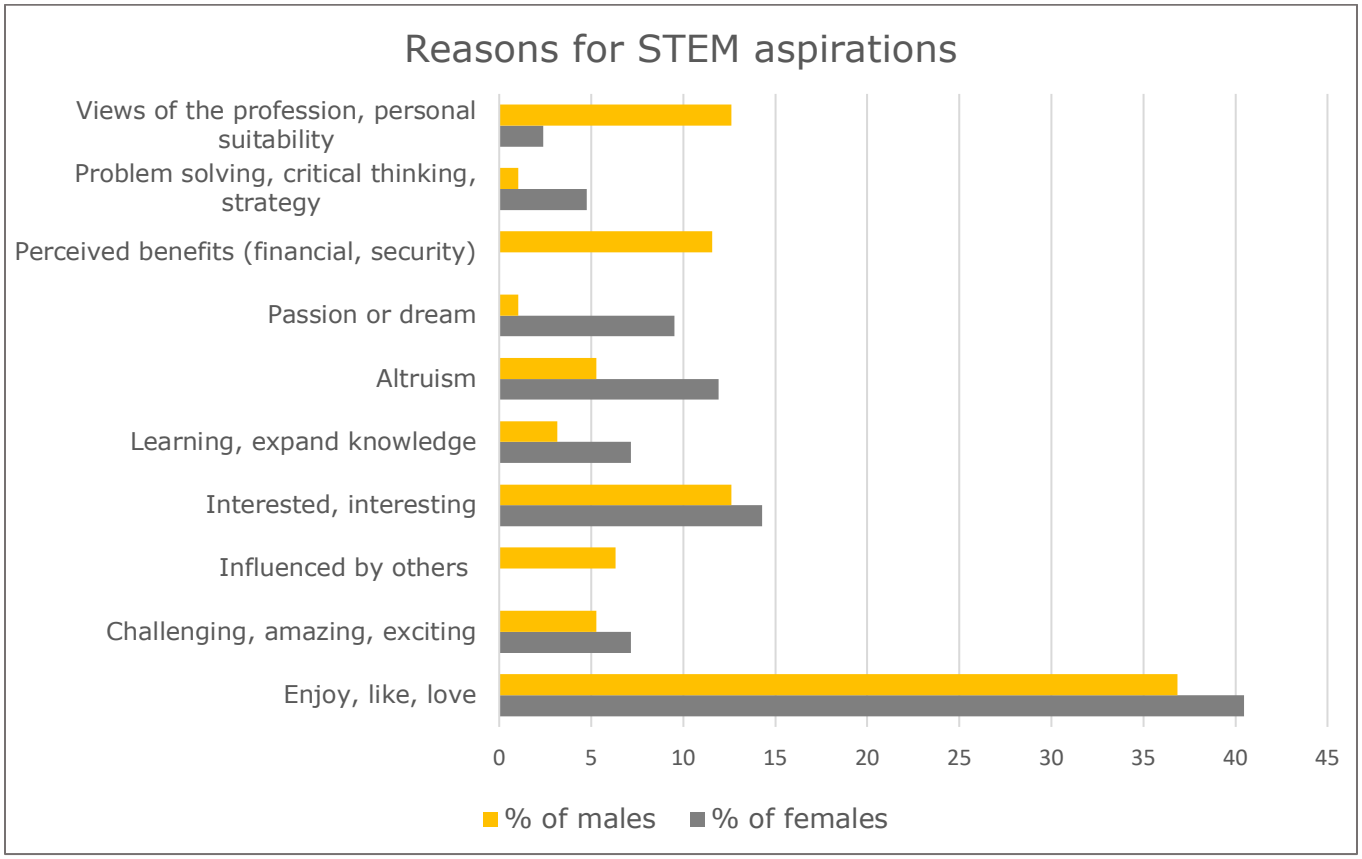

Figure 2: Reasons for students' STEM aspirations by gender

In almost equal proportions, 36.8% of boys and 40.5% of girls said that they were interested in a STEM career because they either enjoyed, liked, or loved the occupation or something connected to the occupation, while 12.6% of boys and 14.3% of girls considered the occupation to be interesting. More boys indicated that they chose STEM for reasons relating to the influence of others (6.3%), their view of the profession and sense of personal suitability (12.6%), and the perceived benefits of a STEM career (11.6%). Altruism (11.9% girls), as well as following a passion or dream (9.5% girls), were more common responses amongst girls than boys.

Qualitative Findings

A number of themes emerged from the analysis of focus group data, including a misalignment between student aspirations and parents' understanding of their child's aspirations; the creation of a supportive environment (including prioritizing education with a focus on achievement); encouraging children to choose a career that they enjoy; and gendered norms. Each of these themes is illustrated below, using excerpts from interviews with students and parents. For each quotation, the participant is identified with a pseudonym, their gender, year level at school (for students), SES quartile, location, and the year in which they provided this response.

Alignment

In some families, the parent's understanding of the aspirations of their child was misaligned with the responses provided by the child themselves. For example, Cath, whose son had reported an interest in engineering on three occasions (2012, 2013, 2014) as well as in his own focus group responses, reported that:

> My son has no idea . . . 14-year-olds, unless they're destined to be something or focused, it's really hard for a kid to be focused and say, "I want this specific career." They don't know what the career fully involves. They don't know what they're good at because they haven't really tried it. It's hard for him. . . . He's like, "I don't know." (Cath, female, mid-high SES, metropolitan, 2014)

Later in the conversation, Cath also stated:

> Always from a young age [onwards] we've encouraged Tommy towards knowing that university would be a good step. . . . He's doing engineering now [as a school elective]. That was a little bit of a push from us and he mentions that sometimes now. (Cath, female, mid-high SES, metropolitan, 2014)

Indeed, Cath's son echoed this guidance and encouragement provided by his family, saying: "My mum, my dad, and my stepdad all reckon that engineering is the way that I should go" (Tommy, male, Year 10, mid-high SES, metropolitan, 2014). This example highlights a possible lack of shared understanding or communication between parents and their children regarding occupational aspirations.

Environment

As Figure 2 reveals, few students indicated in their survey responses any direct parental influence as a reason for their choice of a STEM career. However, other researchers have suggested that parents are a key influence on students' education (Gemici et al., 2014; Khattab, 2015) and career aspirations (Jodl, Michael, Malanchuk, Eccles & Sameroff, 2001). Our earlier analysis also indicated that children are more likely to aspire to a STEM career if they have a parent in a STEM career (Holmes et al., 2017).

The parents in our sample consistently spoke of creating a supportive environment. There was a focus on education, achievement, and choosing a career that was enjoyable. While the same may be true of the parents of other university (non-STEM) and non-university bound students, these conditions serve to elucidate aspects of parental influence.

Parental support

A key finding from parent and student focus groups was the positive influence and support that parents provided for students who expressed an interest in STEM careers, regardless of the gender of their children. This often included financial support in some form:

> Like we all do, I want her to go to uni or do something while her father and I are supporting her so that she doesn't have to struggle. . . . We talk about all that kind of thing but I try very carefully to guide them towards making smart choices. (Tracey, female, mid-high SES, provincial, 2014)

> As parents, you work around to leave the money aside, because we know it's going to cost us a fortune to get him there and enjoy it as a parent. . . . I suppose we do our best to get [support] them and open all the doors that we can to get them to get their dream and at the end of the day it's up to them to make it. (Carol, female, high SES, metropolitan, 2013)

In many cases, parents described and noted the importance of providing a supportive environment, rather than support for a particular career. Millie, for example, spoke about the support she provides to her son, who has expressed an interest in being a video game designer:

> Yeah. I'm happy the future looks bright. I don't mind if he goes to university or not. I think Lazaro will go to university. I can't see how he will do anything that he's interested in without going to uni… I think he would love it. But if he chooses a different career path and it's something that he loves, I'll be just as happy with that, because they need to be happy more than anything. (Millie, female, low-mid SES, provincial, 2013)

Evidence of the support provided by parents was reiterated by their children:

> But dad just says, "Don't really focus on it until it comes to that stage." He just says, "Focus on what you do now and what you need to do before you get to that stage, and then maybe we'll talk about uni and all that." But he says, "You've still got high school yet." (Nathan, male, Year 6, high SES, metropolitan, 2013)

Parental support for students' interest in STEM careers included financial support and the creation of a supportive environment. The support provided was not specifically aimed towards STEM careers, but rather towards guiding students to make "smart choices" and ensuring they were happy with those choices.

Doing your best

Many parents of the children who expressed an interest in a STEM career described how they encouraged their children to work hard and to do their best:

> I just say… "You've got to look after yourself mate. You've got to be the one responsible for your work at school and your homework because when you get to university. . . . there's no one going to be there with you. You're going to have to turn up for class, you're going to have to do your work and nobody [is] going to care if you lose. You're going to have to handle it buddy." . . . it's sink or swim and that's it. (Fred, male, mid-high SES, provincial, 2014)

> And I just encourage that [working hard] and say like, "Even though you might be sick of it, you just need to work hard until you get to that end of Year 12 to keep your windows open and doors open." But yeah… to get to do what they want to do and they've got to work hard to get to that. (Carol, female, high SES, metropolitan, 2013)

This concept of working hard is consistent with a "growth mindset"; the notion that abilities can be developed, and that the more effort you put in—in the form of "hard work"—the greater the reward, learning, and success (Dweck, 2009).

Parents' expectations

In almost every instance, parents of students who expressed an interest in a STEM career reported high expectations of their children. This expectation extended to educational aspirations, as parents exerted implicit and explicit influence over their children and encouraged further education:

> Always from a young age [onwards] we've encouraged Tommy towards knowing that university would be a good step because it would just make life easier for him and [lead to] better career prospects. (Cath, female, mid-high SES, metropolitan, 2014)

This influence was not limited solely to university education; many parents saw some form of post-secondary education as key:

> I think it's essential for them to… get some kind of further education just to set themselves up for a viable life where they can support themselves and have choices. I think it's important. (Tracey, female, mid-high SES, metropolitan, 2014)

High parental expectations were often key to encouraging student aspirations, with parent responses suggesting that higher education is both "a good step" and essential in setting up "a viable life," thus equating higher education with a measure of success in later life.

Happiness

In addition to conveying high expectations and encouraging their children to do their best, many parents placed significant focus on choosing a career that would make their children happy:

> My advice to my boys has always been: "Do what makes you happy. If that's going to uni, go for it. If that's… digging a hole for the council, whatever makes you happy. If that makes you happy, fantastic." (Annie, female, high SES, provincial, 2014)

> I give her things to think about… but I tell them, at the end of the day, that what they want to look at, for any sort of job, is that it's something that they find fun and that they can enjoy because it's a long time to work and "if you can find something that you love and do it from a young age well then that's what you've got to strive for because by the time you're 22 you just need any job. So, at 18, think about what you think would be the best thing that you could possibly do and strive for that." (Renee, female, low-mid SES, provincial, 2014)

Their children's happiness was a key and consistent theme in the parent focus group interviews. However, this happiness was qualified by ensuring that students made some effort to work towards a chosen goal. Annie, for example, says "go for it," while Renee encourages her daughter to "strive for that," suggesting happiness does not come without determination and aspiration.

School choice

School choice was another important consideration for the parents of the students who had indicated an interest in a STEM career (noting that they were all attending government schools). While in previous studies researchers have found that parents base school choice on the aspirations they have for their children (e.g. Beamish & Morey, 2013), we found that parents of students who aspire to STEM careers made conscious decisions based on a number of key considerations regarding school choice. In some instances, parents stated that they chose schools that were best suited to their children:

> Well, I looked at four schools… but I chose to come here. It wasn't because we were zoned, and I think it's a very good school . . . I

> looked at [an independent school] which has got a fairly high reputation [and] I looked at the Catholic schools, but I actually chose here because I believed that it was the best school that I could send my child to. (Ruta, female, high SES, provincial, 2014)

Some parents spoke about the specific subject interests of their children. Craig, for example, said: "The thing I like about the school is the GATS [Gifted And Talented Students] program. That's why my son came here. He came here for it and [he] loves it" (Craig, male, missing SES, metropolitan, 2014). Others indicated that the learning experiences were fundamental to their school choice:

> You know, we could afford to send our kids to the [independent school] or the Catholic schools, but we chose the public system because we think that that gives our kids an opportunity to blend with all the different people from all different cultures and even just your blow-ins [people that have just arrived in a place] . . . . The kids are learning from those experiences. They're learning for themselves, you know, how to get along with all different types of people. (Irene, female, high SES, provincial, 2014)

For other parents, ensuring that their children had every opportunity for success was key to their choice of school:

> This is her first year and they had gone to a public school before coming here and I did really investigate where I was going to send them to high school… I wanted a school that they all could go to and all succeed at. So I did really look at where I was going to send her and I've been so impressed and so happy [with the result]. (Renee, female, low-mid SES, metropolitan, 2014)

These examples signal parental concern about the quality of schooling. Whilst Ruta believed that "it was the best school" for her child, Irene emphasized the opportunity for learning experiences, and Renee highlighted the importance of selecting a school that her child could "succeed at." These responses demonstrate an evaluative process undertaken by parents who were actively engaged in selecting the most appropriate school for their child.

Gendered norms

Whilst the environment provided by parents was an important factor in creating a supportive space in which students can aspire to STEM careers, there were indications that this support was affected by gendered norms. Parents of male children were more likely to suggest STEM careers such as engineering if their child showed aptitude in either mathematics or science:

> You could say, "You're good at maths, the engineering thing could be okay" and he's like, "I don't like maths really. I'm good at it but I want to do something that's going to be fun." They don't know what the whole degree entails so I think it's hard to make the decision to

> make the step on what to study. (Cath, female, mid-high SES, metropolitan, 2014)

For boys, the acknowledgment of interest or ability in mathematics often led to encouragement from their parents to use their skills in appropriate STEM careers. In the following quote, Mae appears to have high expectations and a strong belief in her son's ability:

> See, that's the problem I've got with Luke too, he likes to be something like, you know, testing these games and that, and I think to myself, but I say to him, I say, "But Luke, you love maths, you love science, why don't you use those sort of things?" Like years ago, he was going to be an architect; that's gone out the window. (Mae, female, low SES, provincial, 2014)

Mathematics, science, and in particular engineering appear to be socially acceptable careers for boys, as reinforced by the number of boys who aspire to STEM careers (Holmes et al., 2017), and evidenced in Figure 1. This normalization of a career path for boys is reflected in the responses of parents who encourage their sons towards STEM careers, and further reiterated by students in the focus groups, for example, Tommy who earlier stated that his mother, father, and stepfather all encouraged engineering as an appropriate career choice.

For girls, a career in STEM is not a normalized occupation, with fewer girls aspiring to careers in STEM fields in previous studies (Archer et al., 2013b; Holmes et al., 2017). A career in STEM was, however, perceived as being suitable for those girls who are "super intelligent":

> My daughter is super intelligent; she's grade-skipped two years so she'll definitely go to uni. . . . She has an IQ of 160-something… We didn't even know until two years ago. Yeah, so she'll definitely go to uni. She wants to be a scientist. (Kathleen, female, mid-high SES, metropolitan, 2014)

The belief that science careers and aspirations are only for "super intelligent" students was also reported by many students in the ASPIRES project in the UK (Archer et al., 2013a). When focusing on those girls without science aspirations, Archer et al. (2013a) found an association in both parent and child interviewees between science and "cleverness." The authors reported that for many of the girls in their study this association played a prominent role in making science aspirations "unthinkable" (Archer et al., 2013a, p. 183) because it did not fit with their sense of self as students, or their constructions of desirable femininity. For the other girls in our matched subsample who aspired to STEM careers, there was an absence of any explicit or implicit encouragement towards STEM from parents. Instead, general overall support for education was evident.

DISCUSSION AND CONCLUSION

Focusing on those students who expressed an interest in STEM, the aim of this study was to better understand the critical influence of parents on the formation of STEM career aspirations and to ascertain if this influence varied in accordance with the child's gender. The findings from this study may not be generalizable to the broader population because parents self-selected to answer the survey, the majority of parent surveys were completed by mothers, and the cohort was skewed towards high-SES families and limited to government schools. A key strength of this study, however, is the inclusion of students from Year 3 to Year 12 of their education, thus allowing the exploration of parental influences on student aspirations towards STEM from an early age onwards. This adds to the growing body of evidence that suggests students' attitudes towards working environments and career choices develop from an early age (van Tuijl & van der Molen, 2016; Watson & McMahon, 2005) and that adolescent career-related aspirations are predictive of eventual occupational choice (Webb, Lubinski & Benbow, 2002; Wigfield & Eccles, 2000).

The aspirations of students in this study to attend university were quite high, which is consistent with the findings presented by Archer et al. (2014), who examined the science and career aspirations of children and adolescents in England. This could be attributed to the education level of the respective parent; more than half of the parents in this subsample had a university degree, compared to the larger sample (43.1%). Over 80% of students with STEM aspirations also aspired to attend university, in contrast to 61% from the larger sample. This finding is consistent with the notion that students tend to aspire to at least the same or a higher qualification level as that of their parents.

When considering the aspirations of parents of students in this study (using all the matched student-parent survey data), it appears that fathers and male carers have higher aspirations than mothers and female carers for their children to attend university. However, when considering only those students with STEM aspirations, this difference is not evident. In the context of this study, given that parents self-selected to complete the survey and the majority of parents completing the survey were female, this finding should be interpreted with caution. Nonetheless, it is important to consider the potential differential impact of parents, particularly given the fact that fathers are now more involved and more engaged with their children than ever before (Yogman et al., 2016), and women are working longer hours outside of the home (Bianchi, 2000). A recent systematic review of Randomized Controlled Trials (RCTs) assessing behavioral interventions involving parents and their children demonstrated that researchers often cite "parents" as an important factor, yet frequently this information is provided only from the mother's perspective (Morgan et al., 2017). While some researchers may assume that a mother's perspective is representative of the family unit (Wake, Nicholson, Hardy & Smith, 2007), others have noted that the parenting practices of mothers and fathers may differentially affect child behavior (Lloyd et al., 2014; Patrick, Hennessy, McSpadden & Oh, 2013). Future research should address the potential differing influences that mothers and fathers have on the STEM career aspirations of their children.

We found that the parents of STEM-aspiring male students were more likely (albeit only slightly) to have university aspirations for their children compared to the parents of STEM-aspiring female students. This could potentially be explained by the gendered view that "boys are good at maths" and tasks or activities related to mathematics. It is both possible and conceivable that parents cannot visualize the path for girls into STEM as clearly as they can for boys. Given the importance of STEM role models to children (van Tuijl & van der Molen, 2016), it is just as important to have parents that are aware of those types of role models (male and female) so that they too can see what might be possible for their children. Variations in the aspirations that parents have for their daughters, compared to those for their sons, could also be explained via cultural factors. Bodovski (2010), for instance, found that European American parents had higher educational expectations of their daughters, while in contrast, African American parents had higher expectations of their sons. Furthermore, Polavieja and Platt (2014), using data on British children, found that parents with a lower education level were more likely to have gendered career beliefs when compared to more highly educated parents. However, the authors also suggested that a girl's level of motivation and self-esteem may allow her to aim higher, and thus lead to less gender-typical occupational aspirations, independent of parental characteristics (Polavieja & Platt, 2014).

Our analysis indicates that boys and girls not only aspire to different types of STEM careers, but also provide different reasons for this interest. Boys were more likely to name engineering professions as favored STEM occupations, while girls were more likely to name a career in the life sciences—most notably in marine biology. Despite parents seemingly providing similar supportive environments for their children regardless of their gender, the influence of both others' (including family and other adults) and students' beliefs in their own personal suitability were more prominent reasons for interest in a STEM career among males than females. This could be partly explained by the focus group data, in which we found parents engaged in dialogue with their male children regarding STEM careers in different ways to their female children. In our sample, there was no explicit or implicit encouragement for girls towards STEM careers. Conversely, students who were both male and described as being good at mathematics or science were more likely to report receiving parental encouragement towards STEM careers. Parental encouragement of STEM careers for boys may increase a child's belief in their personal suitability.

Overall, the analysis highlights the importance of considering parental influences on students' aspirations, which may help to inform the activities and strategies that schools and universities undertake in order to attract (and retain) both male and female students into STEM pathways. This notion aligns well with prior studies in which other researchers have also suggested that parents are perhaps the most important factor in raising aspirations (e.g. Gemici et al., 2014). Educating parents about otherwise stereotypical views of STEM that may prevent them from encouraging their daughters as much as they encourage their sons is thus an important consideration. However, given the skewed nature of our data towards high-SES families and the relatively small percentage of fathers involved, further

research is required to understand the specific impact of a parent's gender. Furthermore, the multiple forms of data reported in this study highlight the complexity of how STEM aspirations are formed. Our results also signal a need to develop interventions that successfully leverage the influence of parents and expand on the range of possibilities considered by both girls and boys.

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