SAGE Cygnet Award Application

Attracting girls and women to Engineering and IT studies

UTS

UTS CRICOS 00099F

SAGE
SCIENCE IN AUSTRALIA GENDER EQUITY

SAGE Cygnet Award Application

Name of Institution	University of Technology Sydney
Date of Application	23 October 2023
Application prepared by	Dr Kumudika de Silva, Gender Equity Programs Manager
Contact for Application	Amy Persson Interim PVC Social Justice and Inclusion
Email	Amy.Persson@uts.edu.au
Telephone No.	(02) 95141884

University of Technology Sydney: SAGE CYGNET 1

	✓ Current Cygnet	**Barrier**
Sub-group barrier	✓	Low numbers of women are drawn to Engineering and IT disciplines, beginning in early primary and continuing through secondary and undergraduate education.

Contents

Acknowledgements

UTS acknowledges the Gadigal people of the Eora Nation, the Boorooberongal people of the Dharug Nation, the Bidiagal people and the Gamaygal people upon whose ancestral lands our university stands. We would also like to pay respect to the Elders both past and present, acknowledging them as the traditional custodians of knowledge for these lands.

UTS acknowledges the work undertaken and assistance provided by Women in Engineering and IT staff, especially the Outreach Coordinator Dr Marco Angelini and, WiEIT Director at the time Assoc. Prof. Eva Cheng.

Abbreviations

Abbreviation	Description
Ambassador	Participants in Gender Equity Ambassador program and Student Promotional Representative at UTS (SPROUTS) which are leadership programs at UTS
ATAR	Australian Tertiary Admission Rank
CSJI	Centre for Social Justice & Inclusion
DISR	Australian Government Department of Industry, Science and Resources
ECA	Early career academic (Level A and B academic staff)
EIT	Engineering and Information Technology
FEIT	Faculty of Engineering and Information Technology
FOS	Faculty of Science
HDR	Higher Degree by Research students i.e. Masters and PhD
ICSEA	Index of Community Socio-economic Educational Advantage
SES	Socioeconomic status
STEM	Science, Technology, Engineering and Mathematics
UTS	University of Technology Sydney
WiEIT	Women in Engineering and Information Technology

1 Key Barrier

Women are underrepresented in engineering and information technology (EIT), including in higher education. In 2020, women comprised 18% of undergraduate enrolments in EIT related courses in Australia, and 53% of other STEM undergraduate enrolments (DISR STEM Equity Monitor).

UTS has a range of initiatives in place to encourage women to choose EIT courses. An early entry scheme branded as 'The Edge' program, allows prospective undergraduate students to earn adjustment points to boost their application though subject selection but also includes an ATAR adjustment factor for women applying for undergraduate EIT courses. This scheme, supported via an exemption granted under the NSW Anti-Discrimination Act, is part of UTS's holistic approach to address long-standing gender disparity in EIT. In NSW, adjustment factors are considered for various reasons, including performance in relevant HSC subjects or through the Educational Access Scheme which helps students who have experienced significant educational disadvantage receive a university offer. These schemes have increased the percentage of women enrolling in undergraduate FEIT courses from 18% in 2018 to 26% in 2023.

However, low enrolment is influenced by many years of 'conditioning' including societal influences such as gendered perceptions of EIT (Section 2) which can be traced back to influences in primary and secondary education. From stereotypes such as boys being better at coding, to a lack of teacher and parent knowledge about opportunities in STEM, girls confront a range of barriers in developing interest and self-confidence in STEM. Addressing this is a complex issue requiring interventions at multiple key points in education pathways.

This Cygnet focuses on increasing girls' early engagement with EIT as part of UTS's long-term strategy to increase the cohort of women enrolling in EIT disciplines. Our programs aim to fill a gap rather than replicate existing STEM programs and were specifically created to address barriers that girls face in primary and secondary education.

STEM program participants

2 Evidence of Barrier

UTS Women in Engineering and IT (WiEIT), a Faculty of Engineering and IT (FEIT) program, has been delivering high school outreach for over 30 years. However, by 2016, Bronze Award analysis revealed that only 17% of FEIT students were women. and that the percentage of women studying EIT had stagnated over two decades.

A literature review identified key influences on participation of girls in STEM studies as:

- **gendered perceptions** (e.g. boys are better at robotics and programming) which begin as early as Year 1, with girls holding such views having less interest and self-efficacy in STEM[1];
- **early engagement** of girls in upper primary and early secondary in STEM which increases likelihood of selecting EIT subjects later[2,3]; and
- primary school aged girls can be positively influenced in mixed-gender settings as marginalisation of girls in STEM does not start until later[4].

Other influential factors included:

2.1 having relatable role models[5];

2.2 multiple engagement opportunities with the same cohort of students[6]

2.3 in-curriculum programs[7] rather than out-of-school programs

2.4 professional development for teachers[8]

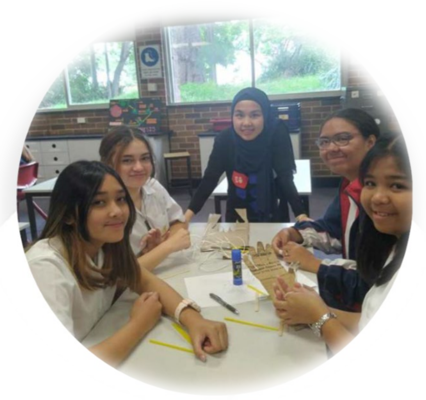
2.5 engaging parents and families[9]

*NOTE: Key factors (**2.1-2.5**) are highlighted throughout the document*

Table 1 References related to evidence for key barrier

Reference No.	Reference
1	Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. Journal of Experimental Child Psychology, 160, 92–106. https://doi.org/10.1016/j.jecp.2017.03.013
2	Egbue, O., Long, S., & Ng, E.-H. (2015). Charge It! Translating Electric Vehicle Research Results to Engage 7th and 8th Grade Girls. Journal of Science Education and Technology, 24(5), 663–670. https://doi.org/10.1007/s10956-015-9555-7
3	Sarkar, M., Tytler, R., & Palmer, S. (n.d.). Participation of women in Engineering : Challenges and Productive Interventions.
4	Hughes, R. M., Nzekwe, B., & Molyneaux, K. J. (2013). The Single Sex Debate for Girls in Science: a Comparison Between Two Informal Science Programs on Middle School Students' STEM Identity Formation. Research in Science Education, 43(5), 1979–2007. https://doi.org/10.1007/s11165-012-9345-7
5	Olsson, M., & Martiny, S. E. (2018). Does Exposure to Counterstereotypical Role Models Influence Girls' and Women's Gender Stereotypes and Career Choices? A Review of Social Psychological Research . In Frontiers in Psychology (Vol. 9). https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02264
6	Lee, S. W., Min, S., & Mamerow, G. P. (2015). Pygmalion in the Classroom and the Home: Expectation's Role in the Pipeline to STEMM. Teachers College Record, 117(9), 1–40. https://doi.org/10.1177/016146811511700907
7	Hecht, D., Chiu, J., Bridgelal, I., & Burghardt, D. (2018). Supporting engineering practices in informal learning environments with a tablet-based engineering design environment. 2018 IEEE Integrated STEM Education Conference (ISEC), 228–232. https://doi.org/10.1109/ISECon.2018.8340490
8	Rockland, R., Bloom, D. S., Carpinelli, J., Burr-Alexander, L., Hirsch, L. S., & Kimmmel, H. (2010). Advancing the "E" in K-12 STEM Education. Journal of Technology Studies, 36(1), 53–64.
9	Simpkins, S. D., Price, C. D., & Krystal, G. (2015). Parental support and high school students' motivation in biology, chemistry, and physics. Journal of Research in Science Teaching, 52(10), 1386–1407.
10	Australian Academy of Science. (2019). Women in STEM Decadal Plan.

In 2018 in Australia, only 1% of the 331 women in STEM outreach initiatives targeted primary schools specifically, with 22% of programs targeting both primary and secondary students; however, many of these programs did not align with STEM curriculum[10].



3 Activities and Outputs

We aimed to increase girls' engagement with EIT studies by specifically addressing the key barriers and enablers identified in the literature review in our programs for later primary school and early secondary school students. This included:

- multiple interactions with participant cohorts,
- supporting teachers to incorporate activities as part of the curriculum,
- providing relatable role models through women undergraduates as program facilitators and
- improving engagement with teachers, girls, and their families.

The programs sought to **increase girls' interest and confidence in STEM**, including in EIT and increase the extent to which they **aspired to a STEM career**.

Our program logic and theory of change (Figure 1) emphasise the benefits of working with schools through the curriculum. Public primary schools provide mixed gender groups and in high schools WiEIT specifically targets mixed gender schools able to include over 50% young women/non-binary students in STEM groups. WiEIT also works with several girl's schools; but not boy's schools. This is deliberately designed to result in around 60% of our total participants being young women/gender-diverse/non-binary.

3.1 School engagement

The school engagement strategy is based on the rationale of maximising the impact of program resources by orienting towards schools where there is greater demonstrable need, and where the project can also meet its core aim of engaging girls and young women in STEM educational pathways. In the last three years, the program has focused on developing school collaborations based on the school's available resources and their capacity to access educational resources. Participation by schools is based on a criteria including:

- teacher engagement/leadership
- profile for target schools: regional and public schools
- potential for embedding/hub development
- equity value (SES score)
- potential for providing minimum requirements of resourcing, good will and staff capacity to deliver the program
- Existing relationships with UTS-Wanago and U@Uni programs
- Proportion of Indigeneity

Most schools were co-educational with programs run as part of the school curriculum involving both boys and girls (Table 2).

Table 2 Participation in STEMx programs 2019-2022

Year	STEMxPlay (Primary Schools)					STEMxImpact (High Schools				
	Total	Girls	Boys	Schools	Teachers	**Total**	Girls	Boys	Schools	Teachers
2019	**448**	224	224	5	18	**None**	-	-	-	-
2020	**1659**	830	829	13	41	**780**	780	None	14	39
2021	**1210**	605	605	11	38	**1313**	712	601	15	36
2022	**1593**	796	797	17	68	**1030**	1030*	None	18*	56*
TOTAL	**4910**	2455	2455	46	127	**3123**	2522	601	47	131

*Regional/rural students, 9 Non-metropolitan schools, 19 Regional/rural teachers
While we include non-binary or gender diverse participants, low numbers of participants in these cohorts exclude meaningful assessment

In 2019, five schools in western and southern Sydney and the Southern Highlands participated in a pilot STEMxPlay program. In 2019-2022 STEMx programs have run in 93 schools with over 8000 students (Table 2).

WiEIT focuses on addressing the cumulative effects of intersectional experiences, targeting schools in low socioeconomic areas, public schools (Table 3), and those with a higher proportion of girls. In 2021, the program was adapted to engage with First Nations and Pasifika students. Increased engagement with First Nations students is through collaborations with UTS Jumbunna and CSJI. This includes adapting the content of our delivery in order to engage students from diverse backgrounds.

Table 3 Characteristics of participating schools

Year	School sector	STEMxPlay (Primary Schools)		STEMxImpact (High Schools)	
		ISCEA <1000	ISCEA >1000	ISCEA <1000	ISCEA >1000
2019	Government	1	3		
	Non-government	0	1		
2020	Government	0	10	2	9
	Non-government	0	4	0	3
2021	Government	4	8	5	6
	Non-government	0	2	0	4
2022	Government	3	6	8	3
	Non-government	0	3	0	3

Since 2021, the STEMx Outreach program has engaged 248 Aboriginal and Pasifika students through its multi touch-point design thinking programs, as well as its STEMx campus visits, collaboration with the UTS CSJI Pasifika engagement program, and collaboration with the Jumbunna outreach program. We did not conduct separate evaluation processes for these students, the evaluation and analysis include data from all students.

Overall, we had multiple interactions with students through our in-classroom programs during a 4-8 week period with a total of 10-12 hrs of classroom engagement (**2.2**). Our STEMxPlay program engages stage 3 primary school students in design thinking projects where students in groups identify solutions to real world problems and develop prototype solutions using technology. Our STEMxImpact program engages stage 4 high school students to prototype solutions using design thinking processes.

FEIT student leaders (**2.1**) are trained to co-facilitate the sessions face-to-face at the schools, or through online communication along with teachers; industry volunteer mentors add real-world relevance and active role-modelling (**2.1**) in the classroom. Program content was developed by WiEIT in collaboration with teachers, parents and educational specialists, and focus on a variety of topics in engineering and IT.
In addition to the STEMxPlay program in primary schools and the STEMxImpact program in secondary schools, our activities included holiday workshops for students, teacher training programs and UTS campus visits. In 2022 WiEIT held 71 events (Table 4).

Table 4 STEMx program events delivered in 2022

Event type	Number of events	Content
STEMx program	33	10-12 hrs of activities in a school over 6-10 days across 4-6 weeks
School holiday workshop	4	7 hrs of workshops, UTS tours and discussions
UTS campus visit	10	6 hrs of STEM workshops, tours and discussions
Teacher training session	24	Professional learning in STEM pedagogies related to STEMx programs

3.2 Program design and delivery

All the features of STEMx program logic specifically articulate to the key findings in the literature review (Section 2): role modelling, multi touch-point design, in-curriculum delivery, teacher professional development, family engagement. Activities were co-designed and delivered in partnership with other UTS units, teachers, education researchers, students' families and industry partners (Engineers Australia and Engineers Without Borders). A variety of engineering and IT topics and subject areas are used in our project delivery, including Biomedical Engineering, Cybersecurity, AI/Data analysis, Civil Engineering and Renewable Energies. Pedagogies to support in-curriculum learning included design thinking processes and inquiry-based learning (Figure 1). The STEMxPlay and STEMxImpact programs are in-curriculum programs (**2.3**) mapped to the science and digital technologies curriculum with indirect links to the maths curriculum.

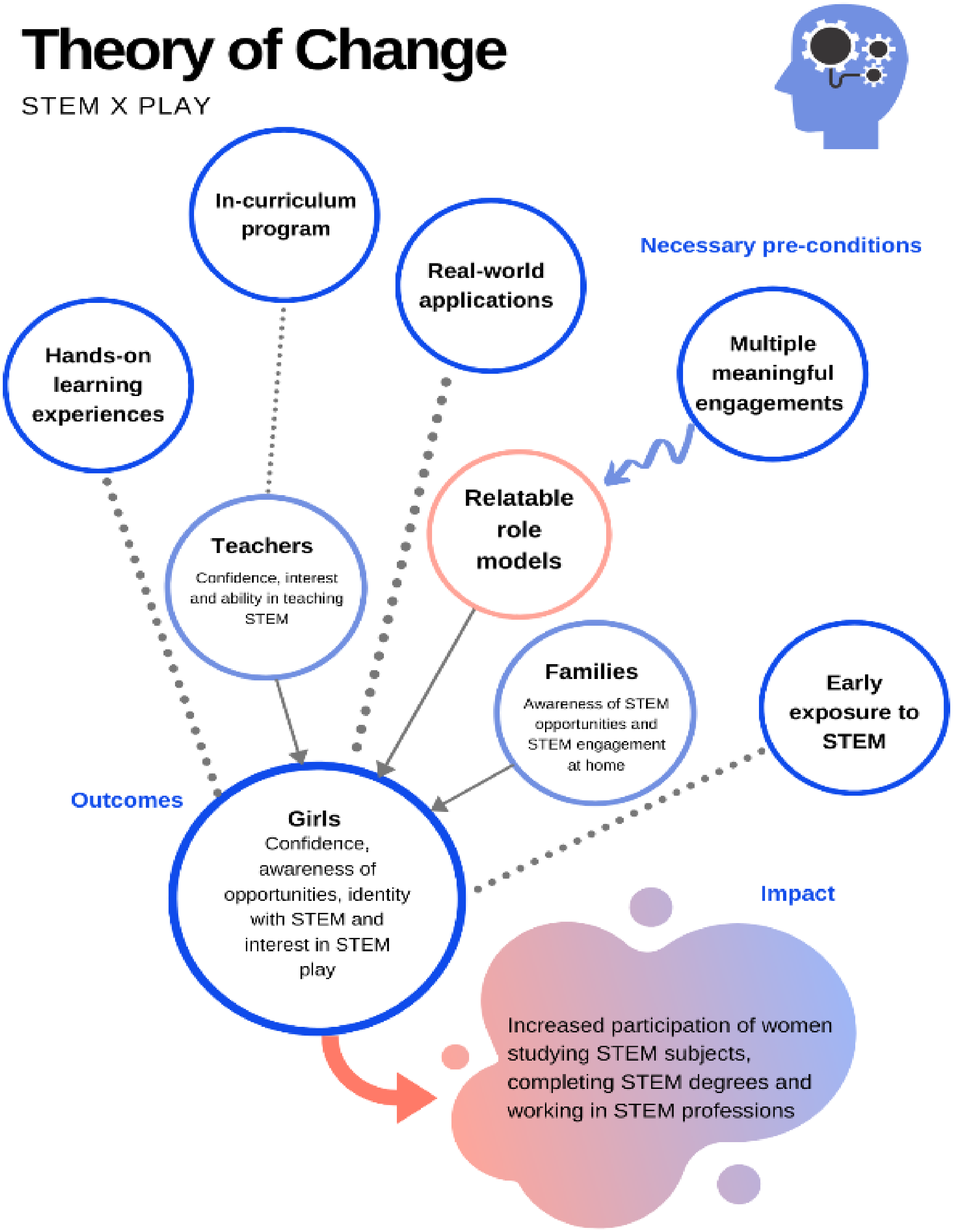


Figure 1A Considerations during program development: Theory of Change model

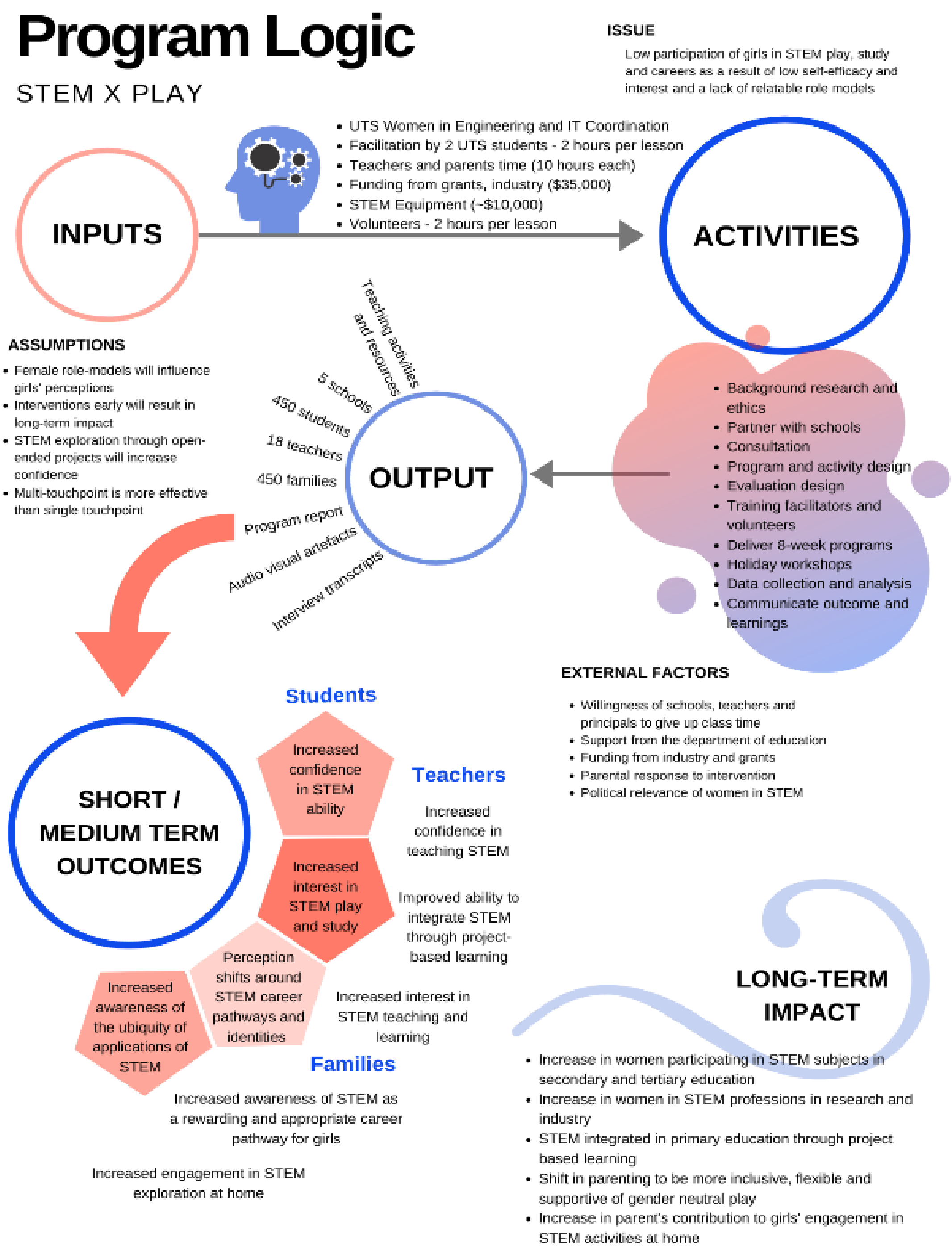


Figure 1B Considerations during program development: Program logic

Program structure (Table 5) includes design thinking and STEM skill development.

Table 5 Design thinking phases within the STEMxs with their associated activities and STEM skill learning outcomes.

Design thinking phase	STEM skills and learning outcomes	Activities
Empathise	Curiosity-driven understanding	Identifying stakeholders of a science-related issue Creating empathy maps for stakeholders
Define the problem	Investigating	Interviewing stakeholders to identify the root cause of the problem
Ideate	Creativity	Brainstorming solutions Researching existing solutions
Refine the solution	Critical thinking	Developing evaluation criteria Drawing flow charts of solutions
Prototype and Test	Designing Building	Data visualization using software tools e.g., Excel Building prototypes using hardware such as MicroBits and Lego Mindstorms
Troubleshoot	Experimenting Problem solving	Programming Iterating designs
Pitch ideas	Communicating	Showcasing prototypes and design process to families and other students

Noting the need to better engage with families (**2.5**), parents/carers were provided a resource pack to facilitate better engagement with their children and invited to join project lessons and be part of the audience during students' project showcase.

COVID-19 necessitated several changes during 2020-2021 with online programs delivered either via video calls to a classroom or individual video calls to students at home. Maintaining student engagement and motivation via enhanced training, communication and relationship management with schools and facilitators was critical.

During online delivery, the program expanded to include:

- additional online teacher resources including slides and lesson plans (**2.4**)
- live video-conferencing for students with UTS Ambassadors and industry mentors
- online collaboration tools for students and facilitators.

Transitioning online also increased reach to regional schools, piloted via a collaborative online STEM Design Challenge during National Science Week in partnership with Tech Girls Movement Foundation and Engineers Without Borders.

By 2022, the programs were fully integrated into curriculum delivery with students engaging with STEM via hands-on experiential learning, providing opportunities for curiosity, creativity, and experimentation. Projects involve solving problems relevant to the local context and curriculum content, using design thinking in collaboration with peers, teachers and families.

Funding was through UTS and external sources (NSW Government Office for Women) emphasising the value of addressing this issue for our university and broader community.

3.3 Facilitators

The WiEIT Deputy Director and Program Coordinator facilitated the first pilot with subsequent facilitators mostly UTS FEIT students chosen for their STEM background, availability, and ability to explain concepts to students. Women were prioritised as facilitators and industry mentors (**2.1**) ensuring that women role models were visible as an inspiration for girls to encourage their confidence and aspirations to EIT careers.

Industry volunteers joined the in-school programs as mentors to guide students' STEM projects, and on-campus visits to share their career journeys in panel discussions - in the last 3 years a total of 32 industry staff from 7 different companies have volunteered to deliver part of the program. Since 2020 the program has engaged 290 UTS FEIT student and staff facilitators as volunteers, Ambassador Leaders (volunteers who take part in our leadership program) and SPROUTS (paid positions, for students who have successfully been through the Ambassador Leadership program and who apply for the role). Since 2020, 94% of our facilitators have been women, and Ambassadors (staff and students) have volunteered a total more than 2500 hours.

3.4 Teachers

Teachers co-designed the program and were involved in content delivery (**2.4**) through the curriculum, co-facilitating activities, setting up classrooms/equipment, and providing time for students to work on their projects during class time. In the pilot phase of the program, 12 teachers from 5 schools were engaged intensively to develop the content and pedagogy of the program, along with processes for engaging families. Since then the program has developed a teacher leadership program, 'STEMxChampions' that gives paid opportunities for leading teachers to contribute more to the program and share good practice among teaching networks. We also deliver teacher professional development sessions, STEMxTeachMeets, to our network of collaborating teachers to share good practice, discuss STEMx pedagogy and maintain a community of practice among our network of practitioners. Each year since 2020, the STEMx program has on average engaged 115 teachers in these ways.

Training workshops for school staff supported program delivery. High school teachers attended professional development sessions designed to facilitate our pedagogical approach and embed program content in school curricula. School careers advisors engaged via resource sharing and co-facilitating events in schools and at UTS.

Participating schools were keen to include STEMx programs as one Assistant Principal noted:

> *We just do our job but it's so rewarding when we get to create opportunities for our kids that genuinely make a difference. Thank you to you and your team for working with us to provide an incredible program for our students this semester. I'm so excited to see what next year brings for our school, students and the UTS team*
>
> Partner school Assistant Principal 2022

Building STEM outreach capacity at a local level was also a key objective to ensure long-term sustainability of the programs. Six school 'hubs' were developed across metropolitan and regional areas to connect local primary and high schools, creating opportunities for collaboration. Two experienced teachers have now taken on the role of 'STEM Champions' to generate additional professional development activities and leadership opportunities for teachers. A collaboration with Tech Girls and the University of Wollongong's Women in STEM Ambassadors has also increased the pool of facilitators.

3.5 Evaluation methodology

Evaluation and consultation processes involved ongoing two-way feedback with school leadership, students, teachers, industry partners and other researchers in the field. Evaluation is rigorously embedded, using pre- and post-participation surveys, focus groups and classroom observations (Table 6). This methodology has ethics approval from UTS and the NSW Government State Education Research Applications Process.

Table 6: Evaluation methods used to collect data on the experiences of students, teachers and parents taking part in the STEMx.

Stakeholder group	Pre-post survey	Reflective writing	Interviews	Observation	Focus group
Students	✓	✓	✓	✓	
Teachers	✓		✓	✓	
Parents	✓				✓

In STEMxPlay, student interest and confidence were gauged through asking '*How fun is…*' and '*How good are you at…*' respectively. Perceptions of STEM were explored through several questions including '*I want to be*' or '*I could be a scientist/engineer/technologist/mathematician*' and '*STEM is important to the community*'. In STEMxImpact, students were asked about their enjoyment of activities including coding, building things, solving problems, and experimenting. Responses to survey questions were on a five-point Likert scale.

3.6 Key Learnings

The pilot identified several areas for program improvement (Table 7) which were subsequently incorporated.

Table 7 Identified areas for program improvement

Designing in project-based learning, real-world problems, design thinking and hands-on activities to engage students
Engaging with students, teachers and families multiple times to deepen impact and develop rapport with role models
Upskilling teachers in design thinking, project-based learning and technical STEM skills prior to the program to assist in co-facilitation and sustained impact post-program
Focusing on engineering and technology where teachers are least confident, and working to authentically integrate science and maths with experiments
Encouraging teachers to provide students with opportunities to develop basic coding skills post-program
Utilising technology equipment accessible to schools
Delivering the program in class size groups rather than a whole grade
Using digital channels to engage families with students' activities each week and provide opportunities for continuous feedback
Having students complete a learning portfolio and participate in yarning circle to reflect on their experiences
Talking specifically about gender stereotypes, gender roles and careers with students

4 Outcomes

These programs are part of a suite of long-term actions at UTS which begins with encouraging young girls and women to consider STEM studies and, eventually, an academic career. As such, the ultimate impact of these interventions is yet to be felt. Nonetheless, our programs saw promising impacts in terms of the key influences on encouraging participation of girls/women in STEM studies, including EIT – improving their confidence and interest with EIT studies, improving perceptions of who can be a STEM professional and seeing themselves in such a career.

Analysis of the impact of STEMx programs which specifically addressed identified barriers to girls' participation (**Section 2**) improved girls' experience in STEM learning. Analysis of outcomes further identified positive impacts on students' perceptions of, confidence, and interest in EIT, with a particularly positive impact on girls' perceptions, especially in primary school. Importantly, there was also positive changes in students aspiring to a STEM career.

It is as yet too early to determine if STEMx program participants will ultimately choose EIT higher education pathways and whether UTS becomes their university of choice. STEMx participants were in Year 5-8 when the programs were run in 2019-2022 and are still too young to enrol at university. Plans to improve monitoring of EIT participation over time are currently being developed as part of our future work program in an effort to better assess the impact of these initiative **(see Section 6)**.

4.1 Perception of STEM professionals

Students in STEMx programs increased their interest and confidence in engaging with STEM activities with each iteration of the program. While this was clear for primary students, there is more work to do to ensure high schools are effectively engaging young women (**FEIT1.1, FEIT1.2**).

Students' awareness of STEM increased and their perceptions of STEM professionals **shifted away from pervasive stereotypes**. Before and after participation in the pilot program (Table 8), students were asked to draw and label what they thought a STEM professional looked like. Drawings of female STEM professionals increased 7% after program participation, alongside a decrease in stereotypical drawings such as crazy hair (12% less) and potions/test tubes (10% less) As shown in an example of a student's drawing in Figure 3, post-program participation this student noted that 'all scientists and engineers are different'. More diverse STEM careers were also depicted in drawings which were often influenced by people they knew e.g. drawing their teachers as mathematicians, or their parents as technologists.

Table 8 Participants responding to program evaluation in 2019

Evaluation	Participants who responded	Schools
Pre-program survey	54	2
Post-program survey	151	5
Written reflection	31 girls and 22 boys	
Observations		2

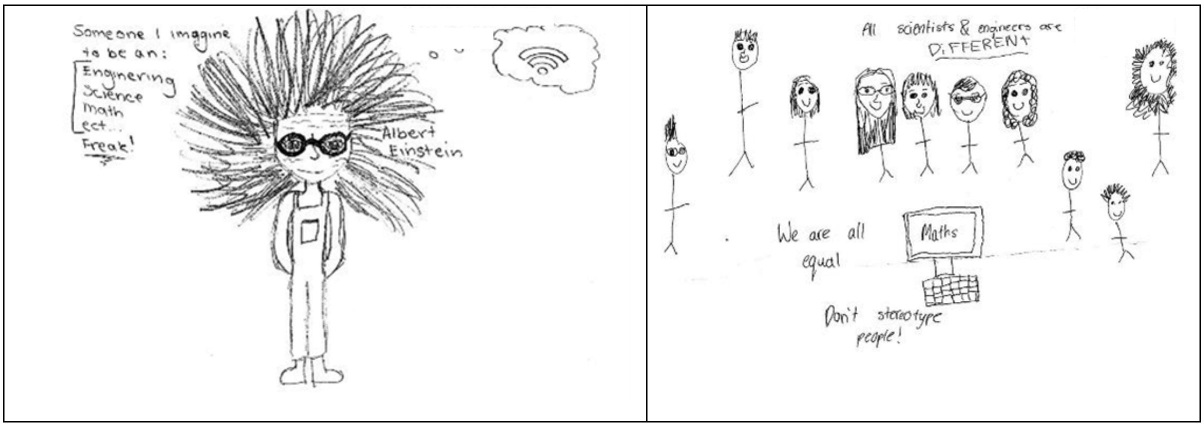


Figure 2 Drawing of a STEM professional by participant before (left) and after (right) engaging with STEMxPlay in 2019.

4.2 Interest and confidence

4.2.1 STEMxPlay: Primary Schools

The overall impact was assessed using responses from those completing both the pre- and post-program surveys (Table 9).

Table 9 Gender data of students who completed pre and post surveys for STEMxPlay (2019 to 2021)

Gender	n	%
Female	172	53.8
Male	135	42.2
Gender-diverse	2	0.6
Prefer not to say	8	2.5
Missing	3	0.9
Total	**320**	**100.0**

Participants and parents both tended to view the program positively:

I've enjoyed STEM more since the program. Before I didn't really enjoy coding but because we did it every week, I've learnt that it's not that bad.

Girl participant

The program has increased her interest in STEM subjects and increased the ability of critical thinking.

Parent

There were several significant differences in girls' responses survey questions pre- and post-participation (Table 10). Participation significantly increased girls' perception that solving problems was fun, that they were good at technology and solving problems, and that they could be good at STEM (Table 10). For boys, the only impact was increased confidence in engineering activities (Table 10).

Participation increased girls' interest in science and maths and skills, with a significant increase in interest in 'building things' (Figure 4). Pre-program, there was a positive significant correlation between being a boy and enjoying building things and being a boy and enjoying solving problems (Table 11). There were no significant correlations after program participation, suggesting that the program had removed this male gender bias.

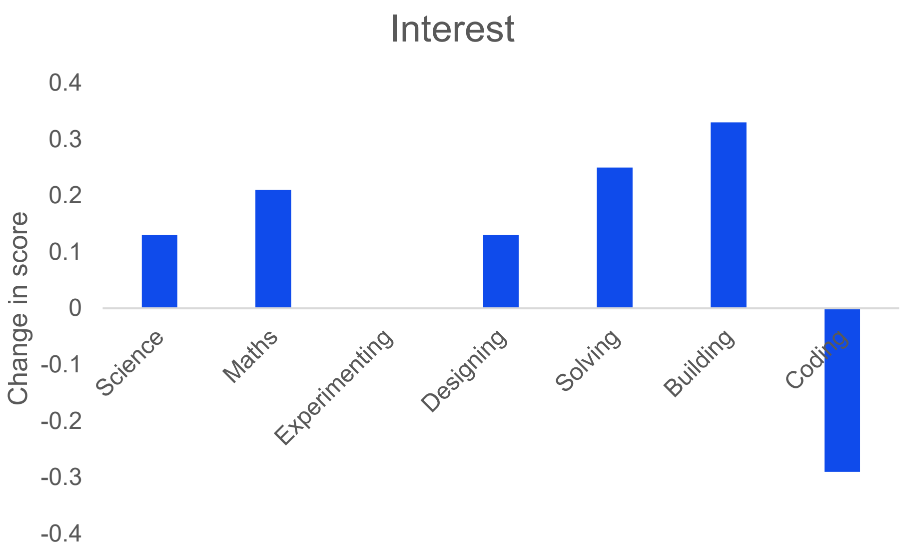


Figure 3 Change in girls' interest after participating in the pilot program increased for science, maths, designing, solving and significantly (p<0.05) for building things

Table 10: Data from pre and post survey responses from students that show statistical significance (p<0.05)

	Mean response (Girls)			Mean response (Boys)		
Survey questions	**Pre**	**Post**	**p**	**Pre**	Post	**p**
How fun is solving problems	3.65	3.89	**0.003**	3.56	3.56	0.956
How good are you at technology	3.81	3.65	**0.012**	4.08	4.07	0.955
How good are you at engineering	3.41	3.48	0.507	3.56	3.77	**0.013**
How good are you at solving problems	3.66	3.81	**0.033**	3.78	3.68	0.126
I could be a scientist, engineer, technologist, or mathematician	3.34	3.56	**0.011**	3.56	3.64	0.429

Table 11 Correlation between gender and interest

(0 = F, 1 = M)	**Pre-program (n=45)**		**Post-program (n=145)**	
How fun is:	**Pearson Correlation**	**Sig.(2-tailed)**	**Pearson Correlation**	**Sig.(2-tailed)**
Coding	-0.044	0.775	0.100	0.224
Science	-0.030	0.847	-0.011	0.896
Maths	0.286	0.057	0.159	0.054
Building things	0.308*	**0.040**	-0.002	0.982
Solving problems	0.326*	**0.029**	-0.019	0.825
Designing	-0.097	0.526	-0.006	0.944
Experimenting	0.033	0.832	-0.023	0.784

**Correlation is significant at the 0.05 level (2-tailed).*
Note: Negative correlations indicate female bias, positive correlations indicate male bias.

Further positive impact of the program is highlighted by **improved girls' confidence in designing** and the weakening of bias towards boys' confidence for coding (Table 12).

Table 12 Correlation between gender and confidence

(0 = F, 1 = M)	Pre-program		Post-program	
How good are you at:	**Pearson Correlation**	**Sig.(2-tailed)**	**Pearson Correlation**	**Sig.(2-tailed)**
Coding	0.392**	**0.008**	0.181*	**0.028**
Science	0.081	0.595	0.055	0.508
Maths	0.261	**0.083**	0.164*	**0.048**
Building things	0.232	0.125	0.017	0.835
Solving problems	0.298*	**0.047**	-0.007	0.938
Designing	-0.102	0.504	-0.166*	**0.045**
Experimenting	0.017	0.913	-0.046	0.579

***Correlation is significant at the 0.05 level (2-tailed). *Correlation is significant at the 0.01 level (2-tailed).*

Note: Negative correlations indicate female bias, positive correlations indicate male bias.

In the 2020 cohort, more primary school girls said they felt 'very good' or that it was 'very fun' to take part in designing things, building things, solving things, and EIT after participating in the program (Figure 5). The **proportion of girls who indicated they felt they could become STEM professionals increased** (Figure 5). They were also interested in participating in the STEMxPlay program again (Figure 5).

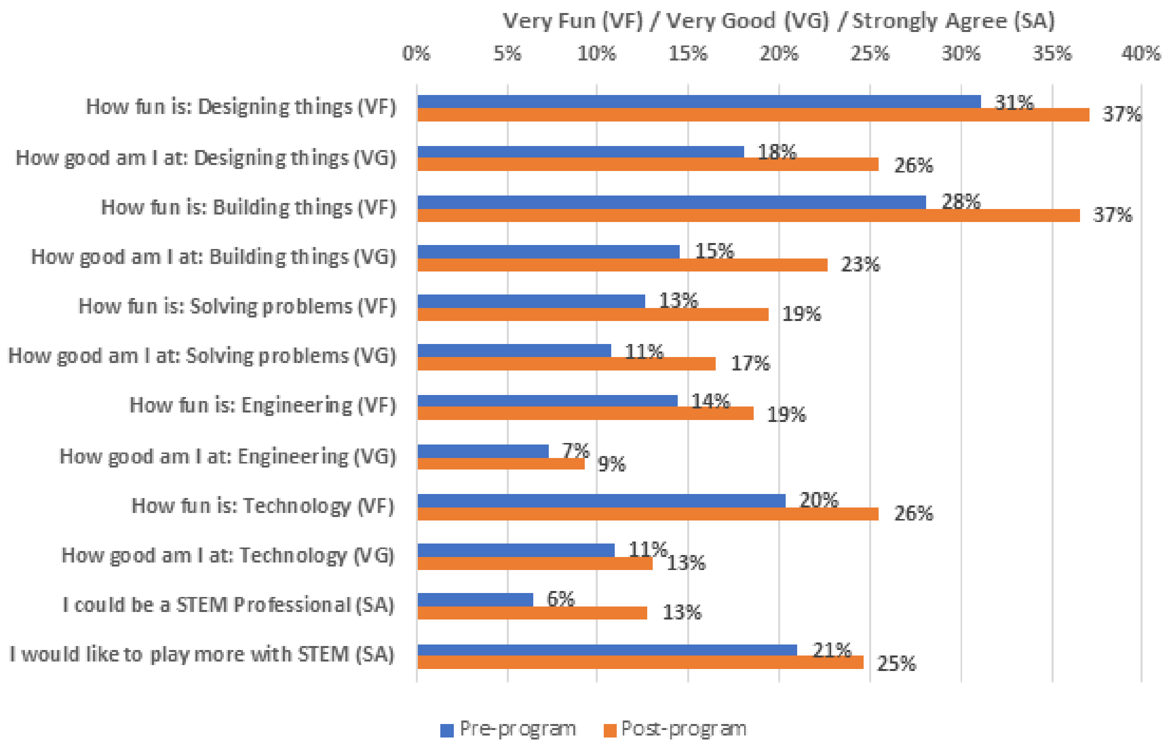


Figure 4: Girls continued to find aspects of the STEMxPlay program very fun, very good or strongly agreed they felt more confident in STEM activities.

In 2022 (Figure 6) the main impact for girls related to their interest in engineering and building things.

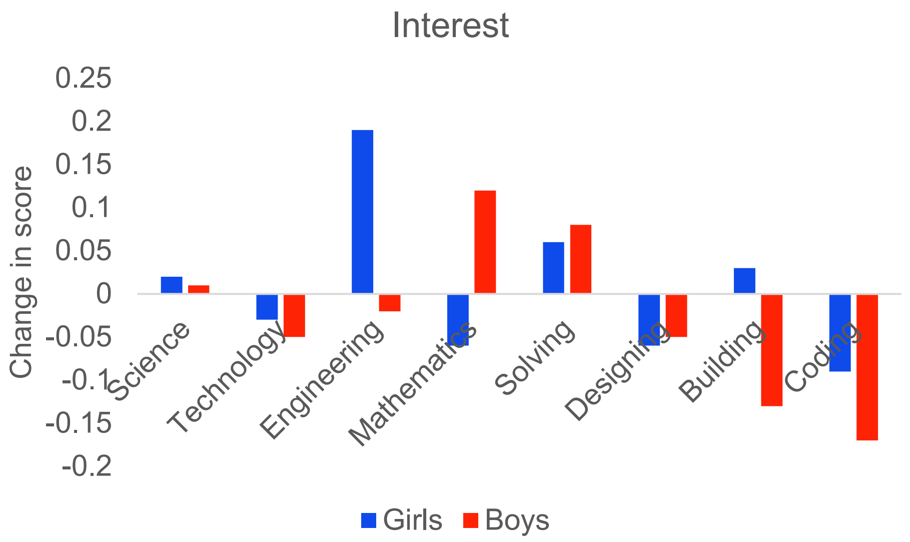


Figure 5 Change in girls' and boys' interest post-program in 2022.

While girls were less confident in most STEM activities than boys (Figure 7) participation increased their confidence for all STEM activities, except for maths. Boys also benefitted from the program with their confidence for science, engineering, solving problems increasing (Figure 7).

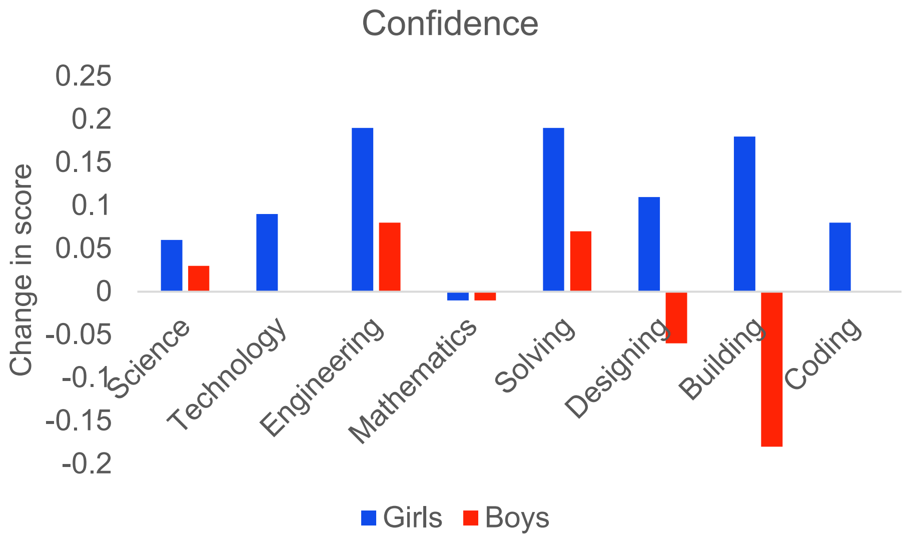


Figure 6 Change in girls' and boys' confidence following program participation in 2022.

Perceptions of STEM

Participants' positive belief in becoming STEM professionals and their capabilities increased (Figure 8). Girls' belief also shifted positively in appreciating the importance of STEM to the community and being comfortable with failure.

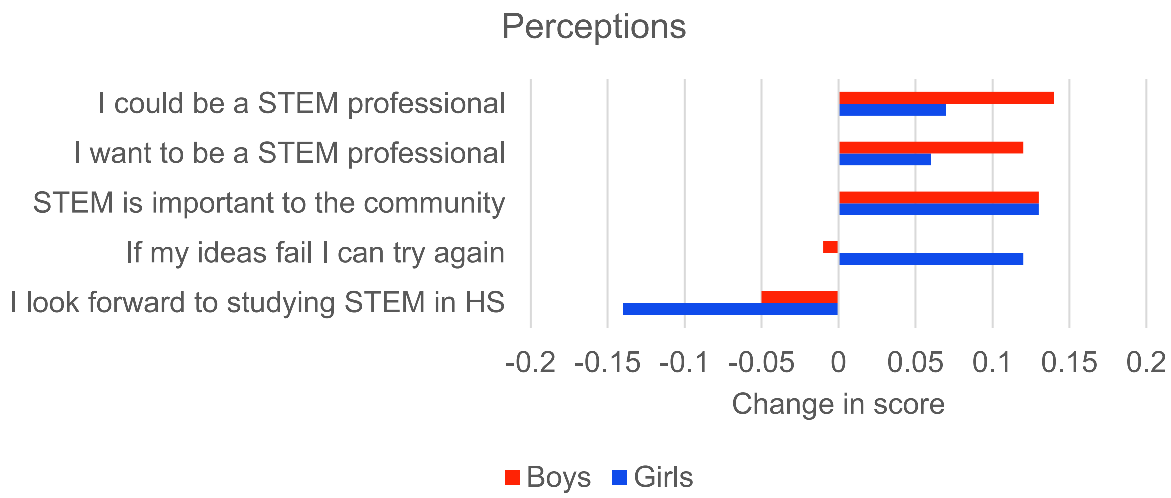


Figure 7 Change in girls' and boys' perceptions following program participation in 2022.

4.2.2 STEMxImpact: High schools

High school students had a more varied experience with significant decreases in several measures post-program. They generally had a positive perception of STEM both pre- and post-participation, with students experiencing a general increase in confidence but a decrease in interest. Post-program, girls' interest only increased in solving problems, while boys' interest only increased in experimenting. **Girls' confidence increased across all STEM activities.**

Families encouraged their children to explore STEM activities, but students felt no change in their encouragement to persist at problems, and whether parents would like them to choose a career in EIT. Interest in choosing a career in EIT also decreased. Compared to boys, girls experienced little change in terms of family encouragement post-program. Despite this, students', especially **girls', rating for their EIT skills increased post-program** (Table 13).

Table 13 Pre- and post-program responses from students in the STEMxImpact program in 2020

How would you rate your engineering and IT skills? 1=terrible to 5=awesome			
	Pre-program	Post-program	p
All students	2.89	3.09	**0.014**
Girls	2.85	3.05	**0.030**
Boys	3.07	3.27	0.366

For girls, their enjoyment in learning new things, experience of their family's encouragement to explore technology, and comfort in an EIT classroom all decreased. Compared to their male peers, girls showed lower confidence in STEM activities both before and after the program.

However, overall, high school students showed increased confidence in all STEM activities post-program with girls' confidence increased across all STEM activities - a strong result for the project.

In response to these outcomes, WiEIT has now iterated the program and established a better integrated pathway of programs to engage with high school students including in later years as well as during transition to university (Figure 9) (**FEIT1.3, FEIT1.4**). This provides multiple opportunities for girls (**2.2**) to build and maintain interest and confidence in STEM learning and may lead to yet unrealised potential for increasing the pipeline of women choosing EIT undergraduate courses.

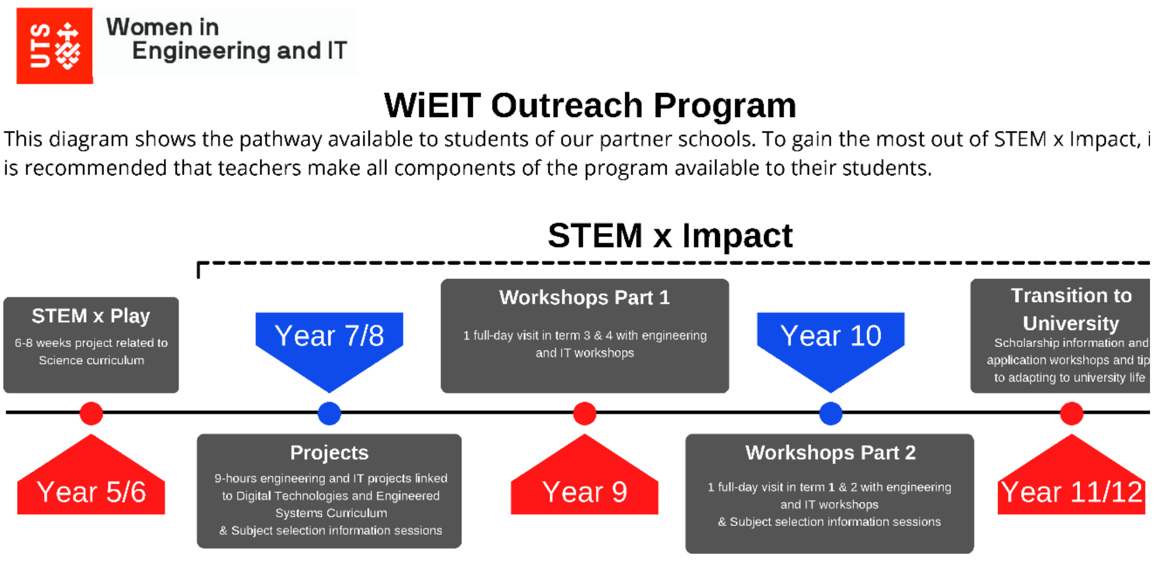


Figure 9 Integrated outreach program pathway available through WiEIT

4.3 School Holiday Workshops

Another point of engagement with participants (**2.2**) were school holiday workshops which impacted girls' attitudes to engaging with STEM studies positively (Table 14). Most participants (>75%) agreed that after participating in these workshops they were **more likely to choose to study STEM** subjects.

Table 14 Impressions of girls participating in holiday workshops

Statement	Year	Proportion of participants agreeing or strongly agreeing
These holiday workshops have been an enjoyable way to study STEM subjects	2021	90%
	2022	82%
I learned something useful to my studies from these workshops	2021	95%
	2022	89%
These workshops have increased the chance I might choose to study STEM subjects in the future	2021	76%
	2022	88%

4.4 Family and School Engagement

Families proved difficult to engage, but those parents who participated in the initial surveys reported their children were engaging positively in the program, and wanted the program to run again in both primary and high schools. Some parents did note an increased interest in STEM as noted in this comment by one parent:

> *Since the project began my child has had more motivation to be in class because STEM provides more fun and exploration while learning*
>
> Parent of 2022 participant

Despite efforts to positively engage families, evaluations indicated high school girls experienced negative shifts related to family encouragement and choosing STEM careers. To address this, parents and families are now being offered shared program documentation to support their understanding of wider STEM issues in education and the professions, and invited to project showcase events (**2.5**). Through these engagements, families have been brought into co-design interactions to enhance project content and offerings.

Post-program in 2021, teachers were asked to consider changes to STEM teaching pedagogical approaches and recognised the potential for integrating STEM into the classroom across existing key learning areas. They noted the program catalysed skill development facilitating further project-based STEM learning in the classroom (**FEIT1.1)**.

Teachers noted that students' collaborative skills had increased and were willing to keep trying no matter how many times they failed. They expressed the need to allocate appropriate time to each activity so that students do not feel rushed.

5 Impact

5.1 Overall impact

Direct evidence from program participants, surveyed before and after program participation (Table 8 and described in Section 4) indicates a positive impact **on growing confidence/ability in STEM education**, with evidence of **increased willingness among girls to see themselves as future STEM learners/professionals**. These are early key factors which could influence more girls and women towards choosing EIT studies in later high school years and subsequently at university. Together with our other initiatives to support women into EIT studies including other WiET high school programs (Figure 10), the on-going ATAR adjustment scheme to encourage women to enrol in EIT undergraduate courses (Section 1), supporting women and nonbinary FEIT postgraduate students (Cygnet 2) and institutional schemes for recruiting and retaining women and nonbinary staff in STEM this is an important step towards increasing this cohort in EIT in higher education.

As noted in **Section 4 and 6**, the full impact of the STEMx programs is yet to be realised as participants are still in high school.

UTS shared insights of these programs through research publications and at conferences (Table 15). The STEMx program was recognised as one of three international finalists at the 2021 Global Engineering Dean's Council awards, receiving a funding prize and formal recognition by peers worldwide.

Table 15 Invited talks and publications

Year	Dissemination of good practice
2021	Gender & STEM conference
	Science Teacher's Association of NSW Conference
2022	Inspiring Australia stakeholder briefing events
	Science Teacher's Association of NSW Conference
	Diversity Interventions Conference

5.2 Impact based on school type

The Department of Education notes that students from a low socioeconomic background are falling behind in STEM education and are less likely to aspire to STEM careers. In addition to the overall outcomes noted in Section 4, we further evaluated impact of our programs on students based on school type categorised by ICSEA score or whether a government or non-government school (Table 3). ICSEA is used by the Australian Curriculum Assessment and Reporting Authority to enable meaningful comparisons between schools.

5.2.1 Low and High ICSEA schools

Interest and confidence in STEM and STEM activities are compared in Figure 10. For some indicators there was a positive impact specifically in low ICSEA schools. **Confidence in maths increased for students in low ICSEA schools** but decreased for those in the high group. **Confidence increased in designing, building, and coding in the low ICSEA group,** compared to little or no change in the high ICSEA group (Figure 12). STEMxPlay, participation by primary school students **increased interest and confidence in engineering regardless of school ICSEA score**.

The overall positive impact of the program on increased student interest in engineering was also noted specifically in girls, regardless of school ICSEA (Figure 10) (**FEIT1.4**).

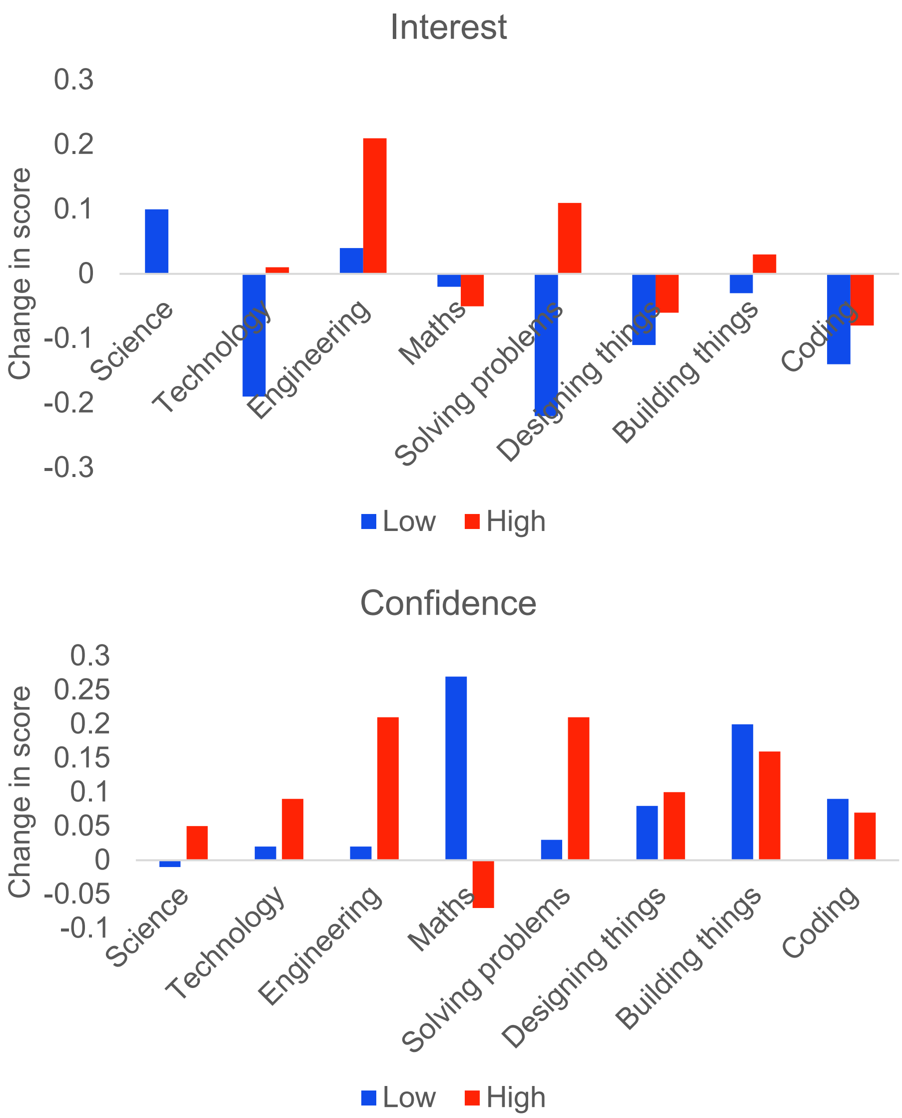


Figure 10 Change in interest and confidence in girls from Low and High ICSEA schools following STEMxPlay participation in 2022

Importantly, students in low ICSEA schools perceived that they could and stated that they wanted to be a STEM professional post-program (Figure 11). High ICSEA school participants' perception that STEM is important to the community increased post-program. Girls from neither group looked forward to studying STEM in high school but their aspiration to a STEM career increased post-program (Figure 11).

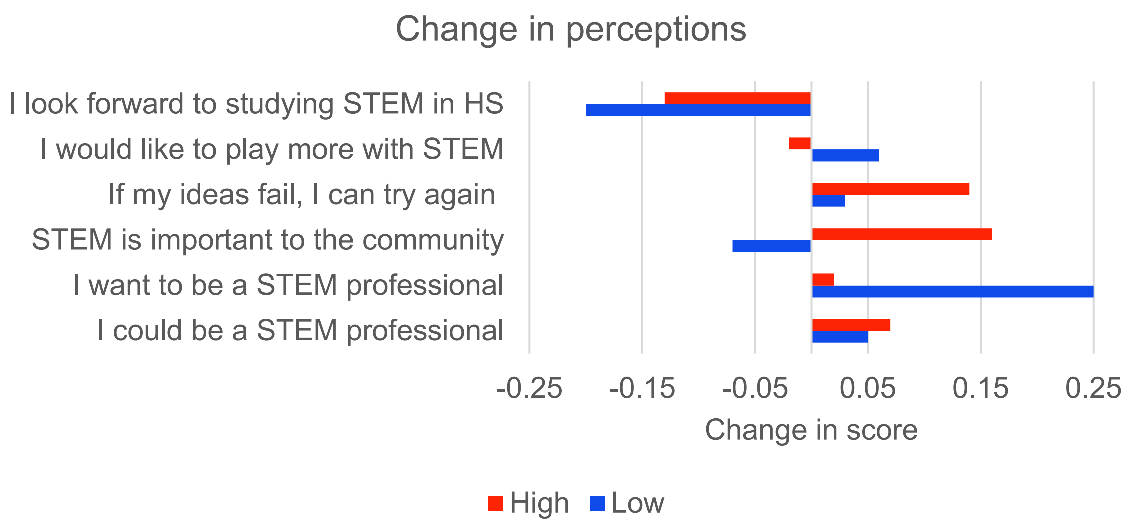


Figure 11 Change in perceptions in girls from Low and High ICSEA schools following STEMxPlay participation in 2022
HS=high school

5.2.2 Government and non-government schools

To determine if there were differences in program impact based on school sector, we also re-evaluated outcomes described in Section 4. Students' aspiration to be a STEM professional was positively impacted by our program regardless of school sector. However, for girls, this was more prominent in non-government schools (Figure 12) (**FEIT1.4**). The view that STEM is important to the community was also positively impacted for all students, including girls. This indicates that **our programs are likely to have made an impact in influencing girls to select STEM studies in the future**.

Interest and confidence in engineering increased for primary school students in both sectors; with a greater increase in the non-government school cohort. For students in government schools, confidence in science and technology increased. Interest and confidence in engineering increased for girls regardless of school sector (Figure 13). For girls in government schools, interest and confidence in science and mathematics increased post-program. Confidence in all STEM activities assessed also increased for all girls independent of school sector.

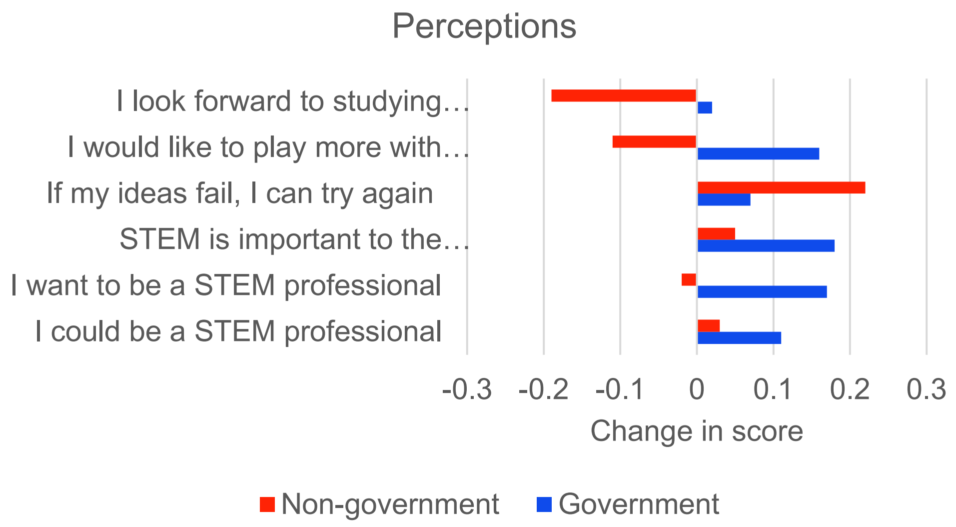


Figure 12 Change in perceptions in girls from government and non-government schools following STEMxPlay participation in 2022

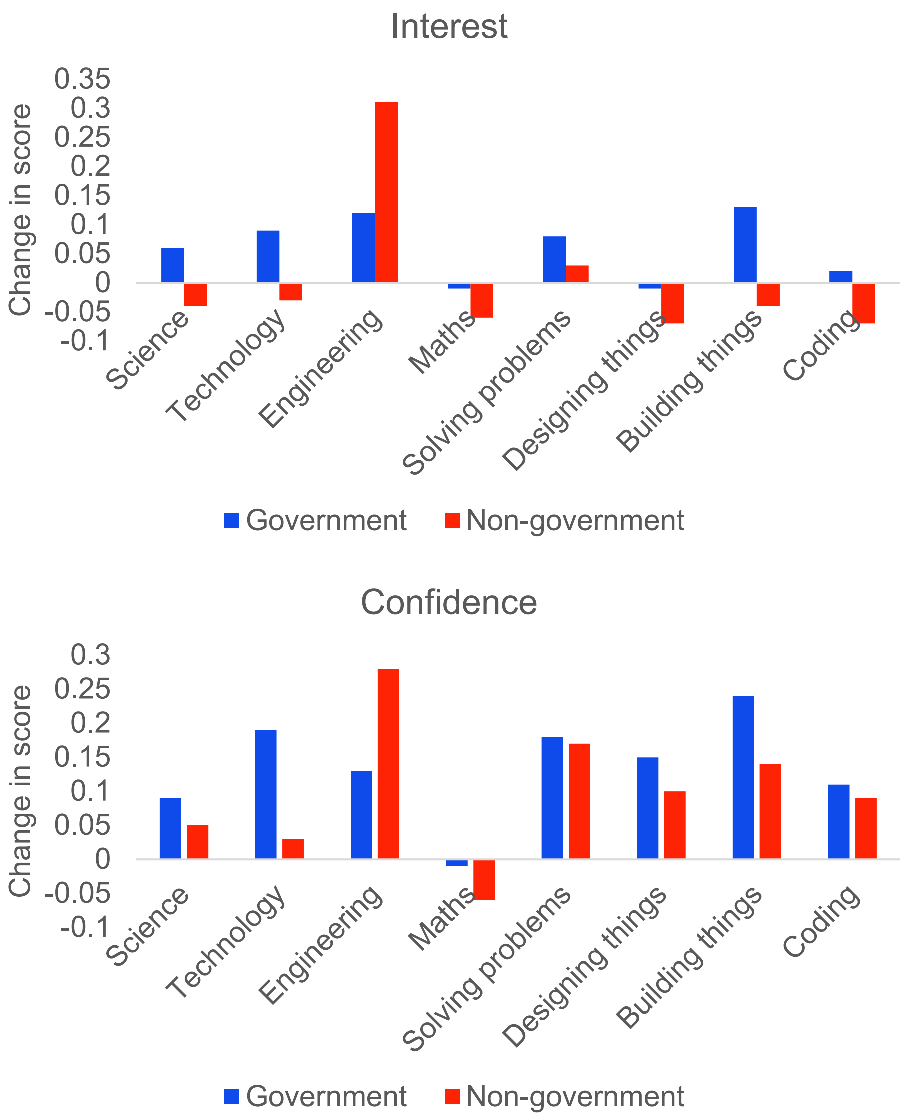


Figure 13 Change in interest and confidence in girls from government and non-government schools following STEMxPlay participation in 2022

5.3 Teacher confidence

In the 2020 pre-program feedback, teachers hoped to gain confidence in teaching STEM, learn effective ways to integrate STEM across key learning areas, and encourage positive student engagement with STEM material.

Following the program, teachers said they appreciated having program facilitators and that they were helpful and knowledgeable. They noted the program structure itself engaged the students (**FEIT1.1)**. As one teacher noted:

> I see this program as informing teachers as well as students. For us to see how you're running this program and how you're taking them through the whole process of coming up with ideas, thinking of design, and thinking of why they'd invent this, this whole process of allowing them to be in this learning pit and come up with their ideas and sweat over an idea, I think we love working like this. We're putting into action something we've been thinking of doing for a long time.
>
> Teacher participant in 2020

Overall, agreement that they provide support to other teachers for teaching STEM increased from 2.7 to 3.5 post-program on a scale where 1=Strongly disagree and 5=Strongly agree.

6 Conclusion

The main goals of the STEMx Programs are to encourage young women to engage positively in STEM pathways, including future study at any suitable tertiary institution, not just UTS. As part of an ethics-approved research project we have been conducting a longitudinal study on intentions to initiate and continue studying STEM subjects. We are planning to track STEMx participants in UTS undergraduate STEM admissions acknowledging that this will represent only a partial picture of the programs' success.

Whilst it is too early yet to draw firm conclusions from the 4 years of data we have analysed towards progression through high school into university study, we shown statistical analysis that STEMx projects' activities have had a significantly positive effect on many girls and young women in terms of their engagement in STEM subjects as well as their intention to continuing to study STEM subjects in future.

The Key Barrier that we have explored is the underrepresentation of women in EIT in higher education due an inadequate pipeline. The STEMx programs are a valuable part of a suite of programs UTS delivers to increase the number of girls engaging with EIT across the higher education sector.

Participants in STEMxImpact program

7 Further Actions

Reference	Rationale/ Evidence	Actions & Outputs	Timeframe (start & end)	Person/Group responsible for implementing action	Senior Leader accountable for action delivery	Desired Outcomes/ Targets/ Success Indicators
FEIT1.1	Quality of content across projects is variable. Feedback from participants and stakeholders.	Review and assess existing material. Prioritise projects. Revise content.	23 Jan-30 June 2023	WiEIT Outreach Coordinator	Director, WiEIT	Review and update of school outreach learning content completed
FEIT1.2	Feedback from facilitators and other stakeholders has identified areas for training: communication, leadership, learning facilitation, teamwork.	Assess training needs. Devise content. Deliver and evaluate sessions.	1 Feb-16 August 2023	WiEIT Outreach Coordinator	Director, WiEIT	Delivered 6 separate training and development sessions for Outreach facilitators, to include: Facilitation Skills (x2); Program Information (x2); Using Educational Tech (x2)
FEIT1.3	Growth of WiIET Outreach requires more staff to deliver programs. New funding streams allow for expansion of team.	Advertise, interview and appoint two staff. Deliver orientation activities.	23 Jan-19 March 2023	WiEIT Outreach Coordinator	Director, WiEIT	Recruit and train two new project officers
FEIT1.4	Core activity in WiEIT Outreach program. Evaluation activity will provide evidence of success.	Identify 30 school partners and create schedule for STEM X program delivery. Deliver information sessions. Book in and deliver program content, and evaluate.	16 Jan-15 Dec 2023	WiEIT Outreach Coordinator	Director, WiEIT	Deliver outreach program activities, to include: 14 STEMxPlay programs, 16 STEMxImpact programs, 8 campus visit, 2 Holiday workshops.
FEIT1.5	ATAR adjustment points increase undergraduate enrolments in EIT courses	Continue providing 10 adjustment points to women/nonbinary students enrolling in EIT courses	On-going	FEIT Dean	Vice Chancellor	Annual growth in women/nonbinary enrolments in undergraduate EIT courses

UTS