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Investigating the Impact of an Outreach Intervention on Girls' STEM Identity Formation

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ABSTRACT
Previous research demonstrates that developing a STEM identity is key to students achieving long-term engagement with STEM. This paper reports on a 10-week intervention combining the use of mentors with real-world problem-solving activities with the aim to contribute to girls' STEM identity formation and improve their interest and participation in STEM. The intervention was delivered in nine schools to 200 girls aged 13-16 in the Hunter region, Australia, with the aid of 31 mentors who supported them as they worked in small groups. All participants were invited to complete post-intervention group interviews [30 interviews, 3-6 per group] to gain insight into their perceptions of the importance of STEM subjects, careers, and skills; and to determine whether our program had any effect on those perceptions. Girls demonstrated a sophisticated understanding of societal influences that impacted their relationship to, and likelihood of pursuing STEM careers, including certain barriers such as gender stereotypes. Girls found the most useful elements of the intervention focused on contextualising how STEM learning could be applied in practice. Incorporating problem-based activities into STEM learning and providing opportunities for girls to see women working in real-life STEM roles emerged as key factors in the development of STEM identities.

KEYWORDS
STEM education; identity; gender stereotypes

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INTRODUCTION

The development of a Science, Technology, Engineering and Mathematics (STEM) identity has been noted by many as key to girls' long-term engagement with STEM. In a systematic review of almost 40 years of STEM interventions with high school girls, the development of a STEM identity emerged as key in girls' long-term engagement with STEM (Prieto-Rodriguez et al., 2020, p. 443). Being able to identify themselves as "legitimate participants in STEM" is an important part of ensuring girls choose STEM courses through high school and into tertiary education (Hughes et al., p. 1980). Success in drawing girls to STEM careers has been identified as dependent on whether girls come to understanding science as "a meaningful part of their lives" (Adams et al., 2014, p. 15). To increase their science 'affinity-identity' and, in turn, make STEM career choices, girls must not only enjoy science but must also "view themselves as active participants in the scientific endeavour" (Adams et al., 2014, p. 15). This entails overcoming "the mismatch between popular representations of science, the manner in which it is taught, and the aspirations, ideals, and developing identities of young adolescents" (Archer et al., 2010, p. 618). Engagement alone is not sufficient, and girls must feel some kind of ownership over, or meaningful connection with, STEM in order to stick with it.

In describing what we perceive to be a strong STEM identity, we have adopted Carlone and Johnson's (2007) definition of a girl with a strong science identity as it combines competency, knowledge, motivation, skilfulness, socialisation, and recognition. Key to identity formation is that girls recognise themselves as science people. Knowledge and skills can be developed, but there may be little motivation to doing this if girls do not recognise themselves as compatible with, or capable of mastering, science or STEM. Even enjoying science or finding it interesting is not enough to ensure girls choose to study it as they progress through high school (Archer et al., 2010). It is essential that if science is to take a formative position in students' lives, then necessarily, "involvement with math and science becomes part of the progression of more fully becoming one's self" (Kozoll & Osborne, 2004, p. 158).

Although developing a STEM identity has been identified as a key strategy in achieving long term engagement with STEM careers, there have been few previous interventions that specifically aim to target the development of such an identity (Prieto-Rodriguez et al., 2020). To address this gap, we designed and evaluated a 10-week outreach program that aimed to increase high school girls' STEM identity in an attempt to foster their long-term engagement with STEM. The design of the intervention was informed by factors (program length, content, and activities) identified in the research literature as promoting an affinity to, or long-term engagement with STEM (Adams et al., 2014; Boudria, 2002; Dasgupta, 2011; Hughes et al., 2013; McCreedy & Dierking, 2013; Prieto-Rodriguez et al., 2020; van den Hurk et al., 2019). With this in mind, the school-based intervention was delivered over a long period (ten weeks) and included project-based learning (solving a community problem), STEM site-visits (Industry or University sites) and mentoring (from young females studying STEM).

The purpose of this research study is to investigate what girls who participate in the program think about STEM, the relationships they feel they have with it now and into the future, and the extent to which our intervention has influenced that relationship. Through a comprehensive analysis of our qualitative data, we aim to gain a better understanding of how girls interact with STEM in the school context, as well as their perceptions of relationships between females and STEM within broader society. We also hope to uncover improvements that might be made to the intervention, which can be applied in future years, or inform other practitioners of STEM outreach. Bearing this in mind, we approach our data with two research questions:

1) What did girls report as being influential on the development (or not) of their STEM identities within a school, and broader societal context?
2) To what extent did our intervention program have any influence on participants' development of STEM identities?

LITERATURE REVIEW

Significant research across multiple disciplines has focused on understanding *how* a 'STEM identity' is formed and the factors that may contribute to the development of such an identity (Brickhouse et al., 2000; Eccles, 2009; Grossman & Porche, 2014; Naizer, Hawthorne, & Henley, 2014; Tan & Barton, 2008). Research in the field of education suggests that the timing of girls' forming a relationship with STEM is imperative. It is often as adolescents that girls decide whether STEM is compatible with their gender identity (Grossman & Porche, 2014). The science classroom is often a place where students acquire "certain identities that are related to who they are and who they want to be", depending on their role within the class (Tan & Barton, 2008, p. 48). Some studies report that girls often show a larger fall in confidence and achievement than boys in mathematics and science as they progress through high school (Naizer et al., 2014; Sadler et al., 2012).

Additionally, a broad spectrum of social experiences influence on girls' interest in STEM (Hobbs et al., 2017). Studies have shown that girls are more likely than boys to receive unfavourable, simplified or discouraging talk about STEM from their parents and educators, starting from when they are as young as one year old (Newall et al., 2018). For example, in some studies teachers exhibit gender bias by having higher expectations of success for boys than girls (Hand et al., 2017) and attaching boys' success in the classroom to having an innate ability whereas girls' success is due to greater effort (Espinoza et al., 2014).

Indeed, during adolescence, "tensions and negotiations" develop between the multiple aspects of girls' identities, with these aspects "often hierarchically valued or positioned by others through power relationships and societal structures" (Tan & Barton, 2008, p. 49). Girls may decide that other identities are more important to them than their STEM identity: their identities as sportspeople, whether they consider themselves as 'artsy' rather than 'sciencey', and their membership of a racial or ethnic group can all influence their STEM identities (Brickhouse et al., 2000, p. 444). In order to further engage girls in STEM, it is therefore essential that we "know how students are engaging in science and how this is related to who they think they are" (Brickhouse et al., 2000, p. 443).

Within the field of psychology, expectancy-value theory acknowledges the importance of identity, focusing on girls' expectations for success. Jacquelynne Eccles notes two aspects of self-perception which contribute to identity: firstly, "perceptions related to skills, characteristics, and competencies" and secondly, "perceptions related to personal values and goals" (2009, p. 78). While we acknowledge the influence of both of these types of perceptions on girls' decisions regarding school electives, senior secondary and tertiary level choices, societal pressures influence how girls perceive their skill levels, as well as their personal values and goals. Identity development is an individual process, however, it is also a process "that is socially situated, giving rise to meanings and positionings that are part of the social world" (Brickhouse et al., 2000, p. 444). Gottfredson's theory of circumscription and compromise tries to explain with how young people recognise and deal with the vocational choices available to them in society, navigating the complexities of what they perceive as (un)desirable or (un)attainable (Gottfredson, 1981). This process requires that young people first learn about different professions and of their own developing identities, and then discern which of these professions have "rewards and requirements that match their still evolving interests, abilities, values, and goals" (Gottfredson, 2005, p. 4). In particular, Gottfredson suggests that there exist four developmental processes which contribute to the decision making that takes place when decisions around occupations are formed: growth in cognitive ability (cognitive growth), a development of the idea of self (self-creation), a progressive elimination of least preferred vocational choices (circumscription), and an adjustment to societal constraints on this choice (compromise). Importantly for the research reported in this paper, within the third of these processes, young people around age 14 "engage in an increasingly conscious search among […] occupations in their social space, for occupations that would be personally fulfilling. That is, they begin thinking about which careers would be compatible with their more personal, psychological selves." (Gottfredson, 2005, p. 17).

In following this theory, it is safe to assume that any early adolescence STEM-oriented intervention for girls should provide with opportunities for increasing cognitive ability, help with the development of a STEM identity and broaden the perceived scope of STEM careers. In this paper we focus on responses to interview questions regarding STEM identity amongst a group of early adolescents who undertook an intervention influenced by Gottfredson's processes and a thorough review of literature into what elements are to be considered when implementing programs to increase STEM participation in females (Prieto-Rodriguez et al., 2020).

METHOD

School-based STEM intervention

Setting. Our school intervention program has run over three years – in 2017 with 27 participants, in 2018 with 69, and in 2019 with over 104 participants. All nine schools were located in the Hunter region of New South Wales, Australia; and were comprised of public schools except for one Catholic school which participated in 2018. There was a level of relative disadvantage within the majority of participating schools. The 2019 Index of Community Socio-Educational Advantage (ICSEA) score for seven of the nine schools was below the national mean of 1000. The average for these schools was 953.7 (range 852 to 1051) (Australian Curriculum Assessment and Reporting Authority [ACARA],

2020). Participants in 2017 were Year 10 girls (aged 15-16 years). Feedback from this year resulted in us offering the program to Year 8 girls (aged 13-14 years) in 2018 and 2019, as we discovered that by Year 10 girls had already made choices regarding STEM which we were too late to influence.

Recruitment. The project and process was approved by the Human Research Ethics Committee of the University of Newcastle, Approval No. H-2017-0216. The method for recruiting students to the intervention varied depending on which approach/es were deemed most appropriate by each individual school. The possible approaches to recruitment included: 1) invitations to the intervention provided to all female students in the relevant year group (Year 8 or 10 depending on the year of recruitment); 2) targeted recruitment of students based on their existing interest in STEM or high-level of academic achievement; and/or 3) recruitment of students based on belonging to the participating teacher/s class. Students were provided with a study information sheet and consent form which were returned to the STEM teacher involved with the program at their school to indicate their consent to participate in the study. All students, except fifteen girls in 2019, self-nominated to take part in the intervention (N = 200).

Intervention Content and Structure. The intervention engages girls in a ten-week program that asks them to identify and solve a community-based problem with a STEM solution. Community-based problems varied widely and included pollution clean-up, road safety, and mental health. Girls work in small groups, aided by female university student mentors, who are STEM PhD candidates or senior year STEM undergraduate degree students. Their STEM teachers remain with the girls during the intervention to provide support if required but are typically not involved in the running of activities. Mid-way through the program, students visit an industry or university site (e.g., a mine, port, lab or water recycling facility), providing them with insight into STEM careers and into applications of STEM in the real world. At the end of the program girls submit a video explaining their STEM solution (e.g., mobile phone applications, websites, physical prototypes, and virtual reality games), and then attend an Awards Night at which local industry and academic representatives present prizes for the winning solutions. Further information about the intervention is detailed in a separate paper by the research team (Prieto-Rodriguez et al., 2022).

Post-intervention focus groups

In the three weeks following the awards night, we visited the participating schools, conducting 30 semi-structured interviews with groups of 3-6 girls that ran for approximately half an hour. Over the three-year period, a total of 129 students participated in these focus group interviews. Girls were asked questions regarding their opinions of STEM subjects in school, what they believe STEM is and how it can be applied, their career aspirations, the opportunities they believe women have in STEM, and what they thought of our program. The full list of questions is detailed below. A number of prompts was used to elicit further commentary from the girls when only short answers were obtained:

1. Do you enjoy STEM subjects at school?
2. How important do you think STEM skills are?
3. Do you get a ‘buzz’ out of understanding how things work?
4. What would you like to do when you grow up?

5. Can you think of any cool jobs that you could have if you studied STEM, either at uni or in TAFE?
6. Do you think women have the same job opportunities in STEM careers as men?
7. What was your experience of the program? Did it influence your STEM identity?

Interviewers allowed the group conversations to digress if the topic was relevant and of interest to the girls. Interviews were recorded, and then transcribed. Names of participants, teachers and schools were removed to ensure anonymity.

Analysis. Creswell's (2013) six steps for qualitative analysis were used to guide analysis. Briefly, the steps included (1) recording interviews digitally and completing transcription verbatim; (2) reading all transcripts to get a sense of the data; (3) completing coding of data through a combination of computer (using Nvivo software) and hand coding; (4) generating key themes via interpreting codes; (5) making decisions regarding the optimal representation of themes, and (6) determining the significance of themes. A combination of inductive and deductive logic was used (for steps 3 and 4) through looking for mentions of identity formation, as seen in previous literature, and searching for any discourse relating to their interest in STEM. The large amount of data extracted from the interviews provide scope for multiple analyses. However, for the purposes of this paper, we will focus on the theme of STEM identity, and the factors which contribute to it. This means we have focused on the data which inform us about various elements that might influence STEM identity.

To promote consistency and consensus regarding themes, a process of continuous reflection and discussion between the first two authors was completed until we reached a saturation point where no more themes were identified, either from the literature or emerging from the interviews themselves. The first author initially coded approximately 60% of the data until saturation point seemed to be achieved, and subsequently the next author reviewed the codes and coded approximately half of these data. Minor discrepancies were identified, and a second round of coding took place by the first two authors. The fourth author did a further check of these data, and a very high agreement was achieved. The first two authors then coded the rest of the data.
Key points are illustrated by only one to two quotes, when many could have been chosen, due to space restrictions. Pseudonyms are used to ensure anonymity of participants.

In order to uncover how our intervention influenced girls' STEM identities, we asked questions which referred both directly, and indirectly, to identity. The first questions analysed here are related to school subject preferences, which we felt reflected the nature of participants' relationships with STEM (Question 1). Secondly, we explored the way that perceptions of gender stereotypes influenced participants' choices (Question 5), and their views of themselves as potential STEM employees (Question 2, 3 and 5). A series of questions specifically related to our intervention asked about the project that was completed, the mentors, and the industry or university site visit. All these questions were relevant to identity because their answers reflect how aligned participants felt with various aspects of their STEM experience. One question asked specifically about girls' STEM identities. We felt it was important to ask

questions which both directly and indirectly referred to identity, because even though girls might not immediately recognise their own improved STEM identity, we felt that engagement with a mentor, a community problem or a site visit could still have a positive effect on that identity.

RESULTS

A total of 40 themes were identified in this study, however, we have focused on summarising the themes that were most frequently cited across participants below Please see Supplementary Table 1 for the complete list of themes and quotes.

STEM at school

Almost five times as many of our participants reported liking STEM subjects at school as those who did not. This was to be expected considering that most participants self-selected for the program. Science stands out as particularly popular. Several girls commented that they liked the experiments and tests in science: "I find it easier if we do pracs and experiments. I learn easier than just copying stuff off a board". The variety and broad application of science appealed to girls: "science is kind of the answer to the majority of things", and has "more paths" than mathematics. One girl explained that science "never stops, it is an endless mystery, there's much more to find out. You never stop because there are more questions". Compared to mathematics, science was perceived as "more creative […]: there's less boundaries". Technology or coding were the least liked STEM subjects, but still evoked very positive responses in a small selection of participants.

Mathematics was enjoyed by many girls because they found "problem solving" satisfying and liked that "there's a straight answer and no question about it". Mathematics was considered to be "like creating a puzzle" and learning mathematics skills was seen to provide the opportunity to find "answers to the questions that sort of can't be solved by other people". Others found mathematics "unenjoyable", "confusing", "difficult" and "irrelevant", and something that "doesn't come naturally". This was often compounded by students' perceptions that some teachers "don't even really help, they just explain it once and expect you to do it" or who "just give you worksheets", or put "it on the board and then assume we can do it". There was a significant amount of feedback about mathematics teachers, which suggested that if mathematics were taught differently, then it might be more accessible and enjoyable. Some teachers were reported to work through material "very fast" and would start to provide answers before students had a chance to work through the problems independently. Others explained things in multiple ways, which was "confusing" for some who preferred one "clear" and "short" explanation. Some girls reported turning to siblings or friends for help, finding their explanations clearer as "they've had to go through the same process as to how to work it out" while the teacher has "known it for many years".

Women in STEM

A lot of our participants' comments focused on their perceptions of Women in STEM. Out of all the coded data, three main topics obtained the most attention from the girls: women's ability in STEM, improvement in equity from the past, and the fact that stereotypes are still prevalent in society.

Equal Ability. When participants were asked about girls and women, and their abilities and opportunities in STEM, they overwhelmingly reported that girls were just as intellectually competent, if not more, than boys and men when it comes to STEM subjects. Girls told us that, "we can do anything boys can do", that girls are "just as smart" and that "women can be just as strong, just as knowledgeable and just as everything as a man can". Several girls suggested that girls are actually smarter than boys, providing comments such as: "I think we're smarter to be honest. We've got a lot more common sense". Some participants elaborated on the idea that girls have qualities which boys might not possess, and that girls might use their "brains differently":

> "We see the world differently. So they see it from one angle we see it from another, which when you're trying to figure something out you've got to come from a different angle, so sometimes being a women can actually change that."

Our interviewees clearly did not see their ability as holding them back.

Improved Opportunity. Our participants also reported that in STEM, women had "a lot more opportunities nowadays" and that some companies "really welcome all the women". They recognised that "there's more girls working as engineers in the mines and like in mechanics jobs". They also knew that positive discrimination contributed to improve the situation for women in STEM: "there are quite a few places that are actively wanting women and there's now programs that help women get into that kind of stuff". Our participants recognised that they were a part of a generation who are being given "opportunities, because people are wanting to change the fact that it hasn't been equal". One girl commented that, "I can do metalwork, I can do woodwork, I can do technology and robotics if I want to. I could be a mathematician; I could be a scientist", adding that she did not "want to just be like a shop keeper or a vet or something like that". Interestingly, one participant commented that girls "have the same opportunities, we just have to choose to take them", implying that girls feel a sense of responsibility to make STEM careers work for them.

Negative Gender Stereotypes Remain. Despite the belief that girls are the intellectual equals of boys, and that opportunities have improved, many of our participants felt that society still did not accept that women and men were equally valid candidates for STEM careers. The word 'stereotypes' cropped up repeatedly. For example, one girl commented, "I think a lot of places are stereotyped – if you're a woman and you go to apply for a job like at a car repair place…", with another girl completing her sentence: "They'd be like "what?"". These girls feel that a 'stigma' remains because "it's like been a man's work area for so long".

Confirming the existing literature, one of our participants observed that:

> "We grow up stereotyped. Boys have trucks, cars and the colour blue. Girls have the pretty Barbie dolls, the fashion, the hair braiding and pink. So girls probably grow up more interested in fashion and singing because that's what they see on TV, and the girls see singing and fashion and the boys see the guys doing forensic science."

Our participants acknowledged the power of gender socialisation:

> "If you've been told your whole life that you're going to be a stay at home mum and look after the kids, it's hard to shake that and it's hard to look past that and say 'well maybe I'm interested in something else', because that's just what you're told and what you believe."

One girl observed that, "the big important jobs are associated, like lawyers, people who work in banks, scientists even, tradies [tradespeople], they're all associated with men". Participants believed that potential employers would "think that men can tolerate things more than women, like they can deal with all the like little problems, timelines and the dates that things have to be due and the workloads and the stress". There was a perception that a "boss might think [a woman is] not fit enough to do it, or they haven't got enough experience to do it like the males do".

Girls were able to identify how complex societal influences shaped their preferences for STEM: "the fact that [girls] don't like [STEM] […], I feel like it's because they've been told not to. I feel like if it was more stereotypical for women to like do woodwork and stuff, I'd enjoy it a lot more". It was clear for these girls that, "what other people might think might affect people's decisions". There was an understanding of the persistence of gender stereotypes, and that although opportunities for girls might have improved, that "because girls weren't given as much of an opportunity before, people say, 'yeah you have a choice', but then they don't really". Our young participants could see that things have changed, but also knew that in some ways they had not.

Interestingly, participants had observed that sometimes women went for stereotypically 'female' jobs, because they just needed an income, and could not afford for their career choices to be overly selective. There was a sense that financial pressures might limit choice: "If we want to get a job and that's the easiest and we need that money, then we're more likely to, then we'll probably go for it, cos it's like 'we'll get it'". Another participant commented that: "Sometimes females just go for the job that people think are for females, just because they might need extra cash". These girls had observed women who were under financial stress, and who were left with minimal choices, and without the luxury of being able to further their training or education.

The intervention and girls' relationship with STEM

Each aspect of our intervention (site visit, mentoring, and problem-based approach) influenced girls' relationship with STEM, often leading to them feeling more like 'STEM people'. The final subsection below, 'Identity', includes responses to a question that asked girls directly about their STEM identity.

Site Visit. The most positive feedback we received about our intervention was regarding the industry or university site visit. Girls found these visits "interesting", "inspiring" and "cool", and the "highlight of the whole program". Seeing STEM in action provided our participants with a clearer picture of what STEM is: "when I thought of engineering, I thought of just being a mechanic, like that was just the only thing, but [the visit] made me realise there's lots of other things". For participants, the visits, "opened [their] eyes up to the different job opportunities". Girls commented that, "we had no idea that any of those people did that sort of stuff", but that now they could see "STEM in real-life jobs, and what it could lead to".

For our participants, seeing women working in real STEM jobs was inspiring: "we got to see how many women there are and what they actually do and the environment they work in. You could see what we're capable of doing". A visit to the university revealed "a lot of girls […] in the like chemistry science labs and there were lot of girls in the technology sort of area". This got our participants "thinking about uni and what [they] want to do" because they "could picture [themselves] doing that one day". Seeing STEM in a real-world context provided girls "a new view of everything we do at school. We're not just doing this because we have to learn it, we're doing it because it's important to our education, that we want to and it's enjoyable for us to do". The visit provided our participants with a context for how their learning might be applied.

Mentors. Participants' relationships with program mentors also emerged as having a significant effect on engagement, and on their emerging relationship with STEM. On the whole, participants "loved working with [mentors]". Mentors gave the girls encouragement and confidence. Participants were attuned to the differences between teachers and mentors: "they're like more than teachers, mentors give us space to be able to think and talk". They appreciated that mentors motivated them but "were just guiding, they weren't telling us to do certain things"; and believed that mentors "helped [them] navigate but without [giving them] the answers, still letting us discover it".

Community problem. Being able to solve a problem in their own community was another significant way in which girls became engaged with STEM. Our participants enjoyed being able to choose a topic that they thought was "important", that they were "interested in", and that they were "trying to solve something that *we* wanted to solve". There was a sense of accomplishment in being able to help their communities: "I kind of like the feeling of accomplishment, like that we actually just did something that could eventually help someone". And they also enjoyed seeing previously theoretical work come to practical fruition: "I liked that it was a real-life application of things we've been learning so it didn't just seem like another lesson – I was using it".

Identity. Many girls found it difficult to answer whether they believed the intervention had improved their STEM identity (using the proxy question "Did this experience make you feel more like a scientist/mathematician/engineer? Why, or why not?"), with one stating that she did not feel she had changed but being unable to explain why. Some claimed that they didn't feel any more like a scientist or engineer, with one girl suggestion that for this to happen they would have to have done the whole project on site at STEM workplace. However, many girls did report feeling more like a scientist or engineer. Understanding the process of research made them feel more aligned with STEM careers, as did practising hands-on experiments: "you have to go through the work and do all the research and getting all the results down". Using laboratory equipment and "advanced technology", building a prototype, "having to help code the app", and learning to "think outside the box" all made girls feel that STEM was part of their identity. For one participant, being able to do hands-on tasks improved engagement: "you actually learnt it, you weren't just doing it for fun, you were paying attention".

Our intervention emerged as an enlightening experience for some, and one that left them feeling aligned with STEM: "as soon as I started it and learnt about

engineering that's when I realised what I wanted to do". Another girl commented: "I didn't know what I wanted to do but as soon as I did [the intervention] I was like 'That's what I want to do!'". One girl was emboldened by "the feeling that you did something that people mostly stereotyped as [for boys]", and another was inspired by the university environment: "I felt like a scientist when I walked into the university, I thought 'I can do anything'".

DISCUSSION

We argue that fostering a STEM identity is key in improving the chances of girls developing a long-term relationship with STEM. The development of a STEM identity relies on multiple factors (Adams et al., 2014, p. 15). Our intervention therefore employs a multi-faceted approach in its attempt at enabling the development of STEM identity in our participants. By tapping into the positive influence of mentors, hands-on activities, real-world settings and independent learning, we hoped to further develop girls' STEM identities and encourage their long-term engagement with STEM careers. Our data suggest we may have had some success. However, girls reported the persistent influence of gender stereotypes within society as being detrimental to their likelihood or engaging with STEM, and their long-term success if that engagement is achieved.

Battling stereotypes

Our data indicate that at the age of 13-16, girls in our region recognise that they are just as capable, when it comes to STEM, as are boys. They also know that opportunities have improved greatly for them, both in school, where they are free to choose the same subjects as boys, and as they progress to university. Despite this, our participants recognise that stereotypes do affect the educational and career paths of girls. They identify two aspects of the way stereotyping is detrimental: firstly, largely men, but also others in society, either directly or indirectly inform girls that STEM is not for them; secondly, girls know that they have internalised these stereotypical ideas about what careers are appropriate for women, and they make choices based on these beliefs. In the school environment some girls reported receiving negative feedback from male and female classmates about choosing STEM electives: "there's a lot of things that people say to make people not do what they want to do". It appears that girls really do worry about what their peers think of them, and they are reluctant to break with gender expectations: "the development of student's motivation and interests at school reflects societal demands of 'fitting in', which during adolescence emphasize gender-role acquisition and one's popularity within a peer group" (Kessels, 2005, pp. 319-320). It follows that if girls do not perceive themselves as similar to the typical "science person" (Kessels, 2005, p. 320), or indeed if the 'science persona' is not desirable within their social group, they will feel discouraged from following a scientific career.

Our interviewees often demonstrated a complex understanding of the different influences at play when it came to their relationships with STEM. They recognise that although opportunities might appear to be equal and that their career path "may feel like a free choice […], it is often constrained by subtle cues in achievement environments that signal who naturally belongs there and who does not" (Dasgupta, 2011, p. 231). On top of this, girls know that if they choose a STEM career, they are likely to be part of a minority working in a largely male field. Girls see this as damaging to women's confidence, and they expect that they might "feel judged" and that the isolation would be "intimidating". Although

the playing field might *appear* to be level, girls know they are actually facing a persistent battle against stereotypes. This is clearly an impediment to their chances of developing STEM identities.

Subject preferences

Understanding subject preferences is of interest to us as these preferences might be key in understanding how girls engage with STEM, and how to encourage identity alignment with STEM fields. We should reiterate that apart from those from one school in one year (approximately 15 out of a total of 129 students interviewed), all students self-selected for the intervention, reflecting their pre-existing interest in STEM. It is perhaps not surprising then that our participants showed generally positive attitudes towards STEM subjects. Although it was not the focus of this study, further exploring the impact of STEM programs specifically among students who are not outwardly interested in such subjects before the program may offer important insights regarding how to best tailor the programs to such children. For our participants, science was preferred over mathematics, and was perceived as being a broader field, allowing for varied interests, and infinite investigation. Many participants stated that they preferred science because they enjoyed the hands-on elements of learning it, compared to mathematics which was largely learnt from the whiteboard. Research has shown that hands on learning in science leads to 'meaningful learning' where knowledge is 'constructed' rather than simply being provided to the student, who is then expected to remember it (Bohlscheid & Davis, 2012, p. 58). A review of the effectiveness of active learning found that Problem-Based Learning approaches lead to positive student attitudes, increased engagement and improvement in long-term retention of knowledge (Prince, 2004). Other studies have indicated that female students respond positively to hands-on elements in their learning (Demetry & Sontgerath, 2013; Laws, 1999). We suggest that ensuring that girls have access to practical and exploratory STEM experiences might be key in capturing their interest and making them feel more like scientists or engineers. This might be a fruitful area for further research.

The finding of student preference for science over other STEM subjects is consistent with previous research (Modi et al., 2012) and may indicate a challenge in fostering female students' interest in non-science STEM subjects, particularly engineering and technology where women are significantly underrepresented. Previous literature suggests that stereotypes about the people (e.g., socially isolated), work (e.g., not a 'helping' field), and values (e.g., masculine interests) of the culture associated with engineering and technology may negatively impact young women's interest in these subjects (Cheryan et al., 2015). One strategy to overcoming such stereotypes is through ensuring such fields are represented by a diverse range of people; demonstrating the fields are not just for one 'type' of person. Although promoting a more inclusive and diverse STEM workforce is beyond the scope of this high-school intervention, ensuring our intervention mentors are representative of a diverse range of STEM professionals may assist in overcoming potential narrow stereotypes regarding male-dominated STEM professions and improve girls' interest in the subjects.

Mentors and role models

Mentors have been demonstrated to make a "tremendous difference" to the way girls relate to STEM (McCreedy & Dierking, 2013, p. 8). Participants' feedback

indicated that they valued the role their university student mentors played in their experience of the intervention. They saw the mentors as intermediaries between the traditional roles of teacher and student, guiding participants without taking control of the projects entirely. Our intention was that the mentors, who all study STEM at university, might act as role models for our participants, exemplifying what is possible for girls who stick with STEM studies. Providing female mentors might go some way to destabilising the stereotype of STEM as a masculine pursuit. This idea has been explored by Dasgupta in her 'stereotype inoculation model' (2011, p. 231). In this model women are exposed to in-group members, that is women who could be considered "experts and peers in high-achievement settings" who act as "social vaccines" by increasing the feeling of "social belonging" and help to "inoculate fellow group members' self-concept against stereotypes" (Dasgupta, 2011, p. 231). The hope is that having female mentors will decrease the likelihood that girls perceive STEM as a solely masculine field. Additionally, it may be worth considering whether the approach taken by mentors in the intervention, in a more guiding rather than directive role, could be incorporated by school teachers to promote further engagement in STEM subjects in high school.

The notion of 'social vaccine' found some success in our intervention. Interviewees reported that meeting women in STEM workplaces on their site visit allowed them to see that women are "strong and independent and able to do everything" and opened their eyes to "what [girls are] capable of doing". But they were less likely to provide such feedback about their mentors. Interviewees' feedback indicates that the potential for mentors to contribute to the dismantling of stereotypes might not have been fully realised. Participants need to see their mentors as bona fide STEM professionals, albeit ones at the beginning of their careers. Perhaps a program session in which an explicit discussion occurs between mentors and participants regarding the mentors' STEM journeys, might promote mentors' status as STEM role models. This might expand the potential for mentors to act as 'social vaccines' against stereotyping; an important contribution to program improvement. The importance of 'social vaccines' may also extend to STEM workplaces, where previous research suggests that the 'people-orientation' of the work environment, facilitated through providing mentoring and team-building activities, may be more important to women compared to men, and contribute to retaining women in male-dominated STEM workplaces (Su et al., 2015). This finding is an important contribution to program improvement.

Our intervention and STEM identity

When we asked participants whether our program had improved their STEM identity, many of them did not understand the question. It came as a novel concept to some that STEM might be considered part of their identity. To assist our understanding of the girls' responses, we refer back to the definition of a science identity provided in our Background section, and look for the elements described there in our participants' experiences. For many of them, our intervention had been an empowering experience in several ways: they felt more competent as STEM practitioners and felt confident that they were capable of following scientific processes, and conducting elements of research. Many of them also left the program with meaningful knowledge and understanding about a STEM field connected to their particular project. They were now more likely to approach problems or to understand the world in a scientific way. And they had

gained skills such as app making, and research methods. Some girls reported a sense of feeling more like scientists because they felt capable of carrying out activities which they identified with the real work of science professionals.

Carlone and Johnson's (2007) definition of science identity includes that a science person must be recognised by others, as well as themselves, as possessing a science identity. Although an important part of the program was about being seen by the community (parents, teachers, and STEM professionals) as a scientist during the final presentations at the end of the ten-weeks, none of the participants emphasised this element of the program as influencing them. Determining whether or not this element of science identity has been achieved, would require further data collection from those who know our participants, such as fellow students, teachers, or family members. Capturing data to measure changes in identity is clearly a challenging process. While we infer from our data that many participants experienced improved STEM identities, and expect that this will increase the likelihood of those girls pursuing STEM careers, only long-term tracking of participants would confirm this. The fact that the intervention did not consistently produce a change in all participants' STEM identity reflects the complex nature of the problem. There are many confounding variables at play, including parental influence, peer influence, teacher involvement and support, differences in mentors and their engagement with the teams. The specific factors that might have influenced girls who did not experience a change in STEM identity is worth further investigation. We also acknowledge that there was a bias in our sample due to the self-selecting nature of recruitment, and the lower-than-average social economic status of the schools. Previous research suggests that students with high levels of SES may be more likely to select and persist with STEM subjects in high school (Panizzon et al., 2018; Tytler et al., 2008), however, this is non-conclusive and requires further research.

CONCLUSION

Our data suggest that participants in our high school intervention experienced high levels of engagement with many factors that contribute to the development of a STEM identity. The hands-on nature of our program, and the industry and university visits, provided girls with a context for their learning, and a depth of understanding about what engineering and science careers look like. The program appears to have influenced students' perceptions of their competence (through problem-based activities and site visits), an important element of Carlone and Johnson's (2007) definition of a 'science identity', whereas improved performance (school grades) could not be confirmed and recognition of themselves as scientists did not appear to be influenced.

Perhaps it is worth noting that even though an important part of the program was about being seen as a scientist by the community (parents, teachers and STEM professionals) during the final presentation at the end of the 10 weeks, none of the participants emphasised that as an aspect of the program they felt had influenced them. They did, however, mention the recognition of other "STEM people" (their mentors), and the possibility of themselves becoming "like them" (the mentors). We believe this is a step towards recognition as understood by Carlone and Johnson (2007).

Additionally, participants saw women working in varied and interesting roles, which demonstrated women's ability and inspired some of our participants to

pursue STEM at university. These experiences enabled them to form more STEM-aligned identities, as they felt more aligned with STEM in the real world. Further improvements to the intervention that were identified in the study included expanding the role of mentors by including a specific discussion regarding their journeys to STEM careers, and ensuring such role models represent the diverse range of women working in STEM professions to attempt to dismantle any potential negative stereotypes associated with such professions. Cultural diversity would also be important to consider in selecting diverse and inclusive role models. This is particularly important for minority girls who might be interested in STEM but often face stereotype threat throughout their education and learning.

Our participants demonstrated a sophisticated understanding of the way societal influences impacted their relationship to STEM, and the likelihood that they would pursue STEM careers. They had an awareness of the conflicts which exist between the purported equitable playing ground that women face in STEM, and the conflicting pressures from society concerning gender roles. Future research would be needed to confirm whether the program affected girls' subject selection in their remaining high school years (Years 11 and 12) and choice of tertiary education, as well as whether there was an increase in the number of female students who chose to pursue a STEM career. Taking the final step towards recognising themselves and being recognised by others as a 'science person' is a challenging one. But steps were taken towards it by some, who felt more confident and "accomplished", and considered studying STEM at university as a "valid option". As one participant said, "we're going to do big things someday!".

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APPENDIX A

Supplementary Table: Frequency of References and Quotes for all Identified Study Themes

Theme category / sub-category	**Themes**	**No. coding references**	**Quotes**
Intervention and STEM			
Negative intervention experience	Clash with schoolwork, sport, activities	33	"It was clashing with all of our school work and we didn't want to keep missing out on classes because we had assessments"
			"…I wasn't there for most of it because I did a lot of sport"
	Disliked topic	15	"Our subject – it wasn't particularly based around STEM. We just created a website that was about palm oil plantation and deforestation."
			"it was very difficult because I don't do computers, I don't do coding, I don't do any of that, so this is the first time for me…"
	Negative mentor experience	24	"We didn't have their full attention. When we wanted to Skype them they were with others schools"
			"...We did things and then like she would think we were doing things this way and we sorta weren't communicating that well. And it would end up like we would do it one way and then she would want us to do it the other way."
	No engagement	8	"Maybe if it was made more exciting then it would be better... I'm pretty sure I can speak on behalf of all the girls that did it, we'd rather go outside and do something practical outside"
			"I wasn't there for most of it because I did a lot of sport, but the sessions I was there for, it was kind of boring, we would finish our stuff early or it was just boring the way some things were run."
	No improvement in STEM identity	22	"No it just felt like an assessment task from school like they give you that thing and just got think up like an idea and just put it together"
			"Nope not really but it got me curious towards things like that though "
	Problem with booklet, Skype, technology	36	"We did try to stick to that but it was difficult because we were doing something and then the booklet said to do something so we would try and do that as well as this and it was kind of a

			little bit confusing, when we still have to catch up on this, but the book was telling you to do the next thing which you can't do until that's done..."
			"Another thing with the technology – with the Wix, it wasn't always working on the internet, so we had to get a teacher to log in or something which wasn't really helpful."
	Problem with group	5	"The only problem wasn't to do with HunterWiSE, it was just the group collaboration, there was a bit of lack of motivation in my group, but that can't really be helped"
			"there was too many arguments"
	STEM career unappealing	4	"I think I'd be able to do it I'm just not sure if I want to"
			"Not really I don't think it's really for me"
	Suggested improvements	44	"Yeah I reckon like small things to change it up like maybe leaving school early and going around to the other groups and helping them out maybe with it so we all contribute to each others just a little bit "
			"maybe like a few more visits with mentors 'cause like, I found that it was a little challenging in the time at the start we were sort of like 'yeah we can do this' and then further to end we were kind of rushed and maybe like a few more visits at the end with the mentors because it was kind of challenging at that end phase"
	Time management	39	"I'm not sure if this was just us but maybe the amount of time we had, maybe it was just us that we didn't manage our time properly but we, at the end we were a little rushed"
			"We didn't have enough time, time was a big factor"
Positive intervention experience	Better understanding of STEM path or careers	41	"I kind of didn't realise before, I knew there was STEM, but I didn't really know what went into it, if you know what I mean. And we've been shown things that we can do, women can do, branching out into STEM which I didn't know about, so I've learnt a lot from it."
			"Opened my eyes up to the like different job opportunities and like that you can get through science, technology, engineering and maths and just the visits were pretty cool I guess"
	Designing or making	15	"Just being able to build on skills that you didn't have or already had a small knowledge of things. Like I had a small knowledge

		of coding and that sort of thing for the app and you could just build on that so much just doing this program."
		"I liked that we got to make our own thing, like our own app, and then show it to people, to tell them what we have."
Enjoyed challenge	4	"I liked how hard it was, cos not everything's easy. I thought it would be easy when we started just like put some things into a computer and then bam it's there, but you actually have to try"
		"Like we didn't get told what to do, we just did it."
Enjoyed groupwork	18	"I liked that it was in teams and it kind of like forced us to actually work in that team environment and as a group not just singular"
		"I enjoyed working in groups and that way we could get it done and we could put all of our ideas together"
Improved STEM identity	55	"I felt like a scientist when I walked into the university, I thought I can do anything "
		" I wanted to experience something that I hadn't really done before, and then after it, and then as soon as I started it and learnt about engineering that's when I realised what I wanted to do"
Site visit	91	"I liked when we went to the university because it got me thinking about uni and what I want to do and stuff like that"
		"It was such a nice workplace, like a good environment to be in for a future job"
Inspired by role model	22	"The ladies that came in seemed pretty strong and independent and able to do everything"
		"Seeing all the women working in the mines was inspiring"
New experience	20	"It was such a different experience to what I've done before. It was really cool."
		"It was a really good opportunity to show you what you could do, because we didn't know anything about all that sort of stuff. "
Positive relationship with mentor	68	"She was really funny and made everything seem a lot easier to do, like the way she explained things was great."
		"Like mentors, yeah they're like more than teachers, mentors give us space to be able to think and talk"

	Program materials	21	"Yeah, it was sort of like a guideline that you could go through and check off that you were doing everything that needed to be met in the project." "I liked the steps in it like the book was very guiding…"
	Solving community problems	37	"I think fact that it was pretty relevant to what goes on around town, it was pretty cool to see how it could affect other things as well" "I liked that it was a real-life application of things we've been learning so it didn't just seem like another lesson – I was using it"
STEM at school			
Dislike	Dislike mathematics	34	"As much as I study for it I can never grasp the concept of some things in maths and it frustrates me" "Yeah I'm good at that too, but I don't like it"
	Dislike other	5	"No, no, didn't like metalwork" "it just doesn't interest me"
	Dislike science	15	"I don't like that there's no straightforward answer, there's infinite questions and they'll never be answered, and I don't like having those questions, cos I can never figure out the answer" "I shut down and I'm like nah I can't do it"
	Dislike technology	5	"I don't really like technology, like on the computer and like media and everything, I don't like that" "The coding bit was boring"
	No interest or engagement at school	26	"We just sit in the classroom and they teach us but we don't really do anything that's interactive, its just sit, write, learn, like you don't get to like put all the things that you do into something, in action…" "My teacher doesn't do many pracs and so its kind of harder to understand and its kind of boring so you don't pay as much attention as we you should"
	Dislike Mathematics teacher	42	"And the teachers that teach it, like they don't even really help, they just explain it once and expect you to do it" "Our maths teacher right now just gives us work sheets and gives a half hour explanation but sometimes I don't get it."

	Dislike Other teacher	22	"Our teachers don't offer us that [problem solving as a a team], and to be honest I get sick of teachers telling me what to do every second I prefer to have that bit more lenience." "Some of them [STEM subjects] are alright but then the teacher sort of ruins them"
Like	'Buzz' moment	111	"It's like you're sitting there and you can't figure it out and all of a sudden it dawns on you " "When you don't understand something in maths and you get it, and your happy about it"
	Like engineering	31	"I like engineering" "I enjoy the engineering part of it, so creating stuff personally."
	Like mathematics	76	"I like equations, they're the easiest things for me to get my head around" "I just like it how there are multiple ways to do something, but it still gives the same answer. I just find it easier than other things really."
	Like experiments	43	"I like the experiment part of science" "I'm pretty sure everyone likes hands-on things cos it's better than sitting at a desk and writing things down. If you're getting up and you're making stuff then it's more interactive and easy."
	Like science	126	" I really enjoy science, not as much maths, but more science" "I just feel like there's a lot more ways you can go with science, like there's a lot of…like biology, and then you can do like zoology and all sorts of similar stuff. Like maths is used in everything but there's a lot more paths you can take with science."
	Like technology, coding	25	"I prefer the technology side, cos there's a whole variety of that as well. It's just enjoyable." "the technology, you can always find new things to do in technology that you didn't know before"
Women in STEM			
	Difficult career path	21	"Especially if you walk in and you're the only woman in the room, that would be really intimidating. I feel like a lot of women back away from it because they just don't want to deal with that"

		" I guess the idea of, if you're one of very few females, then your idea might not be seen as important compared to the males, or someone else might take your idea, and they get all the credit. So you definitely have to fight your way up, work hard to get up that leader board."
Equal ability	49	"Women can do whatever they want to do like if they want to be a scientist "
		"I don't think it's the gender that defines someone, I think it's their capabilities, so women can be just as strong, just as knowledgeable and just as everything as a man can"
Few women	11	"Maybe they don't know that they are able to do it because there's not many women in the area they think that they can't do it"
		"A lot more of STEM per se, like engineering, being a tradie and that, a lot of it there's not many women in there to start with to be welcomed and that, it's just the occasional woman"
Improvement in equity	51	"I think these days it's sort of changing I mean there's more girls working as engineers in the mines and like in mechanics jobs and things like that so in the next few years I reckon it will be equal"
		"I think that like um with more women probably coming up in STEM there's probably a lot more opportunity now than there probably was um in the past, yeah I know that like one of STEM teachers in the school once told us like they're offering a lot more jobs for women in engineering and stuff."
Societal stereotypes negative effect	83	"Yes, cos there's so many men in the thing already I think they're just trying to continue that because they think women are incapable which isn't true"
		"and then the big important jobs are associated, like lawyers, people who work in banks, scientists even, tradies, they're all associated with men."
Women have less opportunities	51	"I think that girls don't get those kind of opportunities because people just think that girls can't do as much as men"
		"I think things are quite difficult with opportunities and everything it's like been a man's work area for so long and it's just women and it's really kind of hard"