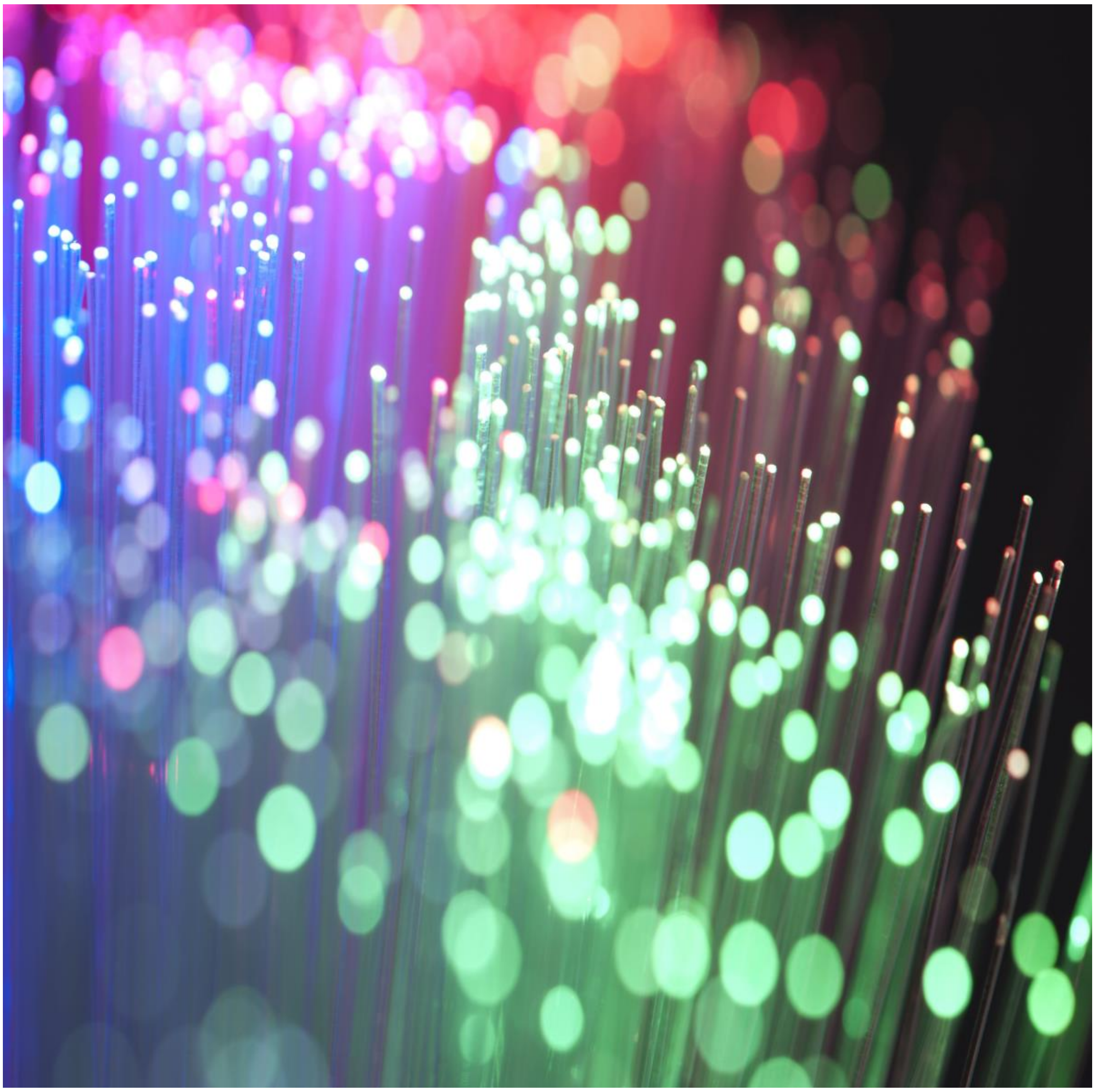
# STEM Teacher Enrichment Academy Research Summary Report

2017-2020



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# I. INTRODUCING THE STEM TEACHER ENRICHMENT ACADEMY

Established in 2014, the STEM Teacher Enrichment Academy offers knowledge, skills, resources, and support to enable teachers to make real change in their classroom teaching of science, technology, engineering, and mathematics (STEM) subjects. The program is the first of its kind in Australia and is helping build the nation's STEM capability by inspiring teachers through enrichment-focused professional development.

## THE STEM TEACHER ENRICHMENT ACADEMY AIM AND GOALS

The main aim of the **Academy** is to improve student engagement in STEM subjects so that more students continue to study these subjects in Years 11 and 12 and beyond. To achieve this, the Academy supports a team of teachers from each participating school to build change in STEM teaching and learning based on students' needs. The academy will:

1. support teachers' knowledge and understanding of, and abilities to implement, pedagogical strategies promoting student engagement in STEM subjects
2. enhance teachers' knowledge of content and approaches to teaching mathematics, science and technology, demonstrated in their design and implementation of tasks and units of work
3. encourage the development of interdisciplinary units of work and/or projects in STEM
4. develop a community of practice between cohorts of STEM teachers by offering ongoing support and engagement through newsletters, and STEM events and
5. develop teachers' knowledge of STEM-related projects in the broader community as well as knowledge of STEM programs at University and STEM careers.

## THE STEM TEACHER ENRICHMENT ACADEMY PROGRAM

The STEM Academy provides NESA-accredited professional development programs for teachers of STEM that focus on themes embedded in the Australian Curriculum F-10. They are facilitated by the Universities leading academic specialists from the Sydney School of Education and Social Work, and the faculties of Science, and Engineering.

Teachers participate in professional learning sessions, which count towards the *Proficient* level of NESA accreditation. To demonstrate the University's commitment to the partnership, funding is available to support teacher relief costs. Principals make a commitment to provide their school STEM team with relief from face-to-face teaching for planning, programming and evaluating their STEM approach.

### Partnerships with schools

Interested schools are invited to submit an **expression of interest** (EOI) to join the Academy. A set of criteria are used to evaluate each submission:

1. What will participation in the **STEM Teacher Enrichment Academy** mean for your school?
2. How will your school support and manage this project which is within and across three subjects and faculties in secondary school settings? – consider communication, collaboration and implementation strategies
3. How will you evaluate and refine the identified teaching and learning strategies both within and across subjects?
4. How will your school build upon this project to improve teaching/pedagogy?

The EOIs are evaluated by a panel (including academics and teachers) with successful schools invited to join the next Academy program.

## Program structure - Secondary

Participating secondary schools send a team of 6 teachers (2 science, 2 mathematics and 2 technology/engineering) to the program. Each program involves up to 13 schools representing a diversity of size, SES, and education sector (DoE, Catholic and Independent). There are usually 2 secondary programs each year – one at the University campus in Camperdown and another in a regional location. To date we have held programs in Coffs Harbour, Tamworth, Newcastle, Orange, and Wagga Wagga.

The year-long program involves 5 days of face-to-face meetings beginning with a 3-day professional learning session to provide schools with the opportunity to evaluate teaching and learning practice, and to reflect on and further develop problem solving and inquiry-based learning approaches. School teams develop a plan to implement STEM-focused teaching and learning at their school. Following this, the Academy mentors visit STEM teams in schools and support them in teaching new units of work using innovative, practical approaches, and implementing and evaluating their STEM projects. Teachers are encouraged to collect data from students as evidence of learning and engagement in classrooms. A 1-day professional learning session is held about 6 months after the first and is designed for teachers to present the outcomes of their work to their colleagues, sharing successes and challenges, and supporting each other in planning future STEM units and activities. This is followed with further implementation in schools and then a 1-day Showcase later in the year. In 2020, due to the Covid-19 pandemic, the STEM Academy programs were paused. However, 10 secondary schools completed the program in a blended learning format.

## Program structure - Primary

Depending on the size of the school, each participating primary school sends a team of up to 4 teachers to the program. Each program involves up to 15 schools representing a diversity of size, SES, and education sector (DoE, Catholic and Independent). There are usually 2 primary programs each year – one at the University campus in Camperdown and another in a regional location. To date we have held programs in Coffs Harbour, Newcastle, Orange, and Wagga Wagga.

The year-long program involves 5 days of face-to-face meetings with the STEM Academy team. The program begins with a 2-day professional learning session, followed by another 2-day session mid-year and a final 1-day graduation at the end of the year. Like the secondary program, school STEM teams evaluate current practice, plan a STEM approach that meets students' needs and uses local community engagement wherever possible. Mentors work with schools throughout the year to support their work.

After completion of all programs, the Academy continues to engage with teachers in a range of ongoing professional learning opportunities at the University. This involves sharing their ideas with new academy partner schools, inviting other partner schools to visit and observe their project work, or collaborating with other local schools and acting as a STEM hub school. Due to the Covid-19 pandemic all Primary programs were paused in 2020.

## Impact – Schools and Teachers

| Year | Secondary Schools | Primary Schools | Connections Program Schools | Teachers |
|---|---|---|---|---|
| 2015 | 13 | - | - | 75 |
| 2016 | 12 | - | - | 71 |
| 2017 | 31 | 12 | - | 236 |
| 2018 | 32 | 29 | - | 304 |
| 2019 | 32 | 29 | - | 277 |
| 2020 | 22 | 27 | 5 secondary + 15 feeder primary schools | 293 |
| **Totals** | **142** | **97** | **20** | **1256** |

# II. RESEARCH PHASES

## PHASE I

After ethics approvals were granted in 2017, the Phase I research stage was undertaken. This qualitative phase of the study took a retrospective approach to evaluation through interviews with past participating **secondary schools** from 2014-2017. Within this time-period 57 secondary schools and 306 teachers participated in the STEM Academy. From this pool, semi-structured interviews were completed with participants from 20 schools: five principals, 18 STEM team leaders/teachers and nine STEM teachers. Interviews were conducted between six months to three years after their school's involvement with the Academy to probe the STEM initiatives in their school, their perceptions of the impact of the STEM Teacher Enrichment Academy, adjustments made to their school's curriculum to accommodate STEM teaching and learning, their involvement with communities of practice, partnerships with industry, and efforts to sustain STEM initiatives in their schools. Content analysis was undertaken, as data were coded and labelled with the primary themes as outlined in the STEM Academy's aims and goals. Secondary themes were determined through an open coding process.

The focus of Phase I was to evaluate how, and in what ways, the aims and goals of the STEM Teacher Enrichment Academy were accomplished in schools after completion of the Academy. Key findings are listed below:

### Sustainability and Growth of Secondary Schools' STEM Programs post Academy

- 95% of schools continue to offer their original STEM Academy project in their curriculum.
- 90% of schools have expanded STEM curriculum and projects beyond their initial Academy project.
- 65% of schools have added a Stage 5 (Years 9&10) STEM elective.
- 85% of schools have an ongoing STEM professional learning team that regularly meets to plan, design, and discuss the implementation of STEM curriculum.
- 70% of schools have established links in forming a partnership with industry and/or local community organisations.
- The majority of schools are involved in STEM related student outreach programs and/or STEM related competitions with their local universities.
- Timetable issues were present in most schools; yet staff were creative in ways to work flexibly with their team to ensure program delivery.
- For most schools, their targeted STEM students (Years 7 & 8) have yet to reach their HSC studies, but a few schools from the earlier Academy programs have indicated an increased interest and uptake in HSC STEM related subjects.

### Key Drivers in Partner Schools that have sustained and expanded their STEM offerings post Academy

- Program success hinges on the support of school leadership and the executive team in providing time and resources to further STEM teaching and learning. This includes
    - A team of dedicated teachers who meet regularly in a professional learning community to plan and implement school-based STEM initiatives/curriculum
    - A designated STEM leader who is given a time allocation in this role
- Collegial hub of STEM faculty expanded beyond the Academy graduates led by a passionate and dedicated STEM leader, forming a community of practice within their school context.
- Growth in STEM curriculum with expanded opportunities for students to experience authentic, "real-world" STEM learning throughout Years 7-12.
- Continuing involvement with university STEM outreach programs that connects students to STEM learning.
- Expanded opportunities for students to experience STEM learning outside the classroom through STEM clubs, STEM competitions and STEM based excursions.
- Growth in partnerships with businesses and community organisations.

Based on these findings and others that are discussed relative to the Academy's aims and goals, recommendations are offered in this report's conclusions that may guide long range program effectiveness of the STEM Teacher Enrichment Academy in assisting partner schools in furthering the growth and sustainability of their school based STEM endeavours.

## PHASE II

The Phase II research protocol, began with the 2018 teacher and student cohorts, was primarily a quantitative study measuring the impact of the STEM Teacher Enrichment Academy from the prospective of multiple stakeholders: teachers, students, and parents. Due to the Covid-19 pandemic and the pause of the program, very limited data were collected in 2020. This report contains data collected and analysed in 2018 and 2019.

### Teacher Survey Results 2018-2019

The data collection sought to determine whether the STEM Academy affected participating teachers' efficacy beliefs (individually and collectively), outcome expectancies and teacher knowledge of STEM careers. All primary and secondary teacher participants from the 2018 and 2019 STEM Academy programs were invited to take part in this research. In total, ten programs were undertaken from 2018 to 2019 (four primary and six secondary). Primary teacher participants are generalist teachers, while secondary teachers were most often subject specific teachers of science, mathematics or technology. The participating teachers represented schools from the DoE, Catholic and Independent education sectors. Consenting teachers completed a pre-survey before the start of the program and a post-survey after the program. The surveys were anonymous, and a code was created so pre- and post-surveys could be matched for analysis. Pre-surveys were completed by 548 teachers, post-surveys were completed by 433 teachers, with a total of 333 matched teacher surveys (144 primary, 199 secondary) and used for statistical analysis (see Table 1). Most primary and secondary teacher participants had more than ten years of teaching experience (see Table 2).

Table 1
2018-2019 STEM Academy teacher pre- and post-survey participants (N=333)

| Program | Completed Pre-surveys | Completed Post-surveys | Matched Surveys | Percentage Matched |
|---|---|---|---|---|
| Secondary | 337 | 259 | 199 | 59% |
| Primary | 211 | 174 | 144 | 68% |
| Total | 548 | 433 | 333 | 61% |

Table 2
2018-2019 STEM Academy teacher survey participants by teacher type and teaching experience (N=333)

| Years of Teaching Experience | Primary Teachers | Secondary Teachers | Total by years teaching | % by years of teaching |
|---|---|---|---|---|
| Not reported | 2 | 1 | 3 | 1% |
| Less than 3 years | 14 | 17 | 31 | 9% |
| 3 to 5 years | 21 | 19 | 40 | 12% |
| 5 to 7 years | 15 | 20 | 35 | 11% |
| 7 to 10 years | 21 | 29 | 50 | 15% |
| More than 10 years | 71 | 113 | 184 | 55% |
| Total | 144 | 199 | 333 | |

The comparison of pre- and post-test survey responses yielded statistically significant results across all factors (see Table 3). Please note that different Teacher Self-Efficacy scales were used for Primary and Secondary teachers.

Table 3
Comparisons of pre- and post-scale indicators using Wilcoxon-Signed Rank Tests (N=333; Primary teachers n=144, Secondary Teachers n=199)

| Scale | Pre-test mean | Post-test mean | Z | p | r (effect size) |
|---|---|---|---|---|---|
| **Teacher self-efficacy[a]** | | | | | |
| Primary[e] (pre α= .814; post α=.758) | 17.14 | 22.30 | -7.23 | .000*** | .60 |
| Secondary (pre α= .894; post α=.857) | 42.07 | 47.56 | -10.07 | .000*** | .71 |
| **Teacher outcome expectancy[b]** | | | | | |
| Primary (pre α= .769; post α=.807) | 30.91 | 31.61 | -2.03 | .042* | .17 |
| Secondary (pre α= .767; post α=.802) | 29.72 | 30.79 | -3.28 | .000*** | .28 |
| **STEM career knowledge[c]** | | | | | |
| Primary (pre α= .914; post α=.886) | 11.17 | 15.38 | -9.51 | .000*** | .80 |
| Secondary (pre α= .906; post α=.878) | 12.70 | 15.70 | -9.98 | .000*** | .71 |
| **Collective efficacy group competence[d]** | | | | | |
| Primary (pre α= .864; post α=.865) | 56.17 | 57.96 | -3.25 | .001*** | .27 |
| Secondary (pre α= .798; post α=.828) | 54.10 | 55.25 | -2.63 | .009** | .19 |

Notes: a. Different teacher self-efficacy scales used with primary and secondary teachers; primary scale range 5-25/secondary scale range 11-55; b. scale range 9-45; c. scale range 4-20; d. scale range 13-65; e. Primary teacher self-efficacy data only collected in 2019, n=74; Effect size (z/sqrt N) small=.1; medium=.3; large=.5; *$p$<.05, **$p$<.01, ***$p$<.001

## *Changes in Pedagogy*

The STEM Academy program encourages teachers to foster a classroom environment that adopts a more inquiry, student-centred approach. As part of the survey, teachers were asked to indicate how often students engaged in prescribed tasks or learning strategies during their teaching time. Comparisons were made between pre- and post-survey responses. Teachers' responses indicate positive changes in their pedagogical approaches aimed at enhancing student-centred learning in STEM. Since attending the STEM Academy, and implementing student-centred STEM tasks, lessons and projects, many teachers indicated changes in their pedagogical practices that were statistically significant (see Table 4).

Table 4
Teachers' indication of student engagement in tasks from pre- to post-Academy using Wilcoxon-Signed Rank Tests (N=333; primary teachers n=144, secondary Teachers n=199)

| During class time, how often do students ... | % Primary | % Secondary |
|---|---|---|
| Develop problem solving skills through investigation or inquiry | 42%*** | 45%*** |
| Work in small groups | 35%** | 41%*** |
| Make predictions that can be tested | 46%*** | 33%** |
| Make careful observations or measurements | 43%*** | 30% |
| Use tools to gather data, e.g., calculators, computers, software, scales, rulers | 45%*** | 32% |
| Recognise patterns in data | 39%*** | 32% |
| Choose the most appropriate methods to express results (e.g., drawings, models, charts, graphs, technical language) | 46%*** | 41%* |
| Create reasonable explanations of results of an experiment, investigation or inquiry | 49%*** | 40%** |
| Engage in content driven dialogue | 48%*** | 36%** |
| Reason abstractly | 52%*** | 43%*** |
| Reason quantitatively | 54%*** | 33%** |
| Complete activities within a real-world context | 45%*** | 31%* |
| Critique the reasoning of others | 58%*** | 38%** |
| Learn about careers related to the STEM subject content | 59%*** | 33%** |

*$p$<.05, **$p$<.01, ***$p$<.001

## *Changes in STEM Career Knowledge*

One of the aims of the STEM Academy program was to increase teacher's knowledge and understanding of STEM careers. Both secondary and primary teachers displayed statistically significant changes in their STEM career knowledge since their involvement with the STEM Academy (see Table 3). This includes knowledge about current STEM careers, where to go to learn about STEM careers, where to find resources for teaching students about STEM careers, and where to direct students or parents to find information about STEM careers.

### *Teacher Reflections*

After program completion, participating teachers were also invited, as part of the program evaluation, to take part in an open-ended reflective exercise in which teachers were asked to offer a written dialogue on their personal experience of engaging in this year-long PD program. A total of 354 teachers (152 primary, 202 secondary) offered a written response to some or all four prompts. Responses were coded, grouped by themes, and quantified based on themes. Tables 5-8 offer a summary of teacher responses based upon their reflections on their changes in STEM teaching and learning, the most common changes they have implemented in their classroom practice, their desired outcomes for future changes in their STEM teaching, and the resources and support they believe they need to continue their growth as STEM teachers. Please note the overlapping responses between Primary and Secondary teachers.

Table 5
Top ten changes in teacher perceptions towards STEM teaching and learning (N= 354)

| Secondary Teachers n=202 | | | Primary Teachers n=152 | | |
|---|---|---|---|---|---|
| Rank | Perception | Number of Responses | Rank | Perception | Number of Responses |
| 1 | Importance of subject integration | 44 | 1 | Acquired increased knowledge in STEM | 55 |
| 2 | I am more confident as a STEM teacher | 34 | 2 | Importance of subject integration | 24 |
| 3 | My vision towards STEM has expanded | 31 | 3 | I am more confident as a STEM teacher | 20 |
| 4 | STEM benefits students and improves engagement | 23 | 4 | Student-led learning is achievable | 13 |
| 5 | Importance of real-world applications | 13 | 5 | STEM benefits students and improves engagement | 11 |
| 6 | Acquired increased knowledge in STEM | 12 | 5 | Importance of collaboration | 11 |
| 7 | Affirmed in my teaching | 10 | 7 | Teaching STEM is achievable | 6 |
| 8 | Teaching STEM is achievable | 9 | 7 | Facilitates school level growth | 6 |
| 9 | Requires school administrative support | 7 | 9 | Teachers need to give up some control | 5 |
| 10 | Requires increased time | 6 | 10 | Importance of real-world applications | 4 |

Table 6
Most common changes in teachers' classroom practices in STEM (N=353)

| Secondary Teachers n=202 | | | Primary Teachers n=151 | | |
|---|---|---|---|---|---|
| Rank | Teaching Practice | Number of Responses | Rank | Teaching Practice | Number of Responses |
| 1 | More integration across subjects | 56 | 1 | Provide more opportunities for student leading | 58 |
| 2 | Provide more opportunities for student leading | 29 | 2 | Apply design process | 34 |
| 3 | Increased teacher collaboration and team teaching | 28 | 3 | More integration across subjects | 23 |
| 4 | More inquiry-based learning | 19 | 4 | Allow students to learn from failure | 14 |
| 5 | More real-world problem solving | 17 | 4 | More confident to apply my new STEM knowledge | 14 |

Table 7
Teachers' desired outcomes for future changes in their STEM teaching and learning; N=346

| Secondary Teachers n=202 | | | Primary Teachers n=144 | | |
|---|---|---|---|---|---|
| Rank | Outcome | Number of Responses | Rank | Outcome | Number of Responses |
| 1 | Design worthwhile projects or units in STEM | 58 | 1 | Apply design skills to more units of STEM work | 24 |
| 2 | More knowledge in other STEM subjects | 29 | 2 | More application across subjects | 19 |
| 3 | More opportunities to upskill | 24 | 3 | More integration of STEM across all grade levels | 15 |
| 4 | More knowledge and skill in technology | 20 | 3 | More knowledge and skill in technology | 15 |
| 5 | More time | 17 | 5 | Develop more links to the state syllabus | 11 |

Table 8
Projection of future support for teachers to continue along a STEM pathway; N=298

| Secondary Teachers n=189 | | | Primary Teachers n=109 | | |
|---|---|---|---|---|---|
| Rank | Desired Resource | Number of Responses | Rank | Desired Resource | Number of Responses |
| 1 | More time | 65 | 1 | More resources | 25 |
| 2 | More resources | 43 | 2 | More training | 18 |
| 3 | Inspirational and sharing of project ideas | 26 | 3 | Inspirational and sharing of project ideas | 17 |
| 4 | More training | 22 | 4 | Community of STEM teachers | 15 |
| 5 | Continued contact with Academy and networks | 22 | 5 | Access to Academy and mentors | 14 |

## Student Survey Results 2018-2019

This research sought to discover if there was any change in student attitudes, interests, and future career projections in STEM since experiencing integrated STEM teaching and learning with teachers who attended the STEM Teacher Enrichment Academy. In 2018 and 2019, pre- and post- surveys were collected and then matched to 2453 students from 84 schools. Schools from every program run in 2018 and 2019 are represented in the student data.

### *Primary Students and Schools*

Overall, there were 1289 matched surveys representing 42 primary schools. The survey contained four scales: *Attitude towards Science, Attitude towards Technology, Attitude towards Maths and Attitude towards STEM*. The *Attitude towards STEM* is a new scale added in 2019 to this year's survey for primary students. It is adapted from the Science attitude scale used in the secondary student survey with language adapted for STEM. We sought to discover if there was any change in student attitudes, interests, and future career projections in STEM since experiencing integrated STEM teaching and learning. The overall results for primary students are presented in Table 9.

While the overall primary student data shows some positive growth indicators, more impressive gains were noticed when individual school results were taken into account. Individual school statistics were generated for schools that had more than 10 matched surveys. Principals received a report with their individual school statistics.

Table 9
Percentage of Primary students that AGREE or STRONGLY AGREE with the indicated STEM Attitude prompt (N=1286; Girls n= 653; Boys n=633)

| **SCALES** | **TOTAL PRE-SURVEY %** | **TOTAL POST-SURVEY %** |
|---|---|---|
| **Attitude Towards Science Scale** | | |
| I would be excited to have a job in science | 38 | 37 |
| Learning science is exciting | 75 | 72 |
| I feel good about learning science | 71 | 70 |
| It would be exciting to be a scientist | 48 | 43 |
| **Attitude Towards Technology Scale** | | |
| I feel good about learning with technology | 84 | 84 |
| Learning with technology is exciting | 85 | 84 |
| It would be exciting to have a job in technology | 58 | 60 |
| I am able to do well using technology | 71 | 76 |
| **Attitude Towards Maths Scale** | | |
| I feel good about learning maths | 71 | 70 |
| I am able to do well in maths | 73 | 74 |
| It would be exciting to have a job working with maths | 36 | 39* |
| **Attitude Towards STEM** [a] | | |
| I feel good about myself when I do STEM | 74 | 77 |
| I might choose a career in STEM | 31 | 34 |
| After I finish high school, I will use STEM often | 37 | 46* |
| When I am older, knowing STEM will help me earn money | 49 | 55 |
| When I am older, I will need to understand STEM for my job | 53 | 53 |
| I know I can do well in STEM | 67 | 75* |
| STEM will be important to me in my future career | 48 | 50 |
| …STEM is not hard for me to understand | 53 | 61* |
| In the future, I could do harder STEM work | 59 | 65 |

*$p<.05$, **$p<.01$*

### *Secondary Students and Schools*

Overall, there were 1164 matched student surveys representing 42 secondary schools. The survey contained five scales: *Attitude towards Science, Attitude towards Engineering/Technology, Attitude towards Maths,* and *21st Century Learning Skills*. The survey also contained additional prompts that asked students to indicate whether they planned to attend university, and what their plans were for enrolling in future advanced mathematics or science classes. We sought to discover if there was any change in student attitudes, interests and future career projections in STEM since experiencing integrated STEM teaching and learning. Additionally, we sought to discover if students were more likely to indicate an intention to take advanced classes in mathematics and science since experiencing integrated STEM teaching and learning.

Overall survey comparisons across the entire cohort of secondary students revealed no statistically significant positive changes from pre-test to post-test in the four attitude scales and the 21st century learning skills factor.

Table 10
Percentage of Secondary students that AGREE or STRONGLY AGREE with the indicated STEM Attitude prompt (or Disagree or Strongly Disagree with Reverse Coded (RC) prompts) (N=1153; Girls n= 673; Boys n=473; no gender listed, n=7)

| **SCALES** | **TOTAL PRE-SURVEY %** | **TOTAL POST-SURVEY %** |
|---|---|---|
| **Attitude Towards Maths Scale** | | |
| I am good at maths | 62 | 59 |
| I can get good marks in maths | 72 | 67 |
| I am sure I could do advanced work in maths | 49 | 46 |
| I can handle most subjects well, but I cannot do a good job with maths (RC) | 56 | 56 |
| I am the type of student to do well in maths | 55 | 55 |
| Maths is hard for me (RC) | 48 | 45 |
| I would consider choosing a career that uses maths | 36 | 35 |
| Maths has been my worst subject (RC) | 62 | 61 |
| **Attitude Towards Science Scale** | | |
| I am sure of myself when I do science | 60 | 55 |
| I would consider a career in science | 34 | 34 |
| I expect to use science when I get out of school | 41 | 39 |
| Knowing science will help me earn a living | 47 | 42 |
| I will need science for my future work | 33 | 33 |
| I know I can do well in science | 73 | 69 |
| Science will be important to me in my life's work | 33 | 31 |
| I can handle most subjects well, but I cannot do a good job with science (RC) | 64 | 60 |
| I am sure I could do advanced work in science | 42 | 39 |
| **Attitude Towards Engineering** | | |
| I like to imagine creating new products | 66 | 59 |
| If I learn engineering, then I can improve things that people use every day | 68 | 63 |
| I am good at building and fixing things | 52 | 52 |
| I am interested in what makes machines work | 48 | 45 |
| Designing products or structures will be important for my future work | 38 | 34 |
| I am curious about how electronics work | 51 | 47 |
| I would like to use creativity and innovation in my future work | 62 | 58 |
| Knowing how to use maths and science together will allow me to invent useful things | 69 | 60 |
| I believe I can be successful in a career in engineering | 35 | 35 |

Note: For (RC) Reverse Coded prompts percentages indicate those that Disagree or Strongly Disagree with statement

Overall, there was a slight decrease in those students who indicated they intended pursuing tertiary studies (see table 11). When delineated for gender and school type, the only increase was seen in boys that attended an all-boys high school (+17%). Though it should be noted that only 38 boys fulfilled that criteria.

Table 11
Percent of students that responded YES to the prompt: I PLAN TO ATTEND UNIVERSITY

| N=1005 | **Attend University Pre-survey %** | **Attend University Post-survey %** |
|---|---|---|
| TOTAL Overall and by School and gender | 70 | 67 |
| GIRLS n=600 | 74 | 72 |
| BOYS n=399 | 63 | 61 |
| BY TYPE OF SCHOOL | | |
| Catholic n=362 | 63 | 62 |
| Girls n=214 | 70 | 68 |
| Boys n=146 | 55 | 54 |
| Department n=344 | 74 | 72 |
| Girls n=238 | 76 | 74 |
| Boys n=95 | 72 | 68 |
| Independent n=309 | 72 | 68 |
| Girls n=148 | 78 | 74 |
| Boys n=158 | 66 | 63 |
| SCHOOLS by Gender Type | | |
| ALL-GIRLS n=177 | 82 | 78 |
| COED GIRLS n =431 | 71 | 70 |
| ALL-BOYS n=38 | 72 | 84 |
| COED BOYS n=377 | 62 | 58 |

Note: small sample size in ALL-BOYS school participants

As they look to the future, students were asked if they planned on taking advanced mathematics or advanced science classes in the future (See Table 12). Overall, there was no change in students' intention to enrol in advanced mathematics classes (34%). There was a decline in students' intention to enrol in advanced science classes (pre: 26%; post: 23%).

Table 12
2018-2019 Percent of students (N=1034) that responded YES to the prompt: I PLAN TO….

| | **Take Advanced Maths Pre-survey %** | **Take Advanced Maths Post-survey %** | | **Take Advanced Science Pre-survey %** | **Take Advanced Science Post-survey %** |
|---|---|---|---|---|---|
| TOTAL Overall and by gender | 34 | 34 | | 26 | 23 |
| Girls n=613 | 27 | 29 | | 21 | 20 |
| Boys n=415 | 43 | 40 | | 34 | 29 |
| TYPE OF SCHOOL | | | | | |
| Catholic n=369 | 30 | 32 | | 22 | 20 |
| Girls n=219 | 24 | 31 | | 18 | 19 |
| Boys n=148 | 40 | 34 | | 29 | 22 |
| Department n=344 | 33 | 31 | | 27 | 27 |
| Girls n=245 | 28 | 26 | | 23 | 23 |
| Boys n=95 | 43 | 44 | | 36 | 37 |
| Independent n=309 | 39 | 39 | | 31 | 23 |
| Girls n=149 | 31 | 33 | | 23 | 14 |
| Boys n=169 | 47 | 43 | | 39 | 31 |
| SCHOOLS by Gender Type | | | | | |
| ALL-GIRLS n=177 | 33 | 39 | | 26 | 27 |
| COED (GIRLS) n =431 | 25 | 26 | | 19 | 16 |
| ALL-BOYS n=38 | 47 | 50 | | 32 | 43 |
| COED (BOYS) n=377 | 43 | 39 | | 35 | 28 |

Note: small sample size in ALL-BOYS SCHOOL participants

However, when those results are delineated by gender and type of school, differences emerge. Boys indicated a greater inclination to enrol in advanced mathematics classes than girls. Comparing pre to post, girls indicated an 8% greater inclination to enrol whereas boys showed a 7% decline in intention to enrol in advanced mathematics. Even with the growth in girls' responses, girls still lag boys in their intention to enrol in advanced mathematics classes.

The greatest gains were seen in girls' intention to enrol in advanced mathematics classes, with a 29% increase noted from girls who attend a Catholic School and an 18% increase in girls who attend an All-Girls secondary school.

## Parent Survey Results 2018

Parents were invited through their schools to complete a short online survey that probed their *Beliefs about STEM* (5 items), *Values about STEM* (5 items) and *Resources School provides in STEM* (3 items). Parent Demographic information was also collected. Four hundred and eighty-seven (487) parents completed a STEM parent survey (413 indicated child's school, 74 parents did not indicate child's school). Table 13 reflects the type of schools attended by students whose parent(s) completed the survey.

Table 13.
Breakdown of parent survey participants by indication of school governance and school type

| | **GOVT** | **CATH** | **INDEPEND** | **No School Indicated** | **TOTALS** |
|---|---|---|---|---|---|
| PRIMARY | | | | | |
| Schools | 11 | 4 | 0 | | 15 |
| Completed Surveys | 117 | 67 | 0 | | 184 |
| SECONDARY | | | | | |
| Schools | 1 | 3 | 5 | | 9 |
| Completed Surveys | 6 | 67 | 156 | | 229 |
| TOTAL SCHOOLS | 12 | 7 | 5 | | 24 |
| TOTAL SURVEYS | 123 | 134 | 156 | 74 | 487 |

Parent surveys were predominantly completed by mothers. More specifically, 86% of surveys completed by primary parents were completed by mothers and 14% were completed by fathers. A larger proportion of fathers of secondary students completed the survey with surveys completed by 78% mothers and 22% fathers.

The surveyed parents were well educated as 83% of parents attended university or tertiary studies with 65% attaining a bachelor's degree or higher qualification.

As indicated by the parent responses (see table 14), on average, parents indicated strong beliefs about STEM and hold high value towards STEM. However, parents were less positive towards the resources that their schools possess to effectively teach STEM.

Table 14.
Parent responses to survey scale items

| | SCALE MEAN | ITEM MEAN[a] |
|---|---|---|
| Beliefs about STEM (scale 5-25) | 22.08 | 4.42 |
| Values about STEM (scale 5-25) | 20.97 | 4.19 |
| Resources of School in STEM (scale 3-15) | 11.50 | 3.83 |

Notes: a. Item mean reflects Likert-type response prompts (1: Highly Disagree to 5: Highly Agree)

To determine if there were significant differences in parent responses based on the type (primary or secondary) of school or the governance (government, catholic or independent) of the school, further testing was undertaken.

Table 15
Parent Survey - Percentage of parents that Agree or Strongly Agree with the Statements by indication of school governance and school type

| | PRIMARY | | | SECONDARY | | |
|---|---|---|---|---|---|---|
| | GOVT n=117 | CATH n=36 | INDEPEND n=31 | GOVT n=6 * | CATH n=98 | INDEPEND n=125 |
| Belief 1 | 96% | 97% | 97% | 100% | 95% | 95% |
| Belief 2 | 98 | 100 | 97 | 100 | 97 | 94 |
| Belief 3 | 88 | 92 | 87 | 100 | 91 | 90 |
| Belief 4 ** | 96 | 97 | 94 | 100 | 97 | 94 |
| Belief 5 | 98 | 100 | 93 | 100 | 97 | 96 |
| Value 1 ** | 97 | 100 | 94 | 100 | 94 | 93 |
| Value 2 | 80 | 94 | 71 | 83 | 81 | 81 |
| Value 3 ** | 96 | 92 | 94 | 100 | 88 | 89 |
| Value 4 | 80 | 89 | 84 | 83 | 87 | 88 |
| Value 5 | 90 | 92 | 87 | 83 | 85 | 91 |
| Resources 1 **; + | 38 | 51 | 32 | 83 | 43 | 52 |
| Resources 2 ** | 94 | 97 | 94 | 83 | 76 | 90 |
| Resources 3 **; + | 54 | 80 | 71 | 100 | 63 | 79 |

Note: * please note small sample
+ indicates statistical significance between school type (PRIMARY/SECONDARY)
** indicates statistical significance between school governance (GOVT/CATHOLIC/INDEPENDENT)

**Statements:**

Belief 1: Students should have opportunities to participate in extra-curricular activities related to STEM
Belief 2: In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say
Belief 3: Students should be exposed to STEM careers during the school day.
Belief 4: During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
Belief 5: A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.
Value 1: Students should learn about STEM fields in order to accumulate knowledge about the world around us.
Value2: Student should learn about STEM fields in order to be able to have an educated debate about policies in our community.
Value 3: Student should learn about STEM fields in order to understand how concepts are used to assist in their desired way of life.
Value 4: Student should learn about STEM fields in order to be able to make educated decisions about moral and ethical issues in current events.
Value 5: Student should learn about STEM fields in order to be able to understand the issues in current scientific research.
Resources 1: Teachers in my school have access to sufficient resources to complete activities/labs.
Resources 2: Students in my school have access to everyday materials such as pens, pencils and calculators.
Resources 3: There is sufficient access to technology in classrooms for curricular purposes.

## III. CONCLUDING COMMENTS ON PHASE I AND PHASE II RESEARCH UNDERTAKINGS

In summary, teachers tend to report significant changes in beliefs and practices although observations in schools would provide additional evidence. Overall, the student data tends to show limited change in attitudes although individual school data reveals far greater diversity. For some schools, students' attitudes towards the STEM subjects change significantly. To date we have some evidence that the following factors contribute to more substantial change:

1. a very strong commitment from school leadership to support the development of STEM education with a clear vision, usually articulated in the school strategic plan;
2. a strong team of school leaders and teachers driving the program;
3. a willingness to create a connected curriculum that authentically embeds key aspects of each of the STEM subjects;
4. a connected curriculum that allows students to see how the STEM subjects can work together to create solutions to interesting problems;
5. a willingness by teachers to learn about new curriculum ideas and to experiment with new technologies;
6. a change of pedagogies within individual STEM subjects as well as in the connected curriculum;
7. the use of problems which engage students; and
8. where possible, the use of community members to share their knowledge and understanding of STEM and STEM careers with students

The identification that some secondary schools were already connecting with their feeder primary schools and that others wanted to investigate how they could use a community of schools to further develop STEM connections led to the establishment of the latest STEM Academy program – the Connections Program –initiated yet paused in 2020.

# IV. LIST OF PUBLICATIONS

Tully, D., & Anderson, J. (in press). Adapting to uncertain times: How one Australian secondary school implemented integrated STEM curriculum during the COVID19 Pandemic. *International Journal of Learning and Teaching* - Special Issue: Significance of STEM Education in Teaching and Learning for the Changing World with COVID19

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Anderson, J., Katrak, Z. (2017). Higher order thinking, engagement and connectedness in lessons based on STEM contexts. *Proceedings of the 41st Conference of the International Group for the Psychology of Mathematics Education* (PME41), Singapore: PME.