# The impact of stem.T4L technology on students' STEM career aspirations

This report presents the findings of research conducted in Semester 1, 2019 on schools participating in the **stem.T4L** project. The research explores the potential link between the use of **stem.T4L** kits and students' STEM career aspirations.

Publish Date: April 2020
Authors: Dr. Rose (Mahsa) Izadinia and Matt Johnson
Email: stem.T4L @det.nsw.edu.au

Technology for Learning Portfolio
Information Technology Directorate
NSW Department of Education

# TABLE OF CONTENTS


Contents ..... 2

Executive Summary ..... 3

1. Introduction ..... 4

2. Methods ..... 6

3. Findings ..... 7

3.1. What did students aspire to do at the outset of the project? ..... 7

3.2. Were there any changes in student likelihood to pursue a STEM career from before to after implementation of the project? ..... 11

3.3. Were there any changes in girls' likelihood to pursue a STEM career? ..... 12

3.4. Did students' STEM career aspirations change due to the project? ..... 14

3.5. How did the project impact students' STEM career choices? ..... 14

4. Key findings and recommendations ..... 22

5. Conclusion ..... 24

References ..... 25

# EXECUTIVE SUMMARY

This report presents the findings of the research conducted in Semester 1, 2019 on NSW schools participating in the stem.T4L project. In this research, we sought to explore the potential link between use of stem.T4L kits and student STEM career aspirations. We hypothesised that effective implementation of STEM technology would trigger students' STEM interest and enhance their self-confidence, which could in turn positively impact their goal aspirations and STEM career choices. Drawing upon a pre/post-test design, we administered online surveys to primary and secondary students that had a stem.T4L kit for one term in Term 1 and Term 2, 2019. In total, 3,494 students (80% primary and 20% secondary) took the pre-survey at the beginning of term, in which 52% of respondents were male and 48% were female. The post-survey was completed at the end of term by a total of 1,478 students, with the majority being primary students (86%) and male (52%). Both pre and post surveys asked students to indicate what they aspire to be and how likely they were to choose a STEM career path. The responses produced both quantitative and qualitative data that was subjected to statistical and thematic analysis, respectively.

The key findings of the research included:

- At the beginning of the project, 45% of students stated that they were likely to have a career in STEM, suggesting a modest interest in STEM fields across the sample. The grouping of the jobs identified by students as their future career approximated this finding, where 41% of the jobs was categorised as STEM. Among the 59% that opted for non-STEM jobs, artistic and creative careers attracted the highest interest from students.

- To understand the factors that shape students' career aspirations, students were encouraged to voice the reasons behind their choices. The majority of students cited self-perceived abilities to perform the job successfully as the main reason for their anticipated career path. This finding confirmed previous research that suggested affective factors such as self-efficacy beliefs and confidence in one's abilities have a determining role in the decision-making process to pursue STEM-related careers. Moreover, the influence of a family member or a teacher was also influential in the choices they made.

- The data from Term 1 and Term 2 suggested an increase from pre to post evaluation in students' STEM career aspirations by 6% and 4%, respectively, suggesting that the implementation of stem.T4L kits enhanced students' STEM interest and influenced their likelihood to choose a STEM career. This finding painted a consistent picture of subtle improvement in student STEM aspirations due to the implementation of the stem.T4L kits. The aggregated data consequently revealed an increase by 5% from pre (n=3,494) to post (n=1,478) evaluation, making the student population sitting on the fence smaller by 3%, and reducing the number of students unlikely to aspire to a STEM career by 2%.

- Gender differences were also examined, indicating that at the outset of the project, a higher percentage of boys (50%) expressed STEM career aspirations than girls (41%). At the time of the post-test, boys still had a higher likelihood to choose STEM fields (54%) than girls (47%). However, the girls' cohort experienced a greater improvement in their STEM aspirations (6%) than boys (4%) by the time of post-test. Based on these findings we argued that, when provided with opportunities to participate in hands-on STEM activities that promote collaboration, team work, and discussion, girls are more likely to express STEM-related career interests.

- In total, at the conclusion of the project, 55% of students agreed that there was a change in their perspective towards STEM and their likelihood to choose a STEM career due to the stem.T4L project. The commentaries provided by students suggested that by the end of the project students gained an increased interest towards the STEM fields, grew more cognisant of the significance of STEM fields for their future lives and job prospects, and this renewed appreciation for STEM contributed to a sense of confidence in STEM learning.

# 1. INTRODUCTION

A myriad of initiatives and programs have been designed and implemented by educators and researchers around the world to promote student interest in STEM (Science, Technology, Engineering and Mathematics). This is because there is a strong link between interest and persistence in STEM (Wang, 2013). In other words, students with high STEM interest and who express STEM related aspirations are more likely to choose STEM careers (Choi & Chang, 2011). It goes without saying that, in a world where economic growth, citizens' health and the nation's stability hinge upon the skills, knowledge and attitudes in STEM (Burke & Mattis, 2007; Bybee, 2013; National Research Council, 2011; Sjaastad, 2012; Prinsley & Johnston 2015), Australia needs STEM literate citizens who can contribute to the STEM workforce. To paraphrase the Office of the Chief Scientist, children entering the education system in 2020 "will be joining a very different workforce" in the 2030s (Prinsley & Johnston, 2015, p.1). As such, it has been a directive of education policy worldwide to encourage young people to pursue careers in STEM fields.

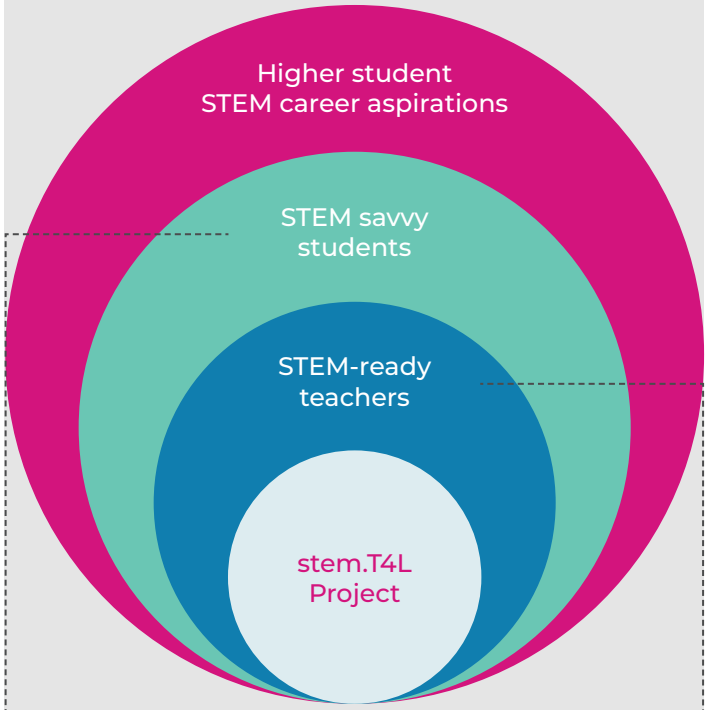
In an attempt to promote young learners' STEM interest, researchers have studied the impact of different, interrelated factors that can steer students in or out of STEM education (van den Hurk, Meelissen, & van Langen, 2019). Some of these factors are to a certain extent malleable, such as school (e.g. the instructional approach of STEM teachers) and environmental factors (e.g. parental beliefs and behaviour). Other factors are less malleable, such as student factors (e.g. aptitude). For education policy makers, targeting the factors that can exert a powerful influence on student STEM interest is a main consideration when designing STEM initiatives (van den Hurk et al., 2019).

The NSW Department of Education's stem.T4L project is one initiative that aims to create new STEM learning experiences for K-12 students by introducing state-of-the-art STEM technology into schools to spark student STEM interest and technology capabilities. stem.T4L was established in 2018 following the NSW Government's Jobs for the Future initiative (Jobs for NSW 2016). The project gives public schools across NSW access to kits containing new educational technologies – for example, robotics kits that teach students computational thinking and coding skills, or 3D printing kits that help students develop design thinking skills. The kits engender classroom environments that are often interactive, immersive, collaborative and problem-based. Teachers are supported through an integrated professional

learning framework of technical and pedagogical support – both face-to-face (the stem.T4L Leaders) and online (predominantly the stem.T4L Learning Library) – in addition to an emerging online community of practising STEM teachers (stem.T4L social media).

Prior research on the stem.T4L project showed that the kits have created a novel experience for students and teachers and the project delivered impressive results in different aspects.

The conceptual model below, created for this project, depicts the achievements gained so far:




- Having a heightened awareness of the significance of STEM
- Displaying competence and confidence in STEM
- Demonstrating advanced 21st century skills
- Being more technology literate

- Acknowledging the significance of STEM education and its benefits
- Investing time and energy in improving STEM knowledge and skills
- Collaborating with other teachers within the STEM Community of Practice
- Demonstrating higher level of STEM teaching competence and confidence

*Figure 1. stem.T4L Project: Conceptual Model*

1. As the second layer of the onion model suggests, we observed significant improvements in teacher readiness to teach STEM. Initially, NSW teachers were cognisant of the significance of STEM education – however, the majority lacked the confidence and competence to teach STEM (please see prior research conducted on this project). Teachers acknowledged an increase in their STEM teaching competence and confidence as they participated in professional learning opportunities offered as part of the project and voluntarily upskilled in STEM knowledge and pedagogy.

2. The project gained noticeable achievements in nurturing STEM savvy students who were characterised by a heightened awareness of the significance of the STEM fields, a higher confidence in using STEM technology, and more advanced 21st century skills (e.g. problem-solving, creativity, team work).

3. The success attained in each of the above-mentioned aspects created subtle changes in student attitudes towards the STEM fields and professions, as found in the present research.

This report presents the findings on the impact of stem.T4L equipment on student STEM career aspirations and interest. We hypothesised that by exposing students to state-of-the-art STEM educational technology and – in the process – modifying and enhancing STEM teaching, student STEM attitudes could be positively changed, which in turn would affect their STEM career aspirations.

# 2. METHODS

The dataset used in this research was collected from NSW primary and secondary schools (Years 5-12) during terms 1 and 2, 2019. As part of ongoing monitoring of the stem.T4L project, self-administered surveys are distributed to students and teachers who are using the kits, at the outset and end of each school term. In this paper, we focus solely on student data. Using stem.T4L communication channels (predominantly social media promotion and emails), links to a Qualtrics questionnaire were provided to teachers, and teachers were encouraged to find time in their teaching schedules to allow students to complete the survey in class. Like previous research conducted on the stem.T4L project, we used a pre/post-test design to compare baseline data against follow-up data to determine the extent of change in students' career aspirations.

The questions raised in this research were:

1. To what extent do students' STEM career aspirations change from before to after using the stem.T4L kits?
2. To what extent do girls' interests in STEM change after the implementation of the project?

We investigated the same concept (i.e. student career interest and aspirations) in Semester 1 to determine if the emerging patterns would be largely consistent among different student populations and through time. Achieving a high degree of consistency across the two terms could indicate that the project was achieving the same results over and over again either positive or negative, which would make the interpretation of the findings and implications drawn more plausible.

The pre-survey included two questions relating to students' career interests and aspirations. The first one was an open-ended item that asked students to indicate what they wanted to be in the future and why. The second question of the pre-survey measured students' self-reported likelihood of choosing a STEM career, using the following Likert scale: (1) Extremely unlikely, (2) Somewhat unlikely, (3) Neither likely nor unlikely, (4) Somewhat likely, and (5) Very likely (we aggregated these into unlikely/neutral/likely for the purpose of analysis). Examples of a STEM-related job (i.e. nurse, accountant, computer engineer, astronaut, scientist) were provided to give students an understanding of what we meant by STEM careers. In the post-survey administered at the end of each term, we measured student likelihood of choosing a STEM career again using this same Likert scale. We also asked students to reflect on their experience with stem.T4L equipment and indicate whether it was their experiences with the kits that had created a change in their choice of future career and, if yes, how did these experiences change their views. In addition, we asked open-ended questions which asked students' reasoning behind their career aspirations in order to uncover the intrinsic and extrinsic motivations contributing to their career choices – these findings could inform the future directions of stem.T4L and school-level STEM education more broadly.

In total, 3,494 students completed the pre-survey, where the majority of respondents were male (52%), and primary students (Years 5 & 6). For the post-survey, we received a total of 1,478 responses with male and primary students accounting for the majority of respondents. The breakdown of respondents in each term is as follows:

### Term 1

| Pre-Survey | Post-Survey |
|---|---|
| N= 1,269 | N=679 |
| Male= 52% | Male= 52% |
| Female= 48% | Female=48% |
| Primary=91%<br>Secondary= 9% | Primary=91%<br>Secondary= 9% |

### Term 2

| Pre-Survey | Post-Survey |
|---|---|
| N= 2,225 | N=799 |
| Male= 51% | Male=52% |
| Female= 49% | Female=48% |
| Primary=76%<br>Secondary=24% | Primary=81%<br>Secondary= 19% |

### Total

| Pre-Survey | Post-Survey |
|---|---|
| N= 3,494 | N= 1,478 |
| Male= 52% | Male=52% |
| Female= 48% | Female=48% |
| Primary=80%<br>Secondary= 20% | Primary=86%<br>Secondary= 14% |

## 3.1 | What did students aspire to do at the outset of the project?

To analyse student survey data, initially the identified jobs in pre-surveys were grouped into STEM and non-STEM categories (STEM Australia, 2019). The list compiled under each category suggested that, at the outset of the project, the greater proportion of students (59%), had non-STEM career aspirations (Figure 2), with 'Art' (e.g. artist, singer, dancer, and musician) attracting the highest interest (11.9%) as Figure 3 shows. Jobs such as teaching (9.5%), sportsperson (9.2%), doctor (7.9%), engineer (6.9%) and veterinarian (6.3%) were also among the most frequently referenced jobs by students.

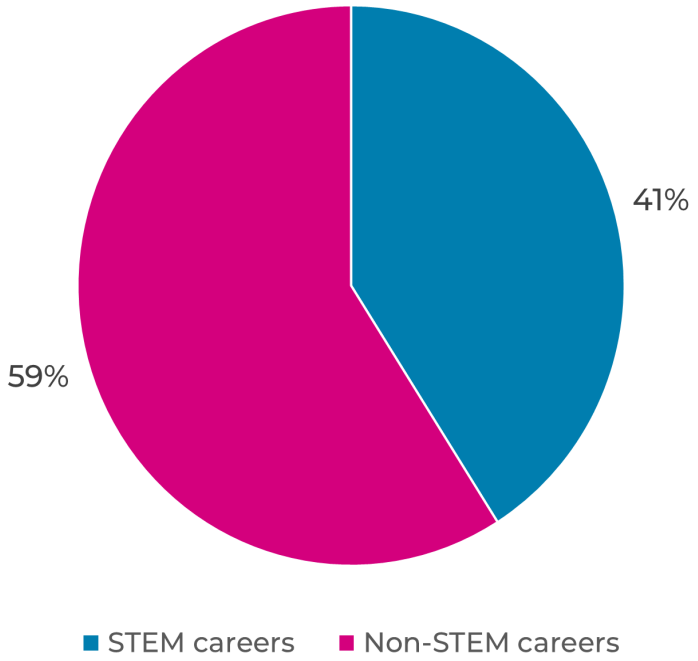



*Figure 2. Student STEM and non-STEM career aspirations: Total-Pre test*

As mentioned above, the surveys explored students' reasoning behind choosing a career in order to better understand the key factors shaping their choices. It is widely accepted that interest promotes early career choices. However, based on Social Cognitive Career Theory (SCCT) personal factors such as self-efficacy beliefs (i.e. one's beliefs about their task capability) greatly influence career aspirations and choices (Lent, Brown and Hackett, 1994). Lent et al. argued "people form enduring interests in activities in which they view themselves efficacious" (1994, p.89). They also added that, when self-efficacy is weak, robust interests do not blossom. This observation was confirmed by our data where we found the majority of students who cited a reason for choosing a future career wanted to be something because they knew they were good at it and had the capabilities to perform the job successfully:

- *I think my future job would be an engineer... I have a very creative mind.*
- *Something in technology because I am extremely good at it.*
- *I am capable to teach.*
- *I am a good instrument player.*
- *A police officer because I am strong...*
- *I want to be a technology maker and fixer because I am a genius.*

As these examples suggest, one's self-confidence and self-efficacy beliefs have a paramount role in generating the motivation and persistence required to pursue a goal (Bandura, 1997). By the same token, students who possess higher self-efficacy in STEM are more likely to pursue a STEM major, which highlights the importance of creating STEM learning experiences that cultivate students' self-efficacy.

In addition to self-efficacy beliefs, contextual factors (e.g. family and other social inputs) exert an influence on student career choices (Lent et al., 1994). The data collected from this research similarly suggested that contextual factors such as simply having a family member in the same profession (e.g. "this is what dad does") or being inspired by a teacher (e.g. "teachers have taught me a lot") appeared to be a driving force for some students in choosing a career. Examples below show the two categories of non-STEM and STEM jobs and students' reasons for their choice.

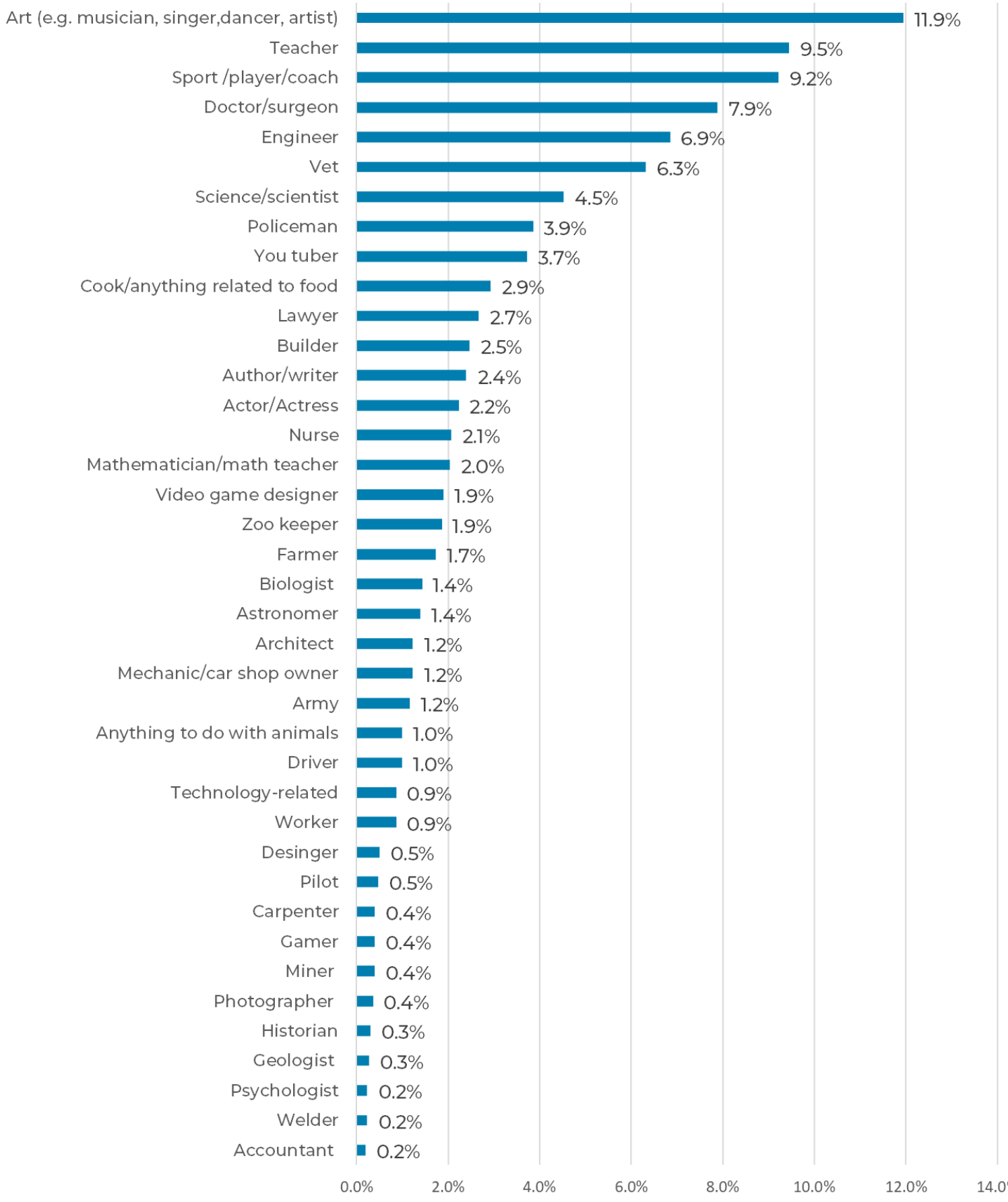



*Figure 3. Student career aspirations by percentage. Total-pre test*

## Non-STEM careers

### Teacher

- *When I grow up I would like to be a teacher because I am capable to teach my classmates. My teachers have inspired [me] throughout my school life.*
- *I think my future job will be Teacher because my Teachers have taught me a lot of things that I can use every day in my life and everywhere I go.*
- *I want to be a teacher because I have the best teacher this year and I want to feel how it is like to be a teacher.*
- *A teacher because we want to help kids grow their learning skills.*
- *I think my future job would be teacher, as I enjoy teaching and being a teacher as a job appeals to me.*
- *My future job would be a PE teacher because I love being active and I love playing sports. I like to learn about what is healthy for you and what's not. This would probably be my future job.*

### Sportsman/player/coach

- *NRL because I like playing the sport.*
- *A professional soccer player because I want to show girls can have an impact in the world and I love sports.*
- *When I grow up I want to be an Olympian. I want to be an Olympian because I love sport and competition. I also want to do intense training and feel the success when all the training pays off.*
- *Being a sport player because I have good sportsmanship and show respect to the other team and the referee or umpire.*

### Art (e.g. musician, singer, dancer, artist)

- *I would like to be a dancer as I do 12 hours a week of classes let alone eisteddfods and extra rehearsals. I think I would love my future job as I love doing dance.*
- *A spray painter and sand blaster because this is what my dad does.*
- *A painter because I love painting and because I will take my grandpas company.*
- *I want to be a musician or an artist because I am really passionate with both art and music.*
- *A session musician because playing guitar is my favourite hobby and I get better every day and it would be very fun.*
- *Musician, because I'm going to a creative and performing arts high school, I already can sing and am going to play alto saxophone.*
- *Musician, I am a good instrument player and singer.*
- *Singer and actress, because I am always writing story's on my computer, singing in the shower and pretending to be in a film like Miley Cyrus.*

### Policeman

- *I think I would be a police officer so I can get criminals off the road.*
- *A police officer because I am strong, I am very helpful and I have a lot of courage.*
- *A police officer because I'm one of the people that love to be active always and showing good examples to others.*
- *I think that I will be a police officer or paramedic because I would love to have a job that can help others and I would love to be happy to go to work every day.*
- *I would like to be a police officer when I grow up because it seems pretty cool and you have to run after bad guys.*
- *I think I will be a police officer or professional gamer but I mainly want to be a police officer because my dad was in the navy and I want to be something like that but not that high up in the forces and hopefully become a detective one day.*
- *My plan is to join the army for 4-5 years them become a police officer.*

## STEM careers

### Engineer

- *An engineer because I like to construct things, sketch up diagrams and reflect on my drawings.*
- *An engineer because my dad is an engineer and I think it is fun. Also you can be at home and do it so if I have a family I can spend more family time with them.*
- *An engineer because I'm good at fixing things.*
- *I think my job in the future will be either a scientist, NASA Engineer or maybe a surgeon.*
- *Engineer because I like programing stuff and fixing.*
- *I want to be an engineer or anything to do with STEM because those 4 subjects I am both good at and enjoy!*
- *An engineer because most engineers are good at maths and I am.*
- *I would love to be a computer engineer because I am really good at using laptops and I love to use anything to do with technology.*
- *I believe I will be a pilot or an engineer because I like to understand how things work and love flying.*
- *An IT engineer because I have a passion for maths and science.*
- *I think my future job would be an engineer as I love working with technology and I have a very creative mind to come up with things no one has come up with before.*
- *I think I will be a computer engineer because I am always connected with technology and fascinated by how much it can help people around the world who are having tough times or have a serious problem that technology can help them with.*

### Doctor/surgeon

- *Doctor, because I am a mini doctor at home. I always try to help others when in need. I help others when hurt. I heard that doctors earn a lot of money and this could be a career for me! And because my parents want me to be a doctor.*
- *A doctor because I like to help sick people.*
- *A doctor, so that I can give my parents a peaceful life afterwards.*
- *Doctor, because I think I really want to be a doctor, like my dads' dad.*
- *I think my future job is going to be a doctor. I would like to be a doctor because I want to help people out and be smart like my mum.*
- *Neurosurgeon. It is the type of surgeon that I've always wanted to be.*
- *I would love to be a surgeon because I would love the money and I would love helping people.*
- *A surgeon because I take interest in the developing organs and all different parts of the body. I embark in a lot of doctor related shows that often feature different types of surgeries.*

### Science/scientist

- *A scientist because I love science and I think it is cool.*
- *Body scientist because I am good at science and I like the human body.*
- *Scientist because I love science and I get to discover and learn about different things.*
- *Scientist (engineer) because I kind of like science and I am good at maths.*
- *When I'm am older I want to be a scientist because when I was younger I loved doing science in school and everywhere.*
- *Scientist. Because I love science and it would be great if that becomes my job.*
- *I would like to become a scientist because of my passion and interest in science and discoveries.*
- *Scientist because I love science and I get to discover and learn about different things.*

### Something to do with technology

- *I think I might be someone who works with technology because I love technology and all the stuff to do with it and it is fun as well.*
- *Making theoretical inventions because I grew up liking technology and was naturally a creative person.*
- *Tech* 😊😁😜👊👍
- *I want to be a technology maker and fixer because I am a genius and the tech could help people with diseases because you can create wheelchairs and more. My hobby will be gaming of course.*
- *Something in technology because I am extremely good at it and I love doing.*
- *Tech Person, because I like tech.*
- *Creative director for Samsung or Apple. I want to go into the field of technology. I think it would suit me as I enjoy designing.*
- *Technology because I fix problems with computers and PS4, PS3, PS2 and Xbox.*

## 3.2 | Were there any changes in student likelihood to pursue a STEM career from before to after implementation of the project?

As mentioned above, in addition to the open ended item, a Likert-scale measured students' self-reported likelihood of choosing a STEM career at the outset and end of each school term. The responses collected from this item indicated that less than half of the students in each term expressed STEM career aspirations (Term 1: 44%; Term 2: 47%). Subsequently, the aggregated data also suggested that of 3,494 students who took the pre-survey, 45% were likely to pursue a STEM career and another 29% were undecided, suggesting that at the outset of the project less than half of students intended to pursue a STEM field. Based on the hypothesis formulated for this study, we expected to see a rise in student likelihood to choose a STEM career from pre to post evaluation as the STEM kits were likely to boost students' interest in STEM.

To measure the changes in student STEM likelihood at the end of each term, we posed the same question: how likely would you be to choose a STEM career? Again, examples of STEM careers were provided to help students understand what we meant by such careers. In total, we collated 1,478 responses from students (52% male, 48% female) across the two terms through post-surveys. As the tables below show, there was an increase in students' STEM likelihood in both terms by 6% and 4%, respectively. Not only did the likelihood increase from pre to post in both terms, but the percentage of students sitting on the fence dropped from 30% to 26% in Term 1 (decrease by 4%) and from 28% to 25% (decrease by 3%) in Term 2. Research suggests students' lack of information about careers in STEM is one of the reasons why they do not pursue STEM fields (Christensen & Knezek, 2017). Given the positive impact of the project on reducing the number of "undecided" students in 2 terms, we concluded that the stem.T4L project broadened the perspective of some students who were less familiar with technology, its affordances, and its impact on their future, and further triggered their interest in STEM fields.

Based on the findings of Term 1 and Term 2, a consistent and positive impact of the project on students' interest and motivation to pursue STEM fields was easily discernible.

### Term 1

| Student STEM Likelihood | Pre | Post |
|---|---|---|
| Unlikely | 27% | 24% |
| Likely | 44% | 50% |
| Neutral | 30% | 26% |
| Total students | 2,225 | 799 |

### Term 2

| Student STEM Likelihood | Pre | Post |
|---|---|---|
| Unlikely | 24% | 24% |
| Likely | 47% | 51% |
| Neutral | 28% | 25% |
| Total students | 1,269 | 679 |

### Total

| Student STEM Likelihood | Pre | Post |
|---|---|---|
| Unlikely | 26% | 24% |
| Likely | 45% | 50% |
| Neutral | 29% | 26% |
| Total students | 3,494 | 1,478 |

When we aggregated the results collected from the two terms, we found modest improvements in students' STEM aspirations from pre (n=3,494) to post (n=1,478) evaluation, as Figure 4 shows. More specifically, the likelihood increased by 5%, making the student population sitting on the fence smaller by 3%, and reducing the number of students unlikely to aspire to a STEM career by 2%.

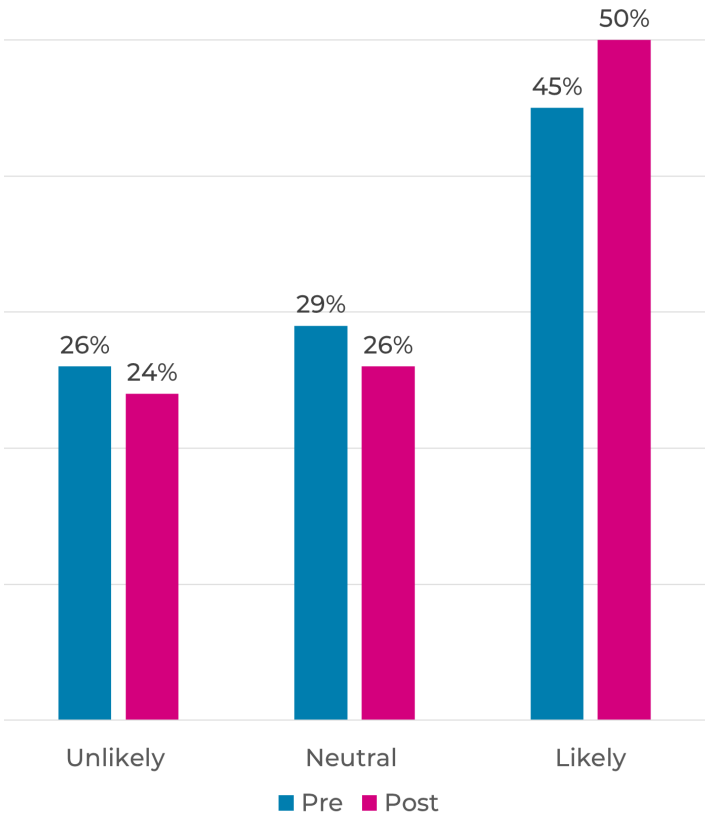



*Figure 4. Student STEM career aspirations in Semester 1 by percentage*

## 3.3 | Were there any changes in girls' likelihood to pursue a STEM career?

Studies show that girls are less likely to express STEM career aspirations (Archer, Osborne, DeWitt, Dillon, Wong, & Willis, 2013). Another line of research also suggests that girls suffer a loss in their interest, confidence and attitudes towards STEM from the beginning of their academic experience, increasing with age and resulting in the gender gap in STEM participation (Fennema, 2000; Hebert & Stipek, 2005; OECD, 2015). As an example, Miller, Blessing, and Schwartz (2006) conducted a study on girls' attitudes towards STEM and they found that girls perceived science to be uninteresting and difficult. The ongoing research on the stem.T4L project consistently focuses on girls, in particular, to determine if the provision of STEM technology can positively affect their perception of STEM and increase their STEM confidence and self-efficacy beliefs. The Term 1 report (please see the Learning Library for previous research on stem.T4L) suggested that there was no statistically

significant improvement in girls' STEM self-efficacy and attitudes from baseline to follow-up. One reason for the observed lack of improvement was argued to be limited exposure to the STEM kits as we found 68% of girls did not use the kits often (i.e. once a week: 32%; only once: 28%; and once in a fortnight: 8%).

For the present research we further investigated changes, if any, in girls' STEM aspirations from before to after implementation of the project in Semester 1. When we cross-tabulated students' gender against their self-reported likelihood to pursue STEM careers, we found that overall a larger percentage of boys indicated a preference for STEM careers in pre (boys=50%; girls=41%) and post surveys (boys=54%; girls=47%). This finding mirrored previous studies indicating girls' lower level of STEM interest (Archer et al., 2013; Eddy & Brownell, 2016).

The pattern emerging from the Term 1 and Term 2 girls data was consistent and showed a rise by 5% in girls' STEM aspirations by the time of the post-test in each term (tables below), indicating that girls became more comfortable with and interested in STEM as they got exposed to the STEM equipment and grew more confident using the STEM technology.

## Term1

| Girls' STEM Likelihood | Pre | Post |
|---|---|---|
| Unlikely | 29% | 24% |
| Likely | 41% | 46% |
| Neutral | 30% | 30% |
| Total | 1,074 | 383 |

## Term 2

| Girls' STEM Likelihood | Pre | Post |
|---|---|---|
| Unlikely | 26% | 23% |
| Likely | 43% | 48% |
| Neutral | 31% | 29% |
| Total | 612 | 324 |

The aggregated data of Semester 1 revealed an increase by 6% in girls' STEM career aspirations by the time of the post-test (total=707), as shown in Figure 5, which was slightly higher than the increase observed in the boys cohort (4%). This finding supported the notion that learning environments that engage girls in hands-on, practical, and technology-enabled activities are more likely to encourage girls' interest and engagement in STEM (Little & León de la Barra, 2009).

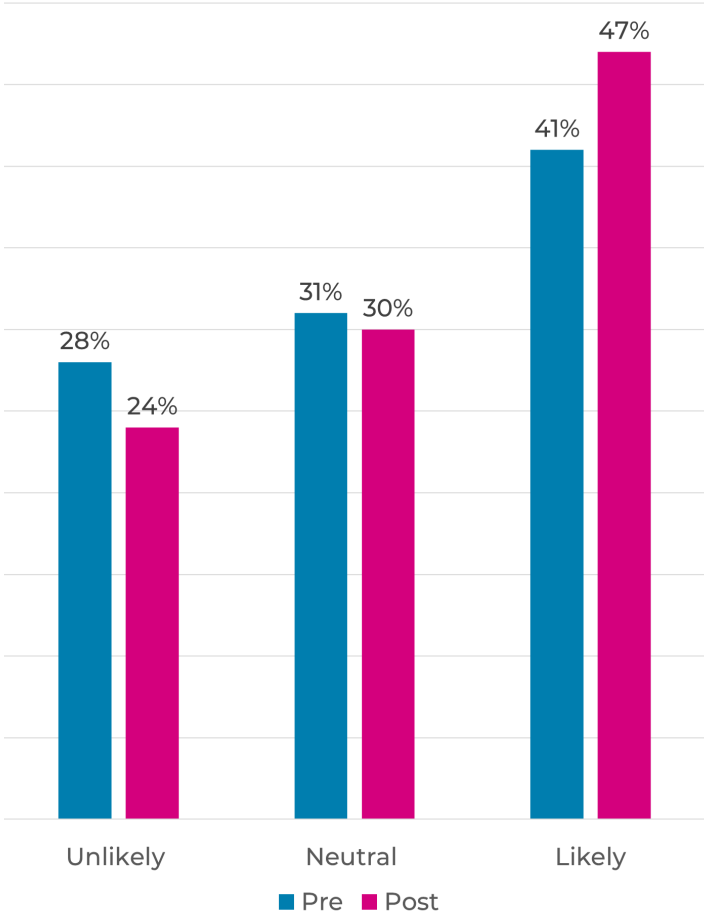



*Figure 5. Semester 1 girls' STEM career aspirations, by percentage*

## 3.4 | Did students' STEM career aspirations change due to the project?

To further crosscheck changes in students' STEM career interest, we explicitly asked students to indicate whether working with the STEM kits had changed their future job aspirations and, if yes, how. Consistent patterns emerged from the data, suggesting that the majority of students in each term agreed that their aspirations for future work had changed due to the project (see tables below).

Across the two terms, out of a total of 1,471 responses to this question, 55% of students said that the kits had changed their perceptions about their future study and career paths.

### Term 1

| | Number of students | Percentage |
|---|---|---|
| Yes | 366 | 54% |
| No | 313 | 46% |
| Total | 679 | 100% |

### Term 2

| | Number of students | Percentage |
|---|---|---|
| Yes | 443 | 56% |
| No | 349 | 44% |
| Total | 792 | 100% |

### Total

| | Number of students | Percentage |
|---|---|---|
| Yes | 809 | 55% |
| No | 662 | 45% |
| Total | 1,471 | 100% |

## 3.5 | How did the project impact students' STEM career choices?

Within the group of students who felt the kit had changed their views, we discerned several themes emerging from students' open-ended survey. The kits prompted: an increased interest in the STEM fields; a reappraisal of STEM education; a reappraisal of their own abilities; increased interest in STEM for girls; and an awareness of the STEM fields' significance for their future lives and job prospects.[1]

### 1. Increased interest in STEM fields

When asked how the kits had changed their view about their future, some students described how their career pathways might now shift towards the STEM fields. For example, one student said their view "has changed from not really being interested, to really interested". A common response was along the lines of, "Now I want to be a scientist one day". Other students described how their experiences with the kits led them to consider careers in particular STEM disciplines. After using the kits, many students were 'dreaming big'. One primary school student wondered that, "Maybe one day I can become an explorer". Another told us that, "Before I did not know [what I wanted to do], but now I know I really want to be an astronaut".

- *The stem.T4L kit has helped me realise that I have a strong passion for science and engineering. This encourages me to become a scientist in the future as well as having some part in biomedical engineering.*
- *After learning about different things like the ocean and space I would like to do something related to them.*
- *It showed me the Great Barrier Reef and how it looked in real life. The VR set was a great influence for some people to be a researcher/s because we got to see what the Great Barrier Reef looked like right now.*
- *I think that most probably I will like engineering because I now know what engineering is about.*

1 These categories are not mutually exclusive, as some students' comments contained a number of themes.

- *I am more interested in science technology engineering and maths and I feel like I would like to choose a career in these fields.*
- *It inspired me to think of options such as engineering, building houses and more - jobs that involve designing and creating new things that work!*
- *I want to be a doctor. Knowing about science will help me to do this.*
- *I now want to be a nurse.*
- *It showed me all about human body so I can be a doctor.*
- *I always have dreamt to be a nurse or a doctor because I strongly believe I can and the way I learn technology impresses people and communities I know. So when I grow up I will always want to be a doctor so I can live a HAPPY life with my relatives and I will always teach my future children to be a doctor as I will hopefully be.*
- *It changed my view because with the stem.T4L it help me with engineering technology and can get me ready for if I be a worker on the railway like a maintainer or an engineer or be a driver.*
- *I want to be an astronaut.*
- *I want to be an architect.*
- *I am now thinking about games designing.*
- *It has changed my view because it has helped bring out an interest of what I like doing. I like to engineer and I like to fix things and engineering is a huge part of STEM.*
- *Because of some interesting and motivational space, I am more engaged and eager to become a cool astronaut for NASA.*
- *I wanted to do nothing but now I want to work with technology.*
- *[I learned] that it would be actually fun to use technology in the future and that it will help me in the future with my career job.*
- *I have learnt a lot about things I haven't, like what a marine biologist does in the sea and what happened in history. Because of it I might even choose a different career.*
- *When I wanted to be an architect that's all I thought of being, but now I have different opinions.*

We observed that some students had moved from considering unconventional or novelty careers (e.g. 'YouTuber', 'detective'), and were now thinking about more pragmatic options (e.g. 'computer fixer'). Some students' perceptions of their future involved supplanting a non-STEM career with a STEM career. This occasionally involved contemplating a shift away from the arts and humanities towards STEM careers, while other students considered moves into STEM from tangentially related fields (e.g. agriculture). For example:

- *I used to want to become a farmer but then it made me realise how much I like building.*
- *From wanting to become an accountant I changed my passion to wanting to become an engineer.*
- *From a YouTuber to a computer fixer.*
- *I was thinking of becoming something like a detective. But now stem kits make me become a computer engineer or something technical so thank you stem.*
- *I wanted to be a vet now I want to be a nurse.*
- *I wanted to be a lawyer, and now I'm considering being an engineer.*
- *I wanted to be a YouTuber. After it, I still want to do that, but I also want to code computer games and bring my imagination to the virtual world. I need all the help and experience of coding I can get.*
- *I felt like I wanted to be a teacher or nurse to help people. Now I want to do something around virtual reality.*
- *It has changed my view because I wanted to be a dancer but now I want to be a teacher.*
- *I used to want to be an artist, and now I still do, but I would rather be an electric engineer.*

The robotics kits appear to have had the greatest influence on students' views about their future. Students linked their experiences with the robotics kits to a new interest in pursuing careers in robotics specifically, while others emphasised that the kits had strengthened their interest in coding and programming.

- *All that engineering and building made me think I want to be a person who does moving robots.*
- *It makes me want to get more involved with coding and technology.*
- *I realised how fun coding can actually be, and I look forward to possibly being a game developer.*
- *I think that the Mindstorms kit has changed my view on them, like at the beginning of the program I only really knew how to make the bot go forward and do some turns, but now I know how to message, how to make it infinite, how to trigger sensors to do what I want it to do, it's really cool.*
- *I have enjoyed doing robotics and coding and I would like to learn more of it.*
- *It made me know that how you can get a job by learning about robots.*
- *Because I never really realised the full potential of robots.*
- *Before I did this I had a limited amount of things I could do as a jobs but now that I know that I can have jobs including everything else I want to do but I have that choice to also code as well.*
- *I like my coding career more now.*
- *I now understand the basics on how a robot works, so I could continue on his task and become a robotics teacher.*

## 2. Reappraising STEM education: 'STEM is fun'

Some students noted that the stem.T4L kits had forced them to reappraise STEM learning – this will, in turn, influence the prospect of them pursuing STEM careers. Many reported that the kits had shown them that STEM education was more fun and less difficult than they had anticipated, and overall a different learning experience. Where students' had revised their perceptions on how enjoyable STEM could be, this was often expressed in quite general terms. Typical responses were:

- *I thought that science wouldn't be a good career because of things being boring, but when I used the stem kits it changed my mind as it was exciting and fun.*
- *I find STEM more fun.*
- *It made me think computer stuff is nice.*
- *I now realise that science is very fun and exciting.*
- *[stem.T4L] has shown me that STEM isn't boring but it's actually really cool.*
- *I love technology now. I used to not like robots, but now I love doing coding with robots. Thank you for letting us code with the robots.*

- *I realised how fun coding can actually be, and I look forward to possibly being a game developer.*
- *I found it more interesting, therefore making it easier to decide that I want to go into this field.*
- *It has changed my view because working with the robots has made me realise that there are not just complex algorithms and equations, but it also has some fun components.*
- *It was fun.*
- *The fact that is it so fun and it inspires me to be myself and do what I like. Everyone should be able to be happy with the kit and be just as excited as I am when using the kit.*
- *I seem more keen to learn at school now.*

Some students offered further detail, describing how their stem.T4L classroom experiences had prompted them to revise their perceptions of what STEM learning could be. This often involved linking their enjoyment of using the stem.T4L kits with an acknowledgement of the pedagogical affordances of the technology. For example, one student described their experiences by saying, "I was not too interested in science [but stem.T4L] has changed my view of it because I have learnt that science can be fun and it has cool experiments". Several students described how the kits made them realise that STEM uses different skills or offers different experiences than what they had previously thought.

- *It makes me realise that all these things we do in school are for an actual reason!*
- *Well, before I thought that STEM was just a little bit of learning about science and stuff but now I know that it's a lot more than that and much better.*
- *It has showed me that science isn't just mixing stuff together.*
- *It helped me learn what science can create if it has the right materials, which is fascinating to me.*
- *More technology less math learning about technology.*
- *It has made me think of STEM as a beauty and not a bunch of random wires joined together to make something.*
- *Because it teaches you to learn better.*
- *Because it inspired me do to better at everything I hope I can be a great engineer when I'm older thank you so much I love you guys thank you really mean that.*

There is the impression here that students are differentiating their stem.T4L experiences from less interactive, theory-driven STEM classes, and this is contributing to the overall appeal of STEM learning and careers. The perceived difficulty of STEM is another area in which the stem.T4L kits have prompted students to re-assess STEM learning. Several students linked their engagement with the realisation that STEM was not as hard as they first thought. Examples included:

- *I thought robotics and coding was hard but now I am good at it and enjoy it.*
- *It has changed me for thinking how easy it is to connect with gadgets like these EV3's and how I can make something that looks pretty cool which I thought I would never be able to do.*
- *At the start before I started it I thought it was going to be hard but when I tried it I loved it.*
- *When I first tried STEM I thought it would be really difficult but in the end I realised it is really easy. For example VR (virtual reality), it looked complicated but it was really easy.*
- *It has shown me that it is easier to code than I thought.*
- *I know it has changed my view because of the way I have learnt to code while using it and creating realistic worlds in tour creator along with coding in co spaces. I honestly think about changing from the job I wanted, to maybe this! It's fun, quick and easy for kids like me.*
- *I thought it would be hard, but when we were on it for a couple of weeks, I started to understand more about the dimensions and how it works.*

Interestingly, some students noted that their revised perceptions of STEM centred on an appreciation of the challenges they faced. The interactive, problem-based pedagogy of stem.T4L contributed to their enjoyment. For example:

- *It helped me realise that technology is very fun if you work hard enough.*
- *It has changed my view by showing me how hands on it is and how fun but challenging it is, and that is the way I like to learn.*
- *It has changed my view because it has got me into liking more technical and challenging tasks.*
- *It has given me more challenging thoughts and makes me want to have a more challenging career.*
- *[The kits did] not necessarily change my view but opened me up and convinced me more and gave me more knowledge of what is capable in the future. I find it interesting and challenging, opening my imagination.*

Although students did not always explicitly acknowledge career pathways when making these comments, this reappraisal of STEM learning (which many students have made while in primary school) has implications for their future study and career decisions. For many students who have used the kits, STEM careers will likely be a more appealing option when the time comes for them to specialise in a particular field.

## 3. Girls and STEM: 'I could accomplish anything that a boy could do'

A number of girls made interesting observations about how their perceptions of STEM had changed after using the kits. This often involved a similar re-appraisal of the difficulty or appeal of STEM learning, but was expressed instead as a new appreciation of girls' equal ability in using STEM technologies. One primary school student said that the kits had taught her, "That boys and girls should be equal when it comes to jobs and possibility". Other students told us:

- *It's changed my view that boys and girls can fix technology.*
- *It has been good for me as it gave me an opportunity to see what I can do. I am in a class where there is only two girls so it was fun to be able to solve the problems.*
- *Well, at first I thought I had no chance at fixing tech or working with it but once I got confident with the iPads I knew that I could accomplish anything that a boy could do.*

New capabilities and dispositions also appear to have been acquired by some girls through this increased exposure and access to STEM learning technologies. Particular Learning Challenges were cited as a source for this newfound enthusiasm, such as the Makey Makey lemon battery exercise or activities with Lego WeDo.

- *After the first couple of minutes playing with the Robots and the Lego WeDo, I realised both genders can do it and that it was really fun and interesting. Overall I had lots of fun in the library playing with the robots and doing the Lego WeDo.*
- *Well, a lot of people say let boys do it because they are stronger but from those STEM activities I feel like girls can do it just as well if not even better. This has really changed my mind about thinking and now I know way more about how the battery works and I am way more educated with science and technology.*
- *It showed me that engineering and science was amazing and also really fun. It was so interesting to learn new things like how to make a lemon battery. It taught me to try new things with new people that I would not normally work with. Overall, I do not think that girls are any less capable to do STEM than boys.*
- *Before we played with the STEM stuff I thought that it was not going to be fun and that it was only for boys, but then when we started to play with the robots and the WeDo Lego it was fun.*

These increases in STEM self-confidence had changed some girls' views about their future. These experiences contributed to a new appraisal of STEM learning, and this is likely to increase the appeal of further STEM study or a STEM career.

## 4. Developing skills and capabilities: 'It made me think that I can do anything'

Both girls and boys spoke about how the stem.T4L kits had changed their self-perceptions of their own abilities. Sometimes this was directly related to a new interest in STEM careers, other times it was a more indirect acknowledgement of how they had improved in certain areas. Most commonly, the kits had made them more confident about approaching STEM learning, specific skill-sets and content areas (e.g. coding) or pursuing a STEM career overall. By inspiring confidence and competence in areas where students had previously experienced difficulty, the kits contributed to increased interest in STEM.

- *I found out that I can do science and technology.*
- *It's made me smarter and has encouraged me to think about STEM :)*
- *It was fun and I feel confident about technology now.*
- *It made me happy and more proud and now I believe in myself and you should as well.*
- *I can now understand that I am capable of things in the STEM activities that I didn't know I could do.*
- *I am more confident about building and programming things now that I have experience.*
- *It told me that I can do coding and building.*
- *It changed to the point I thought I could do whatever I want.*
- *It made me think that I can do anything.*
- *It's told me a lot of things and I can and I might be able to change my future.*
- *I used to think I was terrible with technology but now I realise that I can now be a scientist because I know I'm not disastrous with it :)*

One student also noted their progression over a longer timeframe, reporting that "it has made me feel how good I am at things and how much I have improved from kindy". This confidence was not limited to technical proficiency: a newfound sense of social confidence and a capacity for teamwork or leadership was also evident in the sample. Examples included:

- *When I was little, I was learning how to code but I never really understood so I decided to not do coding anymore but after this STEM activity, I found it easy to work in a group and share ideas I never thought of.*
- *I am more comfortable with learning with others.*
- *Made me think about trying new things and about team work to help me do better.*
- *At the start we didn't know how creative we could be with 3D printing and that we could solve a problem with it. We learned to work better in a team. We didn't realise how much fun it would be learning something new.*
- *It changed my view of being a good leader to others.*
- *It provided new and awesome friendships and made coding more easy.*

Students' eventual career choices will depend on a range of factors, but being comfortable with their peers and learning to share their ideas in a STEM classroom will likely add to their inclination to pursue STEM careers. The sense of curiosity that the kits inspired had, in two student's words, "made me more curious" and "made me more creative and more excited for science".0 Becoming unafraid of making mistakes and learning to bounce back – key attributes of digital resilience – are also contributing to students' consideration of STEM-related career possibilities. Some examples included:

- *I know that it's ok to make mistakes and don't get upset.*
- *Well, I learnt that some things don't work and then you get to figure out what the problem was and you get to try again and see if it works. And, if not, you keep figuring out what was the problem.*

## 5. New horizons: the possibilities and significance of STEM

Students' experiences with the kits also engendered a new awareness about the significance of the STEM fields. There was a pervasive sense among many students that the stem.T4L kits had opened up a new world of possibility and helped them become more aware of the significance of STEM at a broader, societal level. Students communicated how, after using the kits, they had revised their predictions about what they felt the future will hold for them and their peers. One student said their view "went from 2D to 3D". Another student said that the kits "opened my mind to what the future will behold" – pointing to new understandings of a STEM-driven future beyond the question of employment. For one student, visions of a sci-fi dystopia now seemed less likely: "I used to think that robots would take over the world, but they help people do things that are hard for daily life". Other students had similar experiences:

- *It made me think, "Wow! If robots all worked like this, the future would be much more fun and enjoyable".*
- *[My view is now] that it would be actually fun to use technology in the future and that it will help me in the future with my career job.*
- *The kit gave me an idea of what the future would be like including jobs and daily life.*
- *It has changed my view by showing me that technology is going to be in my world when I'm growing up not just sport.*
- *When I went into the Virtual Reality for the first time, I was amazed and impressed about the VR world I was in. It really changed on what I wanted to become when I grew up because of the interesting possibilities I could do when I grow older.*
- *Well now I might be able to fix technology at a store better then what I would've been able to do. Also I might be able to do things in the future that I thought I wouldn't be able to do. My mind has changed about the way I thought about other things. Now I have a better picture in my head of what it will be like. Before I thought it would've been sort of bad but now I think it's good.*

- *It has changed my understanding on how to code. I think that STEM will help in the future*
- *It altered my view by showing me the very basics of high paying jobs, to make my future great.*
- *It has made me more excited for my future.*
- *Because it shows all of the possibilities of technology.*
- *By showing that there are many possibilities.*
- *It changed my view of whether robots will be our future.*
- *When I looked at Virtual Reality for the first time, I was really impressed with all the worlds and different places I could visit without even moving. It changed the way I want to grow up as it showed all the talents people have in this world.*
- *It has enabled me to view the advancements in technology and its exponential growth and significance in our modern day society.*
- *It has given me insight to what technology can be like in the future.*
- *Robots are the next generation.*
- *The future will rely on technology much more than our generation.*
- *It gave me insight into what was achievable with Lego and showed me that there is hope for humanity.*
- *This showed me how relevant technology is going to be in the future and that most jobs will be controlled by robots.*
- *The future with robots could mean less work for humans and the robots might do the repeated jobs.*

Interestingly, some students also noted that their engagement with the kits had encouraged ethical or civic engagements. Sometimes this was a general sense of wanting to help people. Other times, students appear to have had a sudden realisation or 'a-ha!' moment about the societal impacts of STEM.

One student said that the kits have "explained to me that there is more to life than lollipops and rainbows. And I need to care for other people not just myself". Environmentalism was also mentioned by several students, with some reporting that the kits had changed their mind on the potential of technology to ameliorate environmental and social problems (rather than contribute to them), suggesting a new interest in STEM careers on ethical grounds. Examples include:

- *It has changes the way I see my future self, I have also seen the way humans have impacted the Earth and I want to improve that.*
- *Looking at our futures, what is right and what is wrong.*
- *Because of all the robots we can make that helps us as humans and our earth.*
- *Because we are going to destroy the planet and we are going get overthrown by robots this is a bad idea I think we should use this work to save the planet.*
- *The robot kit is fun to play with and it would probably help people in the future.*
- *By showing me what I could do to future generations.*
- *Working with robots isn't just a fun experience it also teaches you many educational things. I want to do something fun but also useful for the society and technology is the perfect match.*
- *Well, I kind of didn't want technology to take off because of trees and pollution, but now I believe maybe technology can help us. It has saved lives in hospitals and helped in many ways. Maybe we could use technology to stop using fossil fuels. But if the future is high tech I still want trees and animals and not a polluted world and no global warming. So maybe we could try balance out the nature and technology. This has changed my mind a lot.*

# 4. KEY FINDINGS AND RECOMMENDATIONS

It has been argued that students' educational experiences have a critical role in fostering interest and predispositions towards STEM majors (Wang, 2013). By tapping into state-of-the-art STEM technology, the stem.T4L project aims to create novel and unique STEM learning experiences for students across NSW. The project aims to not only enhance students' technological capabilities and awareness, but also to prepare a STEM-ready workforce for tomorrow's world by cultivating students' STEM interest and self-confidence.

Goal aspirations and career choices are influenced by interests and self-efficacy (Lent et al., 2000). As such, we hypothesised when students have the opportunity to work with stem.T4L kits, their interest towards STEM would grow alongside their likelihood to pursue a career in STEM. To test this hypothesis, we surveyed a large number of students (Years 5-12) in Semester 1, 2019, drawing upon a pre/post-test design. 3,494 students took the pre-survey run at the beginning of each school term, of which 1,478 participated in the post-surveys.

The key findings of this research are summarised below:

1. Of the 3,494 students who participated in the Semester 1 pre-survey, 45% self-reported an interest in pursuing a career in STEM. While the future of the NSW STEM workforce does not seem entirely bleak based on this figure, still more than half of the student population surveyed at the outset of the project were either neutral or not likely to choose a STEM career path.

2. From the total pre-survey sample, only 41% of the jobs identified by students as their preferred future job was categorised as STEM, with the most commonly (11.9%) selected individual job preference being related to Arts (e.g. artist, singer, dancer, and musician). The small disparity between the percentage of students likely to pursue STEM (45%) and the percentage identifying a STEM-related field as their future job (41%) could be the result of students' misinterpretation of STEM jobs. In other words, the description and examples of STEM careers provided in the survey might have been unclear to the 4% of students who expressed an interest in pursuing STEM but identified a non-STEM career as their future career path. Another explanation for this observed difference is well explained by Holland (1973) who posits that someone might be interested in a field, but is lacking sufficient talent or interest to pursue a career in that field. For 5% of students, STEM might have sounded appealing however factors such as a lack of confidence to be successful in STEM or the perceived difficulties associated with STEM subjects might have encouraged them to opt for choices in non-STEM fields.

3. To better understand what shapes students' career aspirations, we specifically asked students to voice their reasons for opting for their suggested career path. We found there were two main reasons: their self-perceived abilities to perform the job successfully, and the influence of their family or a significant other such as teachers. For the majority of students, it was their own sense of confidence and prior achievements – what Bandura (1977) described as 'mastery experience'– that triggered an interest in a specific field. This finding confirmed previous research that suggested affective factors such as self-efficacy beliefs and confidence in one's abilities have a determining role in the decision-making process to pursue STEM-related careers (Eddy & Brownell, 2016). As such, we propose that to encourage more participation and engagement with STEM careers, STEM teaching techniques and activities should be directed towards increasing students' STEM confidence. The perception that 'I can do STEM' has to be planted in students' minds and watered effectively during different stages of students' academic life in order to build the confidence and interest required to persist in STEM. Researchers stress that efforts to broaden students' interests in and aspirations for STEM should begin at primary schools, as interventions and activities targeting secondary students are "likely to be too little, too late" (Archer et al., 2013, p. 4). The stem.T4L project has taken into account this observation as it provides STEM technology to students across K-12 schools and as the findings of the research suggests it has produced substantial gains in students' STEM aspirations – especially in primary schools.

We observed an increase in students' STEM career aspirations in Term 1 and Term 2 from pre to post evaluation by 6% and 4%, respectively. By aggregating the results of Semester 1 (total pre=3,494 & total post=1,478), we found a modest improvement in students' likelihood to pursue a STEM career by 5%, as well as a decline by 3% in the student population who were sitting on the fence, and another 2% decline in the proportion "unlikely" to aspire to a STEM career. The picture painted here was consistent across the two terms: an increase from pre to post-test due to the implementation of stem.T4L kits that had enhanced students' STEM interest and influenced their likelihood to choose a STEM career. To create a more powerful impact and further boost student STEM career aspirations, STEM technology equipment should be deeply embedded within the NSW education system. Prior research on the stem.T4L project showed that significant results are achievable when such equipment is implemented frequently by teachers (i.e. more than three times a week). Students' interest towards STEM fields will grow significantly when they are given ample opportunities to freely explore the affordances of STEM technology and can find a link between STEM curriculum content and real life STEM careers and applications.

Another approach to encourage STEM participation is STEM careers education. We propose this idea on the ground that students need information, advice and guidance as to how STEM is applicable in real life careers and what opportunities arise when they are equipped with STEM skills, knowledge, and capabilities. In some countries such as the UK, concerns have been heightened over STEM careers education that are recognised as "poorly resourced" in schools (Archer, et al., 2013, p.4). In Australia, greater emphasis needs to be placed on systematically embedding STEM careers education in schools and ensuring its quality and quantity adequately raise students' awareness and familiarity with STEM careers.

4. Inspired by the extensive literature on girls' STEM confidence and interest that frequently suggested a decline in their STEM aspirations (Fennema, 2000; Hebert & Stipek, 2005; OECD, 2015), we also measured girls' STEM career interests and likelihood to pursue STEM. At the outset of the project, STEM career aspirations were higher for boys (50%) than for girls (41%), as has been found in other studies (Eddy & Brownell, 2016). This pattern persisted at the time of the post-test, with boys indicating a higher (54%) likelihood to choose STEM fields than girls (47%). However, we found a more noticeable improvement in girls' STEM aspirations than in boys' from pre (total=1,686) to post (total=707), where the likelihood to pursue STEM increased by 6% in the girls' cohort. Based on these findings we argue that, when provided with opportunities to participate in hands-on STEM activities that promote collaboration, team work, and discussion, girls are more likely to express STEM-related career interests, as observed in previous studies (Little & León de la Barra, 2009). The commentaries provided by girls on the perceived changes in their attitudes toward STEM shed further light on the observed improvement of their STEM confidence. Some of them came to appreciate that girls and boys have equal abilities and potential when using STEM technology. Some are excited about the new capabilities and skills they developed, and have started to feel more positive towards and interested in STEM.

5. Post-survey responses indicated that out of a total of 1,471 students that responded to the question, "Has working with the STEM kits changed your image of what you want to be in the future?" 809 students (55%) responded positively. The finding indicated the positive influence of the project on students' STEM career aspirations, with the majority of students reporting that their aspirations had changed after using the kits. The message coming from students' commentaries was also powerful and positive. The 55% who agreed there has been a change in their attitudes towards STEM stated that they have gained a new perspective into the significance of STEM fields and the enjoyment and possibilities they offer. They had started to realise that STEM learning could be fun and not as difficult as it used to be when they use STEM technology. The renewed appreciation for STEM contributed to a sense of confidence in STEM as confirmed by a large number of students.

# 5. CONCLUSION

Maintaining students' interest in STEM and strengthening their STEM abilities and confidence will help prepare a qualified STEM workforce. Based on the findings of the present research, we argue that one way to increase retention of students in STEM is transforming STEM instructional approaches through effective implementation of STEM technology. stem.T4L technology - when incorporated by teachers who are equipped with a repertoire of STEM knowledge and skills - excites students' interest in STEM fields and further motivates them to pursue STEM careers. The perceptions and choices that students make about their future careers during school are not fixed or static. However, the literature suggests that attitudes formed especially during middle school (ages 11-13) influence students' career choices (Liu, Horton, Olmanson, & Toprac, 2011). It has been even recommended to initiate building student proficiency and interest in STEM before they reach secondary school and begin choosing their courses (Christensen & Knezek, 2017). Given that the majority of our research participants (83%) were students in years 5 and 6, and a larger proportion of this cohort expressed an increased interest in STEM careers by the end of the research project, we conclude that the stem.T4L project has contributed to development of NSW students' interest in STEM careers, especially years 5 and 6. However, the observed difference made in student likelihood to pursue STEM careers from baseline to follow-up was modest, which could be the result of having limited access to the stem.T4L kits. Given that the provision of the equipment to schools is only for 1 term, teachers usually have at most 6 to 7 weeks to use the kits. During this time, technical difficulties, teachers' time constraints, and their lack of familiarity and confidence with the technology might negatively impact the frequency of use and their effective implementation. We postulate that more noticeable results could be achieved by increasing access to STEM technology and resources.

# REFERENCES


Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B., & Willis, B. (2013). *ASPIRES: Young people's science and career aspirations, age 10-14.* London: King's College.

Bandura, A. (1977). Self-efficacy: Towards a unifying theory of behavioural change. *Psychology Review, 84,* 191-215.

Burke, R.J., & Mattis, M.C. (2007). *Women and minorities in science, technology, engineering and mathematics: Upping the numbers*. Northhampton, NJ: Edward Elgar Publishing, Inc.

Bybee, Rodger, W. (2013). *The Case for STEM Education: Challenges and Opportunities. National Science Teachers Association*, NSTA Press, Arlington, Virginia.

Christensen, R., & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science Environment and Health, 3*(1), 1-13.

Choi, N., & Chang, M. (2011). Interplay among school climate, gender, attitude toward mathematics, and mathematics performance of middle school students. *Middle Grades Research Journal, 6*, 14.

Department of Employment, Skills, Small and Family Business (2019). Retrieved from https://www.employment.gov.au/newsroom/stem-jobs-are-growing-faster-other-jobs

Eddy, S. L., & Brownell, S. E. (2016). Beneath the numbers: A review of gender disparities in undergraduate education across science, technology, engineering, and math disciplines. *Physical Review Physics Education Research, 12*(2), 1-20

Fennema, E. (2000). *Gender and mathematics: What is known and what do I wish was known?* Paper presented at the Fifth Annual Forum of the National Institute for Science Education. Retrieved from http://www.wcer.wisc.edu/archive/nise/news_Activities/Forums/Fennemapaper.htm

Hebert, J., & Stipek, D. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Applied Developmental Psychology, 26*(2), 276-295.

Holland, JL (1973). *Making vocational choices: a theory of careers*. Englewood Cliffs: Prentice-Hall, Inc.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice and performance. *Journal of Vocational Behavior, 45*(1), 79-122.

Little, A. J, & Bernardo A León de la Barra (2009). Attracting Girls to Science, Engineering and Technology: An Australian Perspective. *European Journal of Engineering Education, 34*(5), 439-45.

Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. *Educational Technology Research and Development, 59*(2), 249-265.

Miller, P.H., Blessing, J.S., & Schwartz, S. (2006). Gender differences in high-school students' views of science. *International Journal of Science Education, 28*(4), 362-381.

National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Sjaastad, J. (2012). Sources of Inspiration: The role of significant persons in young people's choice of science in higher education, *International Journal of Science Education, 34*(10), 1615-1636.

STEM Australia (2019). Retrieved from http://www.stemaustralia.edu.au/careers.html

Van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education, 41*(2), 150-164.

Wang, X. (2013). Why Students Choose STEM Majors: Motivation, High School Learning, and Postsecondary Context of Support, *American Educational Research Journal, 50*(5), 1081-1121.