



Australia's National
Science Agency

Indigenous STEM Education Project

Third Evaluation Report

September 2014 – September 2018

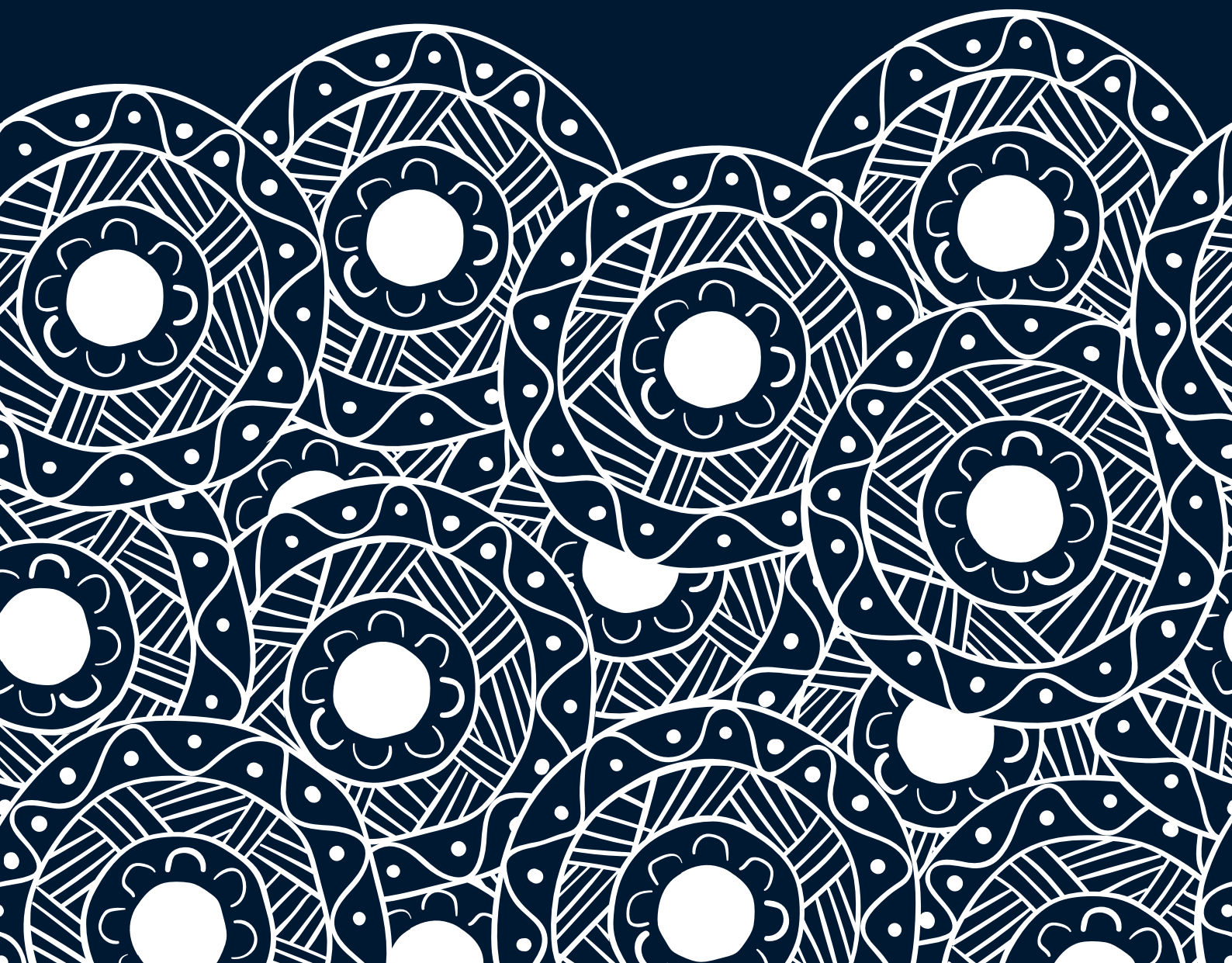


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Acknowledgements

Acknowledgement of Country

Aboriginal and Torres Strait Islander peoples have longstanding scientific-knowledge traditions. These traditions have developed knowledge about the world through:

- observation, using all the senses;
- prediction and hypothesis;
- testing (trial and error); and
- making generalisations within specific contexts.

These scientific methods have been practised and transmitted from one generation to the next and contribute to particular ways of knowing the world that are unique as well as complementary to Western scientific knowledge.

A deep respect for these Aboriginal and Torres Strait Islander cultural practices and knowledge underpin the philosophy and practice of the Indigenous STEM Education Project. Recognition of traditional contexts for technologies and concepts and their application in the past, present, and future—including supporting modern STEM career pathways for Aboriginal and Torres Strait Islander students—reaffirm the ingenuity and creativity of Aboriginal and Torres Strait Islander peoples' knowledge systems.

The Indigenous STEM Education Project team acknowledges the Traditional Owners of the lands on which this Project operates and their vibrant living cultures and knowledge systems. We pay our respects to Elders past and present, and we thank all community members who are providing the leadership to ensure meaningful and effective engagement with Aboriginal and Torres Strait Islander communities for the six distinct but complementary STEM education programs that make up this Project.

CSIRO acknowledges that Aboriginal and Torres Strait Islander peoples make significant contributions to Australia in cultural, economic and scientific domains; for example, incorporating Indigenous knowledge of ecological and social systems is vital to the achievement of sustainable development.

Other acknowledgements

CSIRO wishes to acknowledge the invaluable contribution of Aboriginal and Torres Strait Islander scientists, educators and program leaders—without their knowledge and leadership the development and implementation of the Indigenous STEM Education Project would not have been possible. In addition, CSIRO acknowledges the advice and guidance of the case study reference group for this research. Their wisdom in relation to respectfully engaging Aboriginal and Torres Strait Islander students in the research was enormously helpful and is appreciated.

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In particular, the contributions current and former team members Jessica Fidler, Caja Gilbert, Megan Ladbrook, Celia McNeilly, and Michael Tynan are gratefully acknowledged. Finally, the contributions of Zane Ma Rhea and Shane Phillipson from EEGL, who developed the recommendations in the Second Evaluation Report, are acknowledged.

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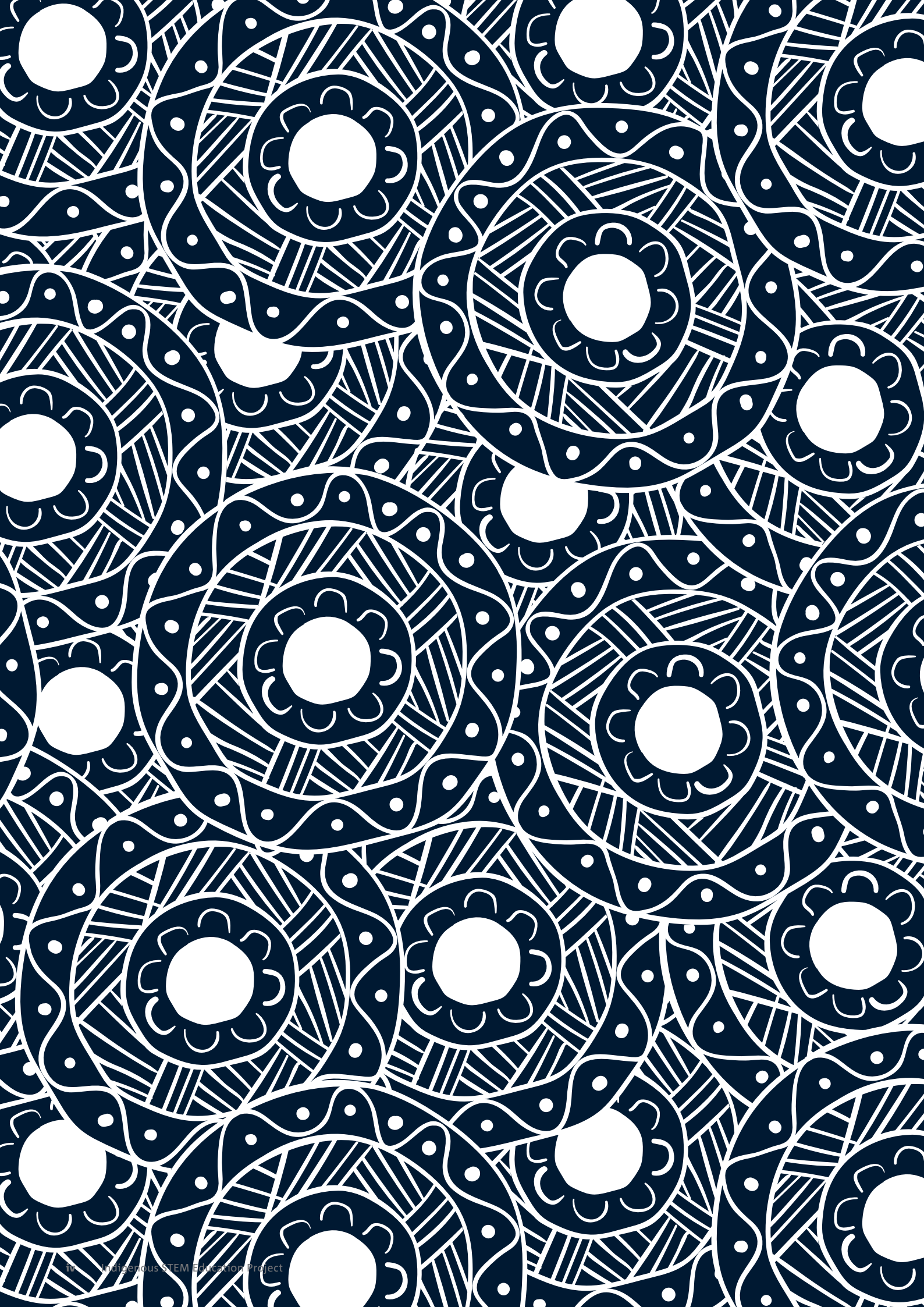
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List of Acronyms

ABC	Australian Broadcasting Corporation
ACARA	Australian Curriculum, Assessment and Reporting Authority
AIEO	Aboriginal and Islander Education Officer
ASSETS	Aboriginal Summer School for Excellence in Technology and Science – one of the Project’s six programs
CEdO	CSIRO Education and Outreach
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEGL	Education Experts Group Limited – consultancy that independently reviewed the Second Evaluation report
ICSEA	Index of Community Socio-Educational Advantage: a scale which allows for fair and reasonable comparisons among schools with similar students
I2S2	Inquiry for Indigenous Science Students – one of the Project’s six programs
MSS	Mean scale score
NAPLAN	National Assessment Program – Literacy and Numeracy
NITV	National Indigenous Television
PISA	Program for International Student Assessment
PRIME	Purposeful Rich Indigenous Mathematics Education
QUT	Queensland University of Technology
RAMR	Reality-Abstraction-Mathematics-Reflection
SBS	Special Broadcasting Service
STEM	Science, Technology, Engineering and Mathematics
YDC	YuMi Deadly Centre: A research centre at QUT that delivers the PRIME Futures program
YDM	YuMi Deadly Maths: a mathematics pedagogical framework



Executive Summary

The Indigenous STEM Education Project aims to increase participation and achievement of Aboriginal and Torres Strait Islander students in science, technology, engineering and mathematics (STEM) education and career pathways. It consists of six programs that cater to the diversity of students as they progress through primary, secondary and tertiary education and into employment. This report is the third in a series of evaluation reports (Ma Rhea et al., 2018; Tynan & Noon, 2017), and focuses on specific program outcomes as well as progress towards whole-of-project outcomes identified in the Indigenous STEM Project Impact Pathway. In the previous evaluation reports, program implementation learnings were presented, as well as early evidence of increased attendance, engagement and achievement of Aboriginal and/or Torres Strait Islander students across the programs. A common theme in previous evaluation reports is evidence that highlights the significant benefits of sharing and integrating Aboriginal and/or Torres Strait Islander knowledges and contexts into the education curriculum for all students.

Across all
8

states and territories

21,116

Aboriginal and/or Torres
Strait Islander
student contacts

793

teachers involved

159

schools participating

“

I have had a really good response from some lower-level students and their confidence to get up there and have a go at something different has really increased which is fantastic!

Key findings

This Third Evaluation Report highlights the following findings for the six programs:

- The ASSETS program has made progress against all of the outcomes addressed through this evaluation. The majority of surveyed participants found its impact to be significant, and often life-changing, in terms of their study and career directions.
- The unique combination of components that make up the ASSETS' model are critical to the success of the program. These include: a strength-based approach that connects participants to what they already know about science; being intentional about exploring cultural identity and linking local Indigenous Knowledge to Western science, and the critical role of Elders, Indigenous knowledge holders and cultural leaders in connecting them; and well prepared and trained staff and academic providers to deliver the science inquiry and cultural components.
- Evidence from the Bachelor of Science (Extended) program suggests that students have had positive experiences in the program and have felt supported in a culturally responsive¹ environment. A crucial learning from this program is that scaffolding and support strategies may need to be tailored to each cohort of students to maximise success.

- Overall, encouraging progress has been made towards supporting Aboriginal and Torres Strait Islander students to complete a Bachelor of Science at the University of Melbourne and then go on to STEM careers.
- The PRIME Futures program is demonstrating gradual positive change at both a teacher and a whole-of-school level. In particular, evidence highlights teacher perceptions of improvements in student engagement and achievement in mathematics.
- There are a few self-reported examples of PRIME Futures success for student cohorts and the broader school community, particularly through connections with cultural leaders and the application of Aboriginal and Torres Strait Islander knowledge to mathematics pedagogy and content. Information collected from teachers and principals confirms that making school-level practice changes can require top-down leadership and additional time for planning and full implementation.
- The Science Pathways for Indigenous Communities coordinators in both Western Australia and Northern Territory report strong engagement in the program by teachers and students, and among schools and their broader communities. Early evidence indicates that some of the key expected program outcomes are being achieved, particularly strong, effective partnerships; and increased community and parental involvement, and capacity building for teachers. These changes will be explored in more detail in the forthcoming case study report and the next overall evaluation report.
- Program data from the Indigenous STEM Awards indicate that there is strong engagement in the Awards program by participants of the programs that comprise the CSIRO Indigenous STEM Education Project, with over 57 per cent of nominations coming from participants in these programs. This exceeded the target of 10 per cent of nominations.
- The reach of the Indigenous STEM Awards has also increased by over 160 per cent from 2016 to 2017, with nominations from all eight states and territories.
- The Inquiry for Indigenous Science Students (I2S2) program findings show that following an inquiry, classroom engagement levels increased across student groups. Overall, forty per cent of Aboriginal and Torres Strait Islander students increased their engagement after an inquiry. An even larger increase was seen among low-achieving students, with 51 per cent of low achieving Aboriginal and Torres Strait Islander students and 48 per cent of low achieving non-Indigenous students increasing their engagement following an inquiry.
- Improvements in academic achievement were observed for Aboriginal and Torres Strait Islander and non-Indigenous students following an I2S2 inquiry, with the most significant improvements observed for low-achieving students. The percentage of Aboriginal and Torres Strait Islander and non-Indigenous students recording an increase in achievement was similar (27 per cent and 26 per cent, respectively). The percentage of 'low-achieving' students increased more significantly, with just over half of all students in this category demonstrating an increase in academic achievement after the I2S2 inquiry.

Progress towards whole-of-project outcomes

Across all programs, increased student engagement and academic results are common indicators of success. Other indicators such as increased teacher capacity, student attendance and choosing STEM pathways vary across programs. Emerging outcome evidence indicates overall positive results in the areas of student engagement, academic results and teacher capacity; whereas evidence of increased student attendance and choosing STEM pathways is less apparent (or applies to only one program).

This Third Evaluation Report highlights the following progress towards the whole-of-project outcomes:

Teacher and school outcomes

Generally, educators have indicated improved capability and capacity in response to program resources, tools, professional development and training. Interview and survey data indicate that when programs have dedicated staff to provide coaching, modelling and support to teachers and schools, the uptake of these resources and integration into teacher pedagogies and school curriculums has been strong. Generally, project learnings indicate that time and resource restraints and lack of educator confidence and experience can impact on this outcome, as can the level of commitment required to make a teaching paradigm shift or implement a whole-of-school or program change.

Family and community outcomes

There were examples of parents, family and other community members having had a positive influence on young learners, especially in areas such as engagement, confidence, aspiration, and confirmation of their existing strengths and goals. In general, lack of parental involvement was not considered to detract from progressing towards outcomes; however, a lack of

¹Department of Education (2015)'s Aboriginal Cultural Standard Framework outlines a continuum with four stages: Cultural awareness (emerging), Cultural understanding (developing), Cultural competence (capable), and Cultural Responsiveness (proficient). The Indigenous STEM Education Project and individual program Impact Pathways refer to 'cultural competence'; however, in terms of the four stages, the Project is aiming for Cultural Responsiveness, the highest level.

engagement with local Aboriginal and/or Torres Strait Islander community members was often referred to by teachers and program staff as a barrier to achieving other project outcomes. These barriers are discussed in more detail in individual program case study reports. Generally, evidence indicates that students and program staff were appreciative of, and benefited from, the engagement of family and/or community members.

Student outcomes

All programs will or have elicited feedback from, or assessed the engagement/achievement of, program participants². Generally, evidence from and about students has been positive. Overall, interview and survey data indicate gradual yet positive changes in engagement and academic results across programs. Some programs also demonstrate progress towards intended outcomes through evidence of meaningful change for individuals. These transformative changes relate to personal journeys, often contextualised by a young person's program experiences or forming/deepening connections with others. These changes tend to be reflected at lesser levels within the broader cohort.

Culturally responsive education

Project evidence indicates some progress towards teachers, program partners, and schools becoming more culturally responsive, including some students describing positive experiences in culturally responsive environments. This evidence is primarily qualitative, and is highlighted by various participants as they reflect on their experiences in and out of the classroom. There are gaps in evidence for this outcome, including capturing the personal reflective work required of individuals to acknowledge how their own culture, values and attitudes impact their pedagogies and evidence collected against recognised standards of cultural responsiveness in an education setting. Additional data collection in these areas will be considered as the project progresses.

The evaluation findings of the Indigenous STEM Education Project should be considered within the broader context of Aboriginal and Torres Strait Islander people's histories, achievements and aspirations, and cultural contexts of STEM education in Australia. While the available outcome data and findings do not always allow for causal inferences, they do provide a robust mixed-method approach to identifying the outcomes achieved to date and some of the critical success factors and barriers to achieving these outcomes. Independent recommendations were made regarding the collection of program monitoring and evaluation data and are available in Appendix A, with

progress notes. This report also provides a discussion of progress towards outcomes from a whole-of-project impact perspective. Overall, positive findings are evident, particularly when authentic and mutual partnerships are in place. A significant proportion of project activities are targeted towards student and teacher outcomes. As a result, positive findings are emerging in these areas, particularly in improving engagement and capacity, respectively. In-depth case study research reports are, or will be, available on the CSIRO Indigenous Education Project website (www.csiro.au/en/Education/Programs/Indigenous-STEM), and will provide further key evidence on the impact and effectiveness of four of the six program elements.

Following the third evaluation report, a process of review will be led by the monitoring and evaluation team to consider the relevance of established program outcomes and the emergence of unexpected outcomes. This process is critical due to the project's adaptive program processes, complex implementation contexts, and unique program designs that are relatively untested in Australia. The purpose of this is to ensure evaluation learnings are reflected in the impact pathways, and that they accurately reflect the logic and impact of each program. This process may result in minor changes to the program impact pathways, including the expected outcomes and indicators that best measure them. Further detail of this process will be included in the next overall evaluation report.



I believe ASSETS has changed the way I view myself. I have never felt so comfortable in expressing who I truly was until I came on this camp. The camp was so supportive in my goals. This was the first time someone had ever told me to just go straight to medicine. Everyone has always told me to aim lower, do an undergraduate degree. So being told that you are worth it and you can achieve anything you put your mind to, was the best experience I have had.” (ASSETS participant)

²PRIME Futures primarily draws on teacher and principal feedback but does compile NAPLAN data from PRIME Futures and comparison schools.

Introduction

The Indigenous STEM Education Project is a partnership between CSIRO, Australia's national research science agency, and the BHP Foundation, an independent charity established by BHP to support large, long-term community projects by not-for-profit organisations. The Project's overarching goal is to provide supported pathways that improve the participation and achievement of Aboriginal and Torres Strait Islander students in STEM subjects and professions. The Project comprises six programs. Three of these are universal programs: Inquiry for Indigenous Science Students (I2S2) and PRIME Futures which are science inquiry and maths programs implemented in metropolitan and regional communities; and Science Pathways for Indigenous Communities which uses Indigenous Ecological Knowledge as the basis for teaching science in remote communities. Three of the programs are targeted: the Aboriginal Summer School for Excellence in Technology and Science (ASSETS) and the Indigenous STEM Awards which support, celebrate and extend high achieving Aboriginal and Torres Strait Islander students and STEM champions; and the Bachelor of Science (Extended) at the University of Melbourne, which provides an alternate pathway to a university science degree for students requiring additional science and/or mathematics background.

Purpose of this evaluation

This Third Evaluation Report draws on data from the Project's commencement until September 2018. It reports on the evaluation of progress towards 'success' outcomes, including quantitative indicators of engagement, attendance, and improved academic achievement of Aboriginal and Torres Strait Islander students in STEM subjects. The core hypothesis of the Indigenous STEM Education Project is that it is delivering innovative programs that are leading to improved engagement, attendance, and academic achievement of Aboriginal and Torres Strait Islander students in STEM. Key findings are made based on an analysis of quantitative and qualitative data.

Project Theory of Change and Impact Pathways

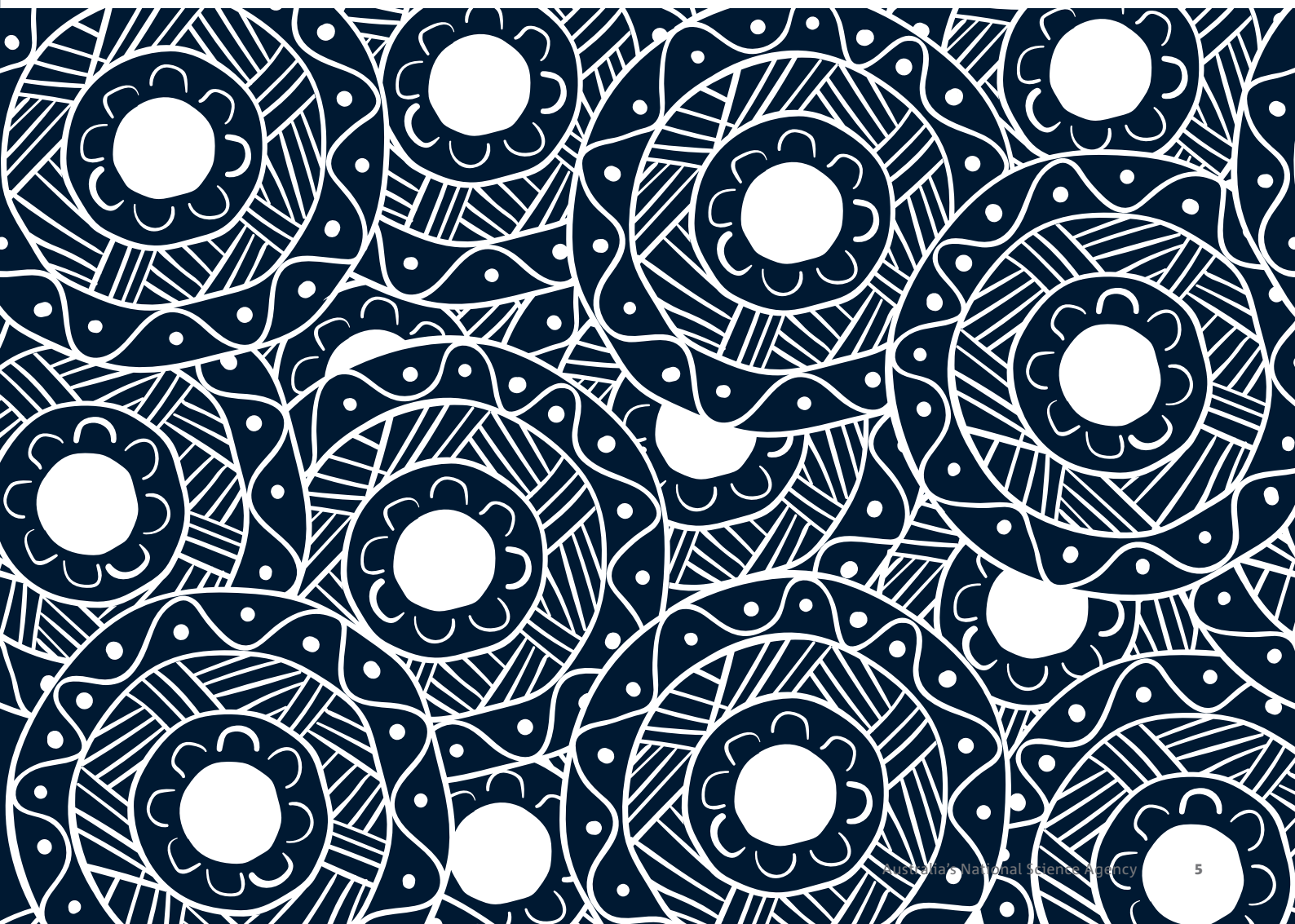
The overall Indigenous STEM Education Project, and the six programs that comprise the Project, each has Impact Pathways. These are available at www.csiro.au/en/Education/Programs/Indigenous-STEM/Monitoring-and-Evaluation/About. These Impact Pathways describe the logic and assumptions of each program and articulate expected outputs, outcomes and longer-term population-level impact. Program monitoring and evaluation data are used to report against these pathways; and program findings are used to revise the Impact Pathway, where appropriate. This process reflects an action learning approach to program implementation, ensuring practice learnings are integrated into future programs.

Methodology and limitations of the data

This series of reports provides a broad evaluative overview of the Project, touching on key implementation and outcome findings. For this Third Evaluation Report, the availability of outcome evidence varies across the programs, as case studies have been staggered and program implementation timeframes differ or have been staggered across regions. There is also limited direct monitoring of student performance (pre and post or longitudinally); instead, there is a strong focus on qualitative and survey data collected from key participant groups, which is supplemented by some direct data, such as NAPLAN results. This creates challenges for determining robust and statistically significant outcome change but provides a better understanding of how this Project benefits students, schools and their broader communities, and which students are receiving the most benefit.

Additional standardised jurisdictional or national data such as individual student results will be used to make stronger comparisons in mean gains between schools or demonstrate education and career pathways over time. Within the current scope of the evaluation, evidence demonstrates indicative impact which can be used to improve future program model design and implementation. Further evaluations targeted at a program outcome level would be beneficial to make stronger causal inferences.

This report outlines each of the six programs that make up the Indigenous STEM Education Project, including a description of each program, intended outcomes, and key findings to date. The report then takes a whole-of-project focus, using principles of sustainability to highlight program strengths and possible longer-term effects. The project-level Impact Pathway (see Appendix B) is then referenced to discuss progress towards whole-of-project outcomes.



Inquiry for Indigenous Science Students (I2S2) program

Program description

The Inquiry for Indigenous Science Students (I2S2) program develops and implements Indigenous inquiry resources targeting middle school students (Years 5 to 9) in mainstream metropolitan and regional schools.

The inquiries are delivered as part of a school's regular science curriculum and utilise multimodal delivery and assessment techniques. The inquiries also allow all students to demonstrate their cognitive science skills through diverse modalities that are not necessarily dependent on written English literacy skills (such as verbal assessments or graphics-based assessments on tablet computers). The I2S2 team also trains and supports science teachers in their delivery of the inquiries, and broader Aboriginal and Torres Strait Islander cultural awareness relevant to their implementation.

At the time of this report, participant numbers for the I2S2 program were: 71 schools, 340 teachers and 3,025 Aboriginal and/or Torres Strait Islander students. Cumulatively, 7,380 students have participated in I2S2 up to the end of 2018. These figures have exceeded the original program targets for teachers (224) and students (2,800). (CSIRO, 2018)

Program outcomes

The I2S2 Impact Pathway comprises nine outcomes (four immediate and five intermediate). These outcomes are outlined below. The I2S2 Evaluation Case Study report will contain more detail about the indicators and definitions associated with the outcomes.

Immediate outcomes

- Increased student engagement, attendance and (academic) results
- Increased student aspirations, sense of value and school belonging
- Increased teacher capability and capacity in both inquiry and Indigenous contexts
- Increased community and parental engagement;

Intermediate outcomes

- Increased number of students pursuing STEM pathways
- Schools are culturally competent³ in delivering Indigenous pedagogy and content in partnership with families and communities
- Sector adopts best practice, and teacher professional development, in Indigenous STEM Education
- School culture of high expectations across curriculum
- Schools supporting other STEM projects.

Research methods: program monitoring and jurisdictional administrative data

I2S2 program monitoring involves several sets of data. The first is student-related, consisting of student results (Grades A to E and N – not assessed), engagement (on a scale of 1 to 5) and attendance (percentage of classes attended) in the term prior and term during the inquiry delivery. Participating teachers completed the student data collection template. Each inquiry has a detailed assessment rubric to assist teachers in the process (see Appendix C for an example). Teachers were instructed to refer to class and school data to assist with this task. The second, the engagement scale, is a simple five-point scale and has been conceptualised as similar to the grading of 'effort' which is a common school reporting practice. Attendance is reported as a percentage to ensure consistency and comparability.

³As previously mentioned, 'culturally competent' was included in the original Impact Pathway.

Jurisdictional administrative data involves aggregated data from schools involved in the program sourced from the relevant Department of Education databases. At the time of this report, one jurisdiction had been approached and provided data for schools involved in I2S2, with other jurisdictions to follow. The data includes grades, attendance and any engagement or effort measures for participation, and matched comparison schools.

For this report, 2017 data was analysed for 28 schools, comprising five in New South Wales, 19 in Queensland, and four in South Australia for which both school principal and jurisdictional consents were obtained. These data are derived from 36 per cent of the 77 total participating schools in the program overall. The overall number of students participating in the I2S2 program includes 794 Aboriginal and Torres Strait Islander students and 2,863 non-Indigenous students. This represents approximately 27 per cent of the approximately 2,895 Aboriginal and Torres Strait Islander students and approximately 32 per cent of the approximately 8,815 non-Indigenous students across the 77 participating schools in 2017. In the next section, current data is compared with 2016 and 2017 data. More detailed 2016 data was presented in the Second Evaluation Report (Ma Rhea, et al., 2018).

Key findings of the I2S2 program

Attendance

Tables 1 and 2 show that attendance decreased for the majority of Aboriginal and Torres Strait Islander students (52 per cent) and for a relatively large minority of non-Indigenous students (40 per cent) participating in I2S2, which was similar to the 2016 results.⁴

One positive result was that 40 per cent of low-achieving non-Indigenous students improved their attendance, although the change was not statistically significant.

Attendance rates of all Aboriginal and Torres Strait Islander students in Australia have remained relatively stable over the past several years.⁵ In Australia, student attendance levels in schools generally decrease as the school year progresses (Department of Education, Training and Employment, 2013). The reasons for student non-attendance are varied and complex, but include cultural factors, family holidays, conflict with other students, and student illness (The University of Queensland, 2017). In one study, 20 perceived causes of student non-attendance were identified (The University of Queensland, 2017). Examining these causes, only one (student disengagement) could reasonably be influenced by a program of the type and intensity of I2S2. All the other causes listed above relate to family and school factors and are outside the influence of I2S2. Therefore, it is unlikely that I2S2, which typically involves two to four inquiries per year in one subject (approximately 30 hours in a term⁶), can substantially influence the overall attendance of students. Nevertheless, it was hypothesised that I2S2 would have some positive (likely indirect) influence on attendance, that could not necessarily be observed.

⁴For all findings comparing 2016 and 2017 results, some of the same students will be in both samples (for example, some Year 8 students in 2016 will be in Year 9 in 2017); however, each sample was considered separately as there were a relatively small number of students whose data could be analysed at an individual level across years.

⁵Across Australia, in government and non-government schools, Aboriginal and Torres Strait Islander students in Years 1 to 10 had attendance rates of: 84 per cent in 2014; 84 per cent in 2015; 83 per cent in 2016; 83 per cent in 2017; and 82 per cent in 2018 (Productivity Commission, 2019). However, attendance rates differ by remoteness. In 2018, across all schools, attendance rates for Aboriginal and Torres Strait Islander students were: 85 per cent in Major Cities; 86 per cent in Inner Regional; 83 per cent in Outer Regional; 76 per cent in Remote; and 63 per cent in Very Remote (Productivity Commission, 2019). Attendance rates are the number of actual full-time equivalent student-days attended by full-time students in Years 1 to 10 as a percentage of the total number of possible student-days attended over the period.

⁶The number of hours spent on inquiries in a term can range from a minimum of approximately 10 hours to a maximum of approximately 60 hours.

Table 1 Teacher assessments of attendance, engagement and academic achievement of Aboriginal and Torres Strait Islander students participating in the I2S2 program (2017)

	STUDENT ACHIEVEMENT LEVEL ² (n) ³	TIME 2 COMPARED WITH TIME 1 ¹			Z ⁷	DIRECTION	EFFECT SIZE (r) ⁸
		PER CENT					
		IMPROVED (n)	SAME (n)	DECLINED (n)			
Attendance ⁴	A/B/C Level (n = 375)	31 (115)	19 (71)	50 (189)	-4.194***	↓	0.15
	D/E Level (n = 296)	34 (102)	10 (30)	55 (164)	-3.874***	↓	0.16
	All levels (n = 711)	33 (234)	15 (106)	52 (371)	-5.530***	↓	0.15
Engagement ⁵	A/B/C Level (n = 400)	33 (131)	54 (217)	13 (52)	-5.583***	↑	0.20
	D/E Level (n = 297)	51 (151)	41 (123)	8 (23)	-9.166***	↑	0.38
	All levels (n = 715)	40 (285)	49 (353)	11 (77)	-10.544***	↑	0.28
Academic Achievement ⁶	A/B/C Level (n = 461)	14 (66)	67 (285)	24 (110)	-3.635***	↓	0.12
	D/E Level (n = 329)	44 (146)	45 (148)	11 (35)	-8.315***	↑	0.32
	All levels (n = 794)	27 (214)	55 (435)	18 (145)	-3.763***	↑	0.09

¹Time 1 data was obtained prior to the beginning of the program. Time 2 data was obtained after the completion of the program. Improved = Positive Rank; Same = Ties; Declined = Negative Rank.

²Students were rated as A, B, or C (high achieving) or D or E (low achieving) at Time 1. See 6

³All values of n are valid pre- and post-data. Note, however, that overall values of n do not reflect the subtotals.

⁴Student attendance was recorded by teachers, which was converted to a scale from 0 to 100 per cent; teachers were instructed to refer to class or school attendance information when entering these data to ensure accuracy. Differences in attendance between Time 1 and Time 2 were tested using a Wilcoxon Signed Ranks Test as the data were not normally distributed.

⁵Student engagement was assessed by teachers using a five-point Likert scale (1 = avoids engagement, 2 = inconsistent engagement, 3 = participates, 4 = engaged, 5 = highly engaged).

⁶Student achievement was assessed by teachers using six categories (N = insufficient evidence, E = very limited, D = limited, C = sound, B = high, A = very high). Students who were not assessed a grade (n) at either pre- or post-test were excluded from the Academic achievement analyses, but were included in the Attendance and Engagement analyses (All levels).

⁷Wilcoxon Signed Rank Tests were conducted, due to non-normal distribution of data (Attendance) and ordinal data (Engagement and Achievement). Significance levels: * p < .05, ** p < .01, *** p < .001.

⁸Effect size *r* was calculated using a procedure similar to the Mann-Whitney U test: $r = Z / \sqrt{n}$, where *n* is the total number of observations (students x 2). Although there are existing classifications of effect size (Cohen's (1988) impressionistic criteria (0.2 small, 0.5 medium, 0.8 large) and Gignac and Szodorai's (2016) empirically derived criteria (0.15 small, 0.25 medium, 0.35 large)), Lipsey et al. (2012) warn of the inappropriateness of using general classifications of effect size for education interventions.

Engagement

Engagement levels increased for Aboriginal and Torres Strait Islander students who participated in the program. Of the 715 students that were assessed on engagement by their teachers, 40 per cent increased their engagement levels after the inquiry, while 49 per cent remained the same, which was a statistically significant increase ($p < .001$). An even larger increase was seen among low-achieving students, with 51 per cent of students demonstrating increased engagement, which was also statistically significant ($p < .001$). This was a larger percentage of students than in 2016, when the proportion was 34 per cent.⁷

For non-Indigenous students, improvements were similar in magnitude. Overall, 28 per cent of non-Indigenous students improved their engagement, and 61 per cent remained at the same level of engagement. However, improvements were more pronounced for low-achieving students, with 48 per cent of students improving their engagement, and 45 per cent maintaining their engagement levels. This change was both statistically significant ($p < .001$) and had a relatively large effect size of $r = .38$. These results were similar to 2016, when 31 per cent of all non-Indigenous students improved their engagement, and 49 per cent of low-achieving students improved their engagement.

Table 2 Teacher assessments of attendance, engagement and academic achievement of non-Indigenous students participating in the I2S2 program (2017)

	STUDENT ACHIEVEMENT LEVEL ² (n) ³	TIME 2 COMPARED WITH TIME 1 ¹			Z ⁷	DIRECTION	EFFECT SIZE (r) ⁸
		PER CENT					
		IMPROVED (n)	SAME (n)	DECLINED (n)			
Attendance ⁴	A/B/C Level (n = 1,923)	35 (667)	23 (450)	42 (806)	-3.221**	↓	0.05
	D/E Level (n = 423)	40 (171)	26 (110)	34 (142)	-0.921	↑	0.03
	All levels (n = 2,546)	35 (893)	25 (640)	40 (1,013)	-2.333*	↓	0.03
Engagement ⁵	A/B/C Level (n = 2,041)	24 (499)	64 (1,300)	12 (242)	-9.667***	↑	0.15
	D/E Level (n = 431)	48 (206)	45 (195)	7 (30)	-11.023***	↑	0.38
	All levels (n = 2,517)	28 (711)	61 (1,526)	11 (280)	-13.947***	↑	0.20
Academic Achievement ⁶	A/B/C Level (n = 2,362)	19 (451)	56 (1,359)	23 (552)	-3.692***	↓	0.05
	D/E Level (n = 490)	59 (289)	35 (172)	6 (29)	-13.726***	↑	0.44
	All levels (n = 2,863)	26 (746)	54 (1,536)	20 (581)	-4.586***	↑	0.06

¹Time 1 data was obtained prior to the beginning of the program. Time 2 data was obtained after the completion of the program. Improved = Positive Rank; Same = Ties; Declined = Negative Rank.

²Students were rated as A, B or C (high achieving) or D or E (low achieving) at Time 1. See 6

³All values of n are valid pre- and post-data. Note, however, that overall values of n do not reflect the subtotals.

⁴Student attendance was recorded by teachers, which was converted to a scale from 0 to 100 per cent; teachers were instructed to refer to class or school attendance information when entering these data to ensure accuracy. Differences in attendance between Time 1 and Time 2 were tested using a Wilcoxon Signed Ranks Test as the data were not normally distributed.

⁵Student engagement was assessed by teachers using a five-point Likert scale (1 = avoids engagement, 2 = inconsistent engagement, 3 = participates, 4 = engaged, 5 = highly engaged).

⁶Student achievement was assessed by teachers using six categories (N = insufficient evidence, E = very limited, D = limited, C = sound, B = high, A = very high). Students who were not assessed a grade (n) at either pre- or post-test were excluded from the Academic achievement analyses, but were included in the Attendance and Engagement analyses (All levels).

⁷Wilcoxon Signed Rank Tests were conducted, due to non-normal distribution of data (Attendance) and ordinal data (Engagement and Achievement).

Significance levels: * p < .05, ** p < .01, *** p < .001.

⁸Effect size r was calculated using a procedure similar to the Mann-Whitney U test: $r = Z / \sqrt{n}$, where n is the total number of observations (students x 2).

Although there are existing classifications of effect size (Cohen's (1988) impressionistic criteria (0.2 small, 0.5 medium, 0.8 large) and Gignac and Szodorai's (2016) empirically derived criteria (0.15 small, 0.25 medium, 0.35 large)), Lipsey et al. (2012) warn of the inappropriateness of using general classifications of effect size for education interventions.

⁷With currently available data, it is not possible to make evidence-based conclusions on the reasons for increased overall student engagement among low-achieving students compared to the previous year. However, the forthcoming I2S2 Evaluation Case Study Report will have access to additional data and will provide more explanatory commentary.

Achievement⁸

Improvements in academic achievement for Aboriginal and Torres Strait Islander students were also observed, although not as extensively as in 2016. Specifically, 27 per cent of all Aboriginal and Torres Strait Islander students improved their achievement levels, with 55 per cent maintaining their achievement levels ($p < .001$). In 2016, 38 per cent improved their achievement levels. The improvements for low-achieving students were larger, with 44 per cent of these students improving their results in 2017. This change was statistically significant ($p < .001$) with an effect size of $r = .32$. The majority of high achieving students (67 per cent in 2017 and 65 per cent in 2016) maintained their achievement levels, likely due to the ceiling effect where many high achieving students were at the top of the achievement scale already and could not demonstrate any improvements. Figure 1 shows the changes in grades from Time 1 (before the inquiry) to Time 2 (after the inquiry) for Aboriginal and Torres Strait Islander students. Overall, there was a small positive shift in achievement with 62 per cent of students having a passing grade (A, B or C) before the inquiry, and 66 per cent after the inquiry. This change was not as high as the 2016 data when the proportion increased from 49 per cent to 66 per cent. As mentioned, improvements in achievement were similar for non-Indigenous students (see Table 2).

Specifically, 26 per cent of non-Indigenous students improved their achievement, while 59 per cent of low achieving non-Indigenous students had improved achievement (significance was $p < .001$ and the effect size was $r = .44$). The I2S2 program may have contributed towards these improvements. However factors such as sample size and type (non-random) and imperfectly correlated variables create some statistical issues with drawing strong conclusions, and may explain the variability in results. More explanatory information on the potential reasons for these changes will be provided in the forthcoming I2S2 Evaluation Case Study report.

In terms of next steps, I2S2 is developing an Online Learning Program to increase accessibility among teachers across Australia. The first phase of the program was launched in October 2018 and comprises a course with five learning modules. Learners who complete the course are invited to an online community of practice to take part in additional activities, share with other learners, and ask questions of program staff. Also on completion, learners receive access to inquiry resources to support them in the classroom. Ongoing monitoring of the Online Learning Program is being conducted and results will be presented in future reports.

ABORIGINAL AND TORRES STRAIT ISLANDER STUDENT ACHIEVEMENT

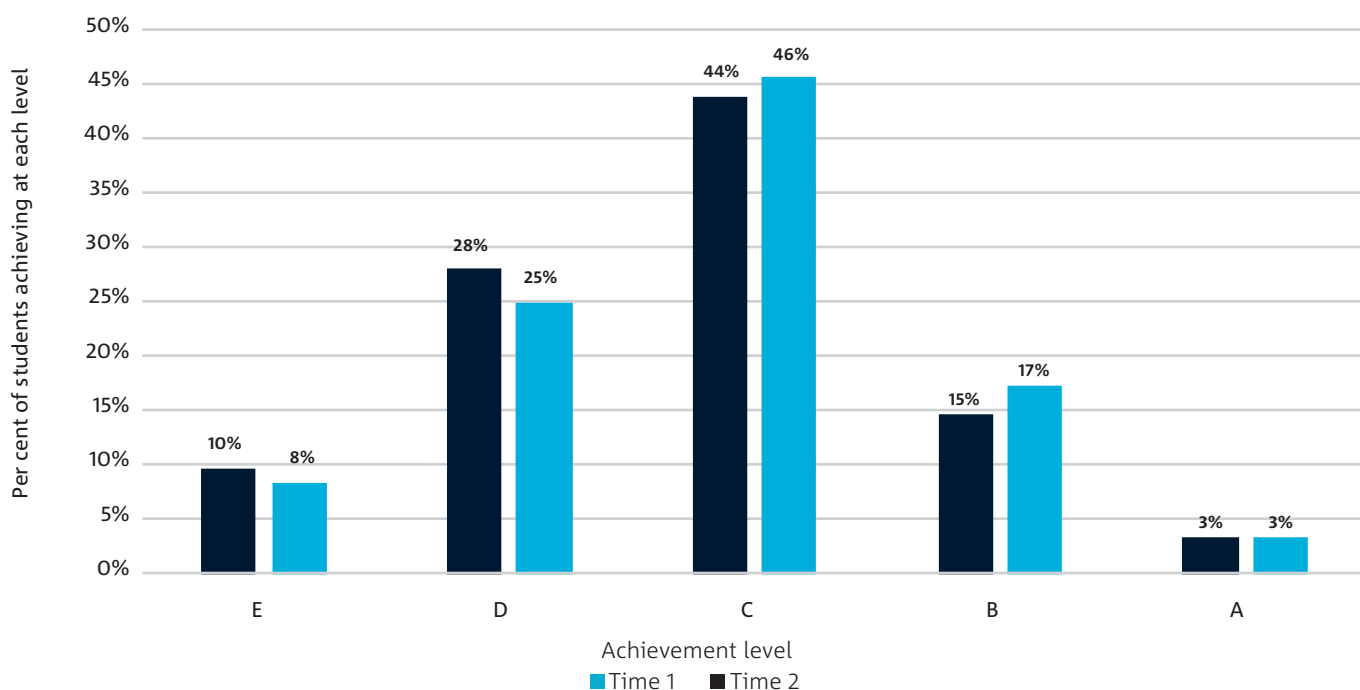


Figure 1 I2S2 Aboriginal and Torres Strait Islander student achievement levels (Time and Time 2)

Note: The diagram shows the number of students at each achievement level at Time 1 and Time 2, where E = very limited, D = limited, C = sound, B = high and A = very high. Students that were rated N (insufficient information) were not included in this analysis.

⁸ Achievement by Aboriginal and Torres Strait Islander students across Australia has been improving in some STEM areas but has been more variable in others. For example, the proportion of students achieving at or above the national minimum standard in numeracy has increased across all measured year levels from 2008 to 2017: Year 3 was 78.6 per cent to 82.2%; Year 5 was 69.2 per cent to 80.2 per cent; Year 7 was 78.6 per cent to 79.9 per cent; and Year 9 was 72.5 per cent to 84.0 per cent (Productivity Commission, 2019). In science, results have been variable. The proportion of Year 6 Aboriginal and Torres Strait Islander students at or above proficient standard in science achievement performance was: 25.5 per cent (2006), 19.6 per cent (2009), 20.1 per cent (2012) and 23.4 per cent (2015) (Productivity Commission, 2019). In Information and Communication Technology, Aboriginal and Torres Strait Islander student achievement is also variable. The proportion of students attaining the proficient standard was: Year 6: 30 per cent (2005), 24 per cent (2008), 31 per cent (2011), 22 per cent (2014), and 24 per cent (2017); and Year 10: 35 per cent (2005), 32 per cent (2008), 36 per cent (2011), 20 per cent (2014), and 24 per cent (2017) (Productivity Commission, 2019). These data are estimates only and have relatively large confidence intervals; see Productivity Commission (2019) for more details.

PRIME Futures

Program description

PRIME Futures comprises YuMi Deadly Maths (YDM), developed and delivered by the YuMi Deadly Centre at the Queensland University of Technology (QUT)⁹. YDM is a mathematics pedagogical framework applying the RAMR (Reality, Abstraction, Maths, Reflection) model and covering all aspects of the Australian Mathematics Curriculum from Foundation to Year 9. The framework is also based on Indigenous learning and takes account of local culture and knowledge. PRIME Futures seeks to achieve whole-school change in the teaching and learning of mathematics by adopting a systemic approach over two or more years, facilitated by the principal or another school leader, and working with a core group of teachers using a train-the-trainer model (Queensland University of Technology, 2018).

Geographic clusters of schools have joined the PRIME Futures program in a staged roll-out implemented in three phases from 2015 to 2018. During this time, some schools that joined initially later withdrew due to their changing internal priorities. As at September 2018, there were 10 clusters comprising 63 schools and approximately 290 teacher-trainers, which exceeds the targets for PRIME Futures across all three phases, of 60 schools and 120 teachers. Exact figures on the number of Aboriginal and Torres Strait Islander students were not available because data was collected at the school level, with limited capacity to undertake detailed data collection. However, the target of 1,500 Aboriginal and Torres Strait Islander students was almost certainly met. This is because there was an estimated total of 7,083 Aboriginal and Torres Strait Islander students attending the 63 schools involved in the program as of September 2018. It is highly likely that at least 21 per cent (1,500 out of 7,083 students) of students would have received YDM teaching, even considering that staff training and classroom application was a gradual process.

Program outcomes

Immediate outcomes

- Increased teacher capability and capacity – pedagogy skills, local knowledge, expectations of students, use of resources
- Positive student engagement with the new pedagogy and deeper understandings of maths concepts
- Building partnerships with Aboriginal and/or Torres Strait Islander leaders and Elders (leadership and change cycle);

Intermediate outcomes

- Improved student cohort (academic) results
- Stronger partnerships with parents and the local community
- Schools adopt best practice and innovation in mathematics education
- Schools and students applying to awards and excellence programs.

Research methods: surveys and national standardised test data

As part of their commitment to ongoing action research, the YuMi Deadly Centre at QUT has collected quantitative and qualitative data on the PRIME Futures program. The following data have been provided to CSIRO for the purpose of this report:

Surveys – six-monthly survey data is elicited from the teachers and principals leading the implementation of the program in participating schools. The survey respondents are asked several questions about program implementation, teacher capacity, and student engagement and academic achievement¹⁰. Educators were invited to complete a survey every six months, with the first survey completed between three and six months after the program start date, and the final survey undertaken on exit from the training program. The exit survey includes retrospective ‘before and after’ questions.

National standardised school performance data¹¹ – Publicly available NAPLAN (National Assessment Program Literacy and Numeracy) numeracy data has been compiled to indicate broad changes in student achievement for each school in phase one. Data collected from ACARA’s My School website (ACARA, 2019b) is used to compare YDM and statistically similar non-YDM schools over a longer-term period of 2009 to 2016. For any particular school, the mean gain over two years is calculated as the difference in the mean scale score (MSS) achieved in the NAPLAN numeracy test(s) by a cohort of students in that school with the MSS of the same cohort in that school two years later. NAPLAN data have several limitations in the context of measuring the outcomes of PRIME Futures, including that it is a point-in-time measure, and that it is a summative measure of a school year-level, even if only a portion of the classes within that school had been taught YDM.

⁹ The YuMi Deadly Centre is closing at the end of 2019.

¹⁰ Teachers are asked to make assessments of academic achievement about all relevant students that they teach the YDM to (i.e., not individual classes or students).

¹¹ Yumi Deadly Centre assessed that it was not feasible to obtain the jurisdictional approvals required to obtain class-level administrative data.

Key findings of the PRIME Futures program

Teacher capability and capacity

The PRIME Futures survey tools used a five-point rating scale¹², which was aggregated into cluster averages at regular intervals across the life of the two-year program. Using this rating scale, principals and teachers within each cluster (1 to 10) felt, on average, that since the implementation of PRIME Futures, teacher capability (skills, knowledge, confidence) and capacity (training, resources, dedicated time, school change) was improved. In clusters 1 to 6 where teachers had completed two years of professional development, both principals (n = 24 respondents) and teachers (n = 81 respondents) identified in the exit survey that teacher ‘mathematical knowledge’, ‘pedagogical skills’ and ‘confidence in teaching mathematics’ were ‘moderately’ improved (rated on average by teachers as 3.84, 4.24 and 4.04 respectively and rated on average by principals as 3.75, 4.21 and 3.96 respectively). Over this period, principals and teachers identified teacher ‘pedagogical skills’ as the most improved capability. Teachers who responded to survey 3 (n = 128 respondents; clusters 1 to 10) felt that all PRIME Futures resources improved their capacity to teach mathematics; in particular, workshops were identified as the most useful program component (average rating of 3.7). While teachers in the exit survey (n = 81) felt, on average, their capacity to incorporate Indigenous knowledges into their mathematics pedagogy had increased moderately (average rating of 3.7), this component of the program showed relatively less change compared to other areas of knowledge and skill development. However, this positive change is still very encouraging, given that no change would likely have occurred without the program. More substantial changes would likely be observed over time as teachers gain confidence, build support networks, and change attitudes towards Indigenous knowledges.

Application of the YDM approach in the classroom, via a range of practices, is evident in responses to teacher Survey 3. For example, a majority of teachers indicated that they applied YDM in the classroom via multiple activities (73 per cent) and by using their own YDM lesson plans (67 per cent). This aligns with the results that half of the teachers reported a reduction in the use of textbooks and worksheets (down by 10 per cent from Survey 1). One teacher explained how YDM provided an additional resource to engage an under-performing student when traditional practices were not working: “I can see that he has a great amount of knowledge – it’s just what I am doing is not necessarily accessing that.

The lesson I talked about ... was really for me to observe his engagement ... It was great for him, it reinforced how the RAMR planning will work for him and my other Indigenous students”. Despite the reported benefits, in Survey 3, teachers most commonly noted the high level of preparation required as an obstacle to implementing YDM. One teacher noted that “some colleagues feel like what they’re doing works well enough and are unwilling to take on extra work”. While another teacher noted that the extra time required can be worth it: “creating resources can be time-consuming though they are definitely reusable ...”. It is clear that during the period covered by this report, YDM was being implemented by teachers through a range of activities and practices.

Student engagement and achievement

All student groups increased engagement to a considerable extent with the delivery of the enhanced YDM curriculum. Teachers, on average, most frequently noted ‘increased engagement’ (91 per cent) and ‘improved learning/understanding’ (80 per cent) in their students (Survey 3, n = 128; clusters 1 to 10) (see Figure 2). The results improved from Survey 1 to Survey 3 as well, with an increasing proportion of teachers reporting ‘increased student engagement’ (80 per cent to 91 per cent, an increase of 11 per cent), ‘improved learning/understanding’ (61 per cent to 80 per cent, an increase of 19 per cent), and ‘better test results’ (14 per cent to 33 per cent, an increase of 19 per cent). According to the retrospective before/after survey, Aboriginal and/or Torres Strait Islander students, and students in the lower ability range, improved engagement the most (from ‘somewhat’ to ‘moderately’ engaged). One teacher explained how the RAMR approach had influenced engagement: “this approach has seen my [Aboriginal and Torres Strait Islander] students shine Through connecting learning with their home context, they can see its relevance so much more ... now I see their excitement.” This emerging connection between the YDM approach and a student’s home (and culture) highlights the potential for increasing engagement in mathematics education.

¹²1 = not at all; 2 = very little; 3 = somewhat; 4 = moderately; 5 = extensively.

WHAT STUDENT OUTCOMES HAVE YOU OBSERVED WHEN USING THE YDM APPROACH?

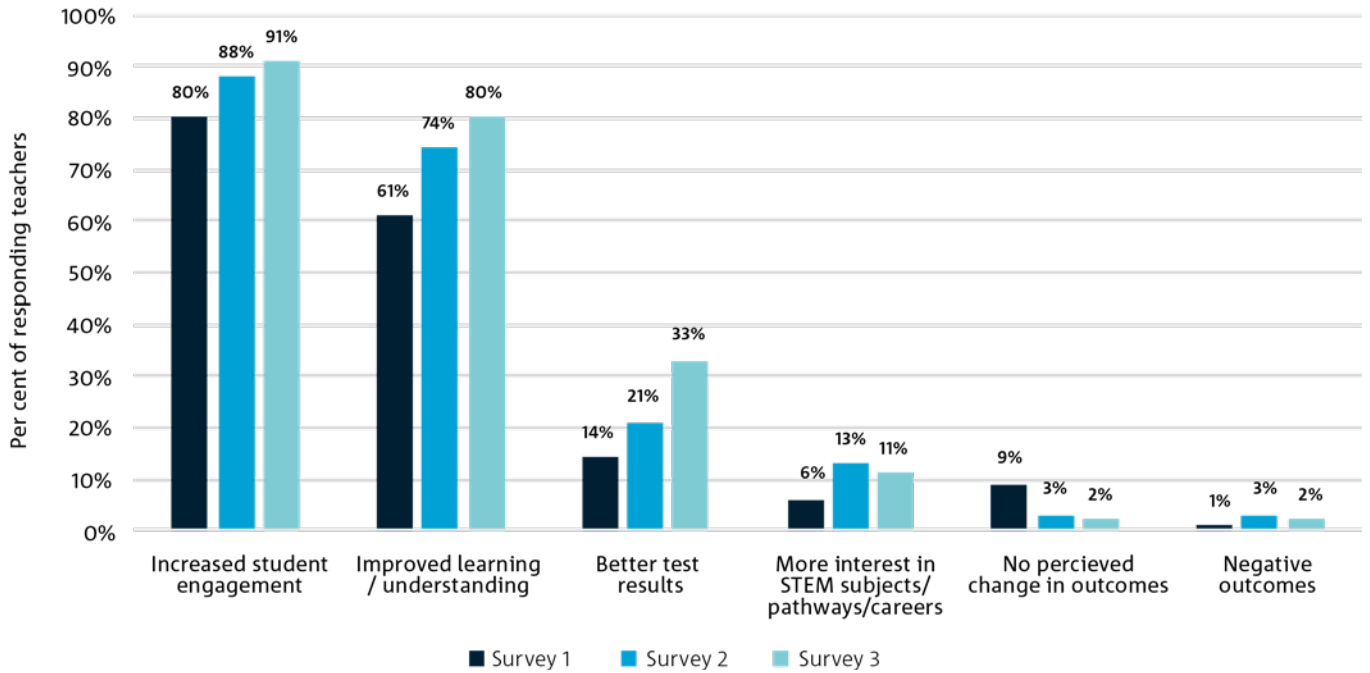


Figure 2 PRIME Futures teacher perceptions of student outcomes using the YuMi Deadly Maths approach

Note: Survey 1 (n = 163); Survey 2 (n = 152); Survey 3 (n = 128).

When asked about the extent of their students' engagement within the YDM classroom, teachers gave the highest rating to student behaviours: willingness to 'have a go' (4.10 for Survey 3) and their readiness to 'teach and learn from each other' (4.10 for Survey 3) (see Figure 3). In a separate survey, reflecting on student engagement before and after PRIME Futures, teachers retrospectively rated 'students' positive attitude towards learning mathematics' as one of the most improved, from an average rating of 3.0 to 4.2 (n = 81; clusters 1 to 6). Teachers provided enthusiastic feedback about student engagement, such as:



I have had a really good response from some lower-level students and their confidence to get up there and have a go at something different has really increased which is fantastic!



the YuMi approach to teaching has really increased the discussion around mathematics in the classroom! Confidence of students is higher and engagement is also up as they are loving it!

In addition to success in the classroom, some PRIME Futures schools and students have demonstrated strong engagement and achievement through their participation in awards programs, including some PRIME Futures students winning national STEM awards.

THINKING ABOUT YOUR RECENT MATHEMATICS LESSONS, PLEASE GIVE YOUR OPINION ABOUT THE FOLLOWING STATEMENTS CONCERNING THE EXTENT OF YOUR STUDENTS' ENGAGEMENT IN THOSE LESSONS

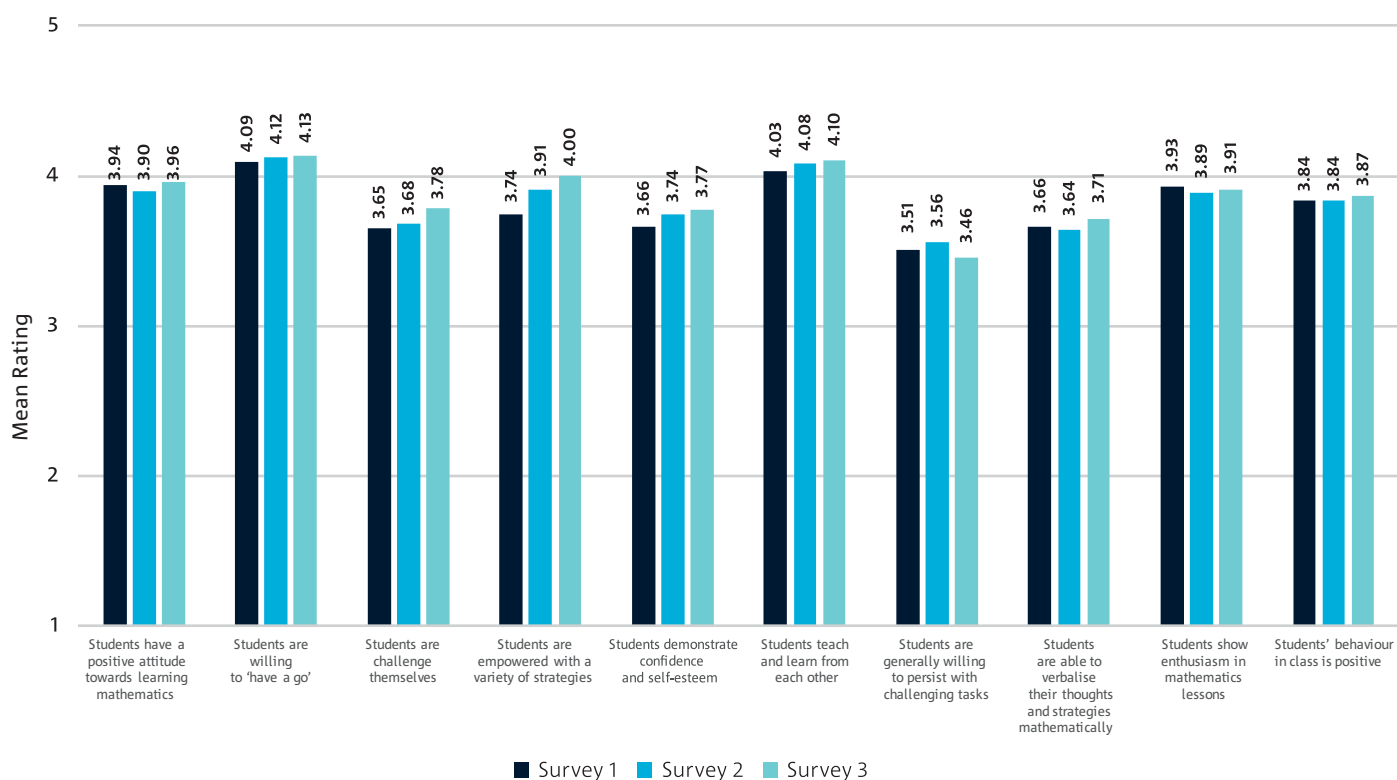


Figure 3 PRIME Futures teacher perceptions of student engagement in recent mathematics lessons

Note: 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree; 5 = strongly agree. Survey 1 (n = 163); Survey 2 (n = 152); Survey 3 (n = 128)

Teachers indicated an improvement in all student mathematical outcomes, when retrospectively considering outcomes before and after PRIME Futures (n = 81; clusters 1 to 6). Teachers noted, on average, positive changes in students being able to 'verbalise their thoughts and strategies mathematically' (average rating of 3.9) and their 'willing to persist with challenging tasks' (average rating of 3.8). Although results are derived from generic teacher assessments, there is evidence that YDM is having a substantial positive impact on students' engagement and achievement, including a 19 per cent increase in test results from Survey 1 to Survey 3.

School leadership and change

PRIME Futures aims to influence leadership and pedagogy at the school level. Therefore whole-school benefits can also be expected. In the survey responses, teachers acknowledge that this system-level change requires coordinated effort: "The drive for YuMi needs to come from "above" me and needs more of a commitment to encouraging teachers to try it out" and "Breaking down the traditional ways of doing things ... poses new challenges".

Despite this, and other constraints identified by teachers such as 'maintaining the interest and progress of YuMi in a busy and time-poor school with other equally important priorities', almost all teacher survey respondents (97 per cent in the exit survey) reported having trained or supported their colleagues in YDM. Almost half of those (48 per cent) had trained or supported all teachers in the school/department by the end of the program. Teachers retrospectively identified that practice of YDM by colleagues was evident in their increased use of 'hands-on activities' in the classroom (increasing from an average rating of 2.9 to 3.9), with the largest improvement seen in colleagues' use of the RAMR approach rated at 2.8 after PRIME Futures, up from an average rating of 1.3 (n = 81; clusters 1 to 6).

Another identified area of school change is about the benefits of YDM's cultural leadership and change element. One principal noted that 'Aboriginal culture and teaching and learning practises that support students are gradually being embedded more and more into our teaching and learning programs. YuMi has provided the impetus for this to be extended to the Maths learning area'. Across Surveys 1 to 3, principals identified strategies used within their schools to improve the influence of cultural knowledge and local leaders in teaching mathematics.

Based on surveys with principals, a high proportion of schools were:

- generating awareness of the importance of cultural identity and acknowledging the diversity of cultures within the classrooms (93 per cent);
- participating in, or attending, community-based cultural events or forums (91 per cent);
- creating awareness of Indigenous histories, cultures and knowledges (84 per cent); and
- using contextual resources (80 per cent).

In turn, principals noted increased engagement from Aboriginal and/or Torres Strait Islander parents and community in part as a result of PRIME Futures. Teachers (exit survey; n = 81, clusters 1 to 6) also indicated, on average, that their knowledge of local Indigenous culture and community had improved (from an average rating of around ‘satisfactory’ to ‘good’). This increasing knowledge has important ramifications: as teachers become more culturally responsive, they can improve teaching responses and identify opportunities that lead to better outcomes for students, for the remainder of their teaching careers (Burgess & Cavanagh, 2015). For early-career teachers, this could mean a generation of students that are experiencing culturally responsive pedagogies.

Other school-level factors are evident in the data provided. While survey data showed outcomes such as engagement/learning to be significant, teachers across all clusters (Surveys 1 to 3) reported that interest in STEM subjects, pathways and/or careers was also somewhat more frequently being observed among students over the course of the program (from 6 per cent to 11 per cent). Teachers also reported a slight improvement in student attendance throughout the program, from an average rating of 3.4 to 3.8, which is a critical success factor for YDM.

Whole-of-school NAPLAN numeracy results (the gain from Years 3 to 5) are included in Figure 4 to provide a general comparison from 2009 to 2016 for the primary schools¹³ in PRIME Futures (Clusters 1 and 2) and similar schools. Figure 4 indicates that schools that are trained in YDM are slightly more likely to demonstrate an improvement in mean NAPLAN numeracy scores than similar schools that are not using YDM (6 of the 9 PRIME Futures schools out-performed groups of similar schools). It is difficult to make concrete conclusions about why individual PRIME Futures primary schools fared better or worse compared to similar schools; however, it is worth noting that the mean difference for all nine PRIME Futures schools showed an increase of 94.4, a positive result in and of itself. While NAPLAN data for PRIME Futures schools is indicative only at this early stage of implementation, in previous evaluations involving larger clusters, NAPLAN results have been used to triangulate findings around impact (Spina et al., 2017).

MEAN DIFFERENCE IN NAPLAN NUMERACY SCORES: 2009 TO 2016

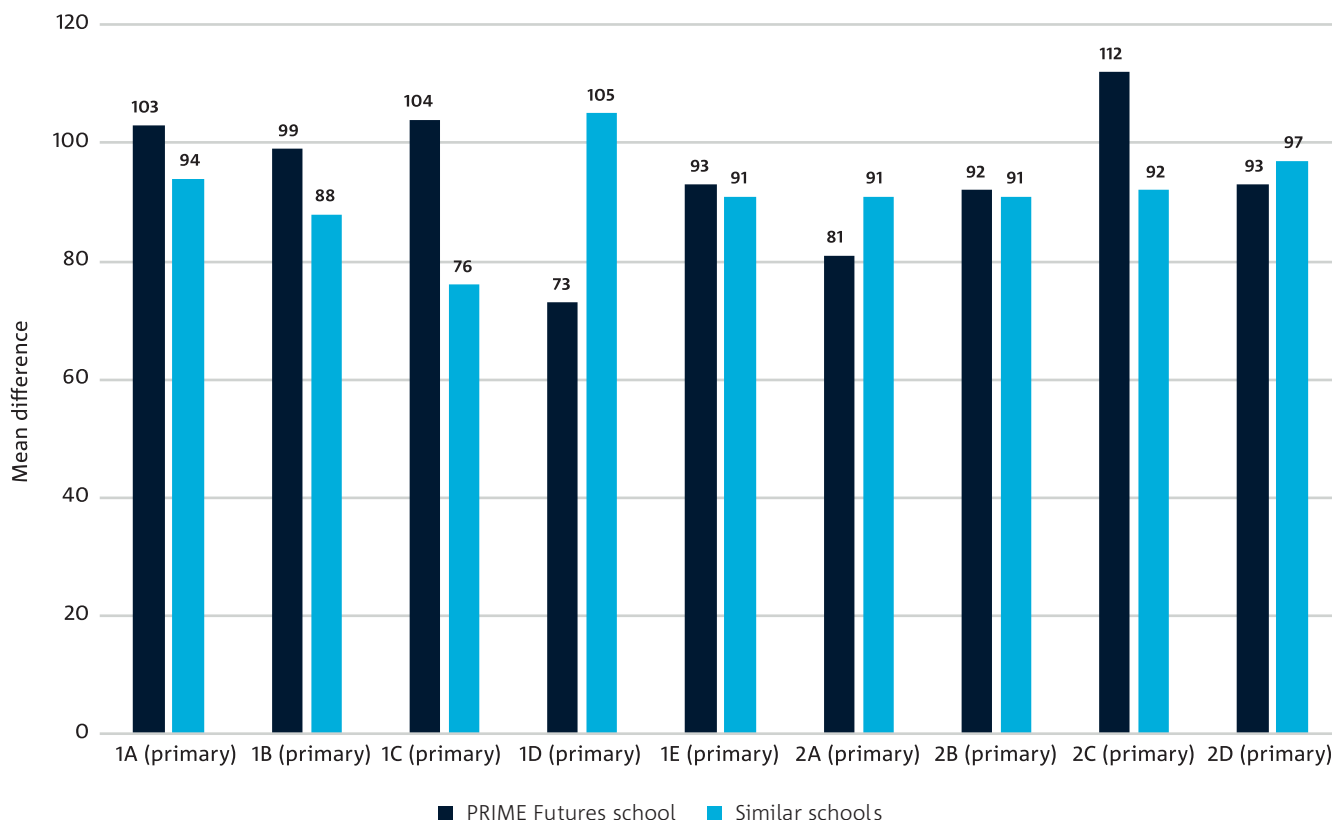


Figure 4 Mean difference in NAPLAN numeracy scores: 2009 to 2016

¹³ Secondary school results have not been included in this report because data from only six schools and from 2015-2017 was available and/or relevant.

Aboriginal Summer School for Excellence in Technology and Science (ASSETS)

Program description

The ASSETS program provides an opportunity for high achieving Year 10 Aboriginal and Torres Strait Islander students, with an interest in science, technology, engineering and mathematics (STEM) to explore the study and career options available to them in STEM fields. ASSETS has three components: an intensive nine-day residential summer school; a two-year leadership and support program; and an integrated and overarching cultural program. The primary component of the program is the nine-day summer school (also referred to as ‘camp’ by some participants), which comprises the following three strands:

Cultural and leadership

Ensures the inclusion of Indigenous knowledges and the exploration of cultural identity, overseen by a Program Patron (local leader in Indigenous education) and Cultural Mentors.

Academic

Focuses on the science inquiry process, with students undertaking team based inquiry projects supported by local academics.

Leadership and support

Opportunities are provided for reflection on, and development of, personal skills and goals, including exploring study pathways and career options. Support continues over Years 11 and 12 and can include advice and opportunities to participate in cadetships or work placements within STEM fields. Students can connect with each other through an online forum.

The recruitment process for the ASSETS program occurs once a year. See Table 3 for a summary of locations and attendance.

Table 3 Summer school locations, applications and attendance (2014 to 2017)

YEAR	LOCATIONS	NUMBER OF APPLICANTS	NUMBER OF PARTICIPANTS	PROPORTION OF APPLICANTS ACCEPTED
2014 – 2015	Adelaide	30	28	93 %
2015 – 2016	Townsville, Newcastle, Adelaide	119	98	82 %
2016 – 2017	Townsville, Newcastle, Adelaide	175	101	58 %*
2017 – 2018	Townsville, Newcastle, Adelaide	118	104	88 %
Total		442	331	75%

* The relatively lower portion of applicants accepted in 2016-17 is a consequence of the higher number of applications received.

Program outcomes

Immediate outcomes

- Schools, jurisdictions, stakeholders valuing the summer school and leadership program
- High aspiration for a STEM career
- Better understanding of, and confidence in, pursuing STEM career pathways
- Greater confidence in cultural identity and the relevance of culture for a STEM career
- Growth in student and professional networks
- Increased community and parental engagement;

Intermediate outcomes:

- Greater demand for ASSETS from schools and the sector
- Success in STEM subjects in Years 11-12, and direct university entry
- Subject choice referencing prerequisites for university STEM courses
- Schools and students applying to awards and excellence programs
- Participation in broader STEM initiatives.

Research methods: surveys and interviews

A case study approach has been undertaken for ASSETS, focusing on interviews of stakeholders from one summer school and supplemented by online survey data from all summer schools. The value of case studies is that they allow in-depth exploration of the ‘how’ and ‘why’ of interventions (Hudson, 2017; Kelaher et al., 2018; Muir & Dean, 2017); and allow participants to tell their stories and describe their views of reality (Johnston, 2013). The case study comprises a range of data sources and methodologies, including:

Interviews

A series of interviews were undertaken with students, program staff and program partners who attended the January 2017 summer school held in Newcastle. Interviews were semi-structured, and participants were asked about their summer school experiences, their recommendations for improvement, and their future aspirations. There were 19 individual interviews and nine group interviews (each with two participants), resulting in a total of 37 participants.

Online surveys

Summer school participants were invited to complete a pre and post-survey, as well as annual follow up surveys over Years 11, 12 and post-high school. Parents completed a survey following their child’s attendance at summer school. All surveys included both quantitative and qualitative response types and focused on perceptions of personal development and awareness, engagement, aspirations and program impact. Almost 45 per cent of student participants completed pre and post-surveys, and 30 per cent of parents completed a survey.¹⁴ These relatively high survey response rates are likely a result of participants’ and their families’ high levels of engagement with the program.

Key findings of the ASSETS program

The findings have been organised under the following six outcomes:

- High aspiration for a STEM career and subject choice referencing prerequisites for university STEM courses (these two outcomes have been considered together)
- Better understanding of, and confidence in, pursuing STEM career pathways
- Greater confidence in cultural identity and the relevance of culture for a STEM career
- Growth in student and professional networks
- Increased community and parental engagement.

Outcomes

High aspiration for a STEM career and subject choice referencing prerequisites for university STEM courses

In general, program staff and participants recognised the critical role that families and schools play in supporting young people to have a disposition of high aspiration throughout their education and career pathway. ASSETS program staff believe their role is primarily to build on this high aspiration by fostering a passion for learning. Case study evidence indicated that generally, students attending the program already held high career aspirations. However, some students indicated that ASSETS “made me work harder to reach my goals” or provided “...a clearer direction for Grade 11 and 12”. Similarly, some students reported that ASSETS helped build their educational aspirations, including subject selection to support progression to university and STEM careers. Generally, ASSETS participants showed an increase in awareness of university pre-requisites (2017 and 2018 Summer Schools). Some students also reported that ASSETS confirmed that they were on the right track, with their high aspirations reinforced through increased confidence, knowledge, real-life experiences and/or contact with STEM professionals.

Better understanding of and confidence pursuing STEM career pathways

The case study findings suggest that generally, ASSETS students’ confidence increased and their STEM perspectives were broadened, primarily through increased knowledge and understanding of STEM career pathways and university options. The mechanism for this change in student understanding and confidence was understood differently by case study participants. Many program staff felt the presence and influence of STEM professionals was critical for students to understand better the skills required to pursue STEM careers, including the ability to collaborate with others to solve problems. Both program staff and STEM professionals emphasised the importance of imparting life skills such as “a positive work ethic”. Students themselves identified a range of ways that ASSETS improved their confidence, such as the courage to apply for jobs; feeling informed; and feeling better prepared for the future. Some students reported experiencing individual transformations, such as in public speaking, writing, and leadership skills. Similarly, many parents confirmed this increased self-confidence in their children. One parent remarked,



[it] was astounding. His independence and confidence surprised us all.

¹⁴The response rates for web-based surveys among students are commonly below 20 per cent (Van Mol, 2017).

Greater confidence in cultural identity and the relevance of culture for a STEM career

Cultural confidence appeared to be a supporting factor for some students to feel generally confident, have high aspirations, and make good progress. Some program staff noted that students who were highly connected with their culture were most often the ones to integrate with other students and complete the task the quickest. The ASSETS program provided an opportunity for students with minimal or no cultural knowledge to learn about their culture. Creating this connection between Indigenous science and Western science was identified by some students as something that had been lacking in their schools. Some participating STEM professionals noted that when this connection was made, student engagement increased, as students found the learning program to be relevant to their own cultural and personal contexts. A small number of students suggested that the cultural component could have been more comprehensive, to provide real value. While students generally reported enjoying the integration of Indigenous knowledges and science inquiry into their learning, they did not frequently articulate the links between culture and STEM careers, possibly because those links were not clearly identified in the ASSETS curriculum or elsewhere. In general, students were more likely to make connections between their STEM work and how they could give back to their own communities if they pursued a STEM career, including as role models for others in their families and local communities.

Growth in student and professional networks

ASSETS program staff described the summer school as an opportunity to develop and grow student networks. ASSETS participants had diverse pre-existing sizes and types of peer networks before attending ASSETS; however, the intensity of the program and expectation of program staff that students commit and succeed meant many students reported making connections that they would not usually make. The group was described by many students as inclusive and made up of like-minded members who accepted each other without judgement. These characteristics were appreciated by some students who reported feeling less restricted to participate and more confident extending their current networks. Some students also noted the positives of being in the company of a large group of Aboriginal and/or Torres Strait Islander students, with a few students indicating that it was their first time experiencing this situation. A significant proportion of students also continued to utilise the online social collaboration group to maintain contact with their ASSETS networks in the years after their summer school.

In contrast to student networks, the growth of students' professional networks was not as strongly identified. Generally, students appeared to understand the potential benefits of their professional wider networks. Some students agreed that ASSETS had improved their confidence around STEM professionals, and their ability to meet others and work outside their comfort zones.

Increased community and parental engagement

While students reported varied parental engagement in the school environment (most describing it as minimal), program staff reported strong support from families around the summer school. Communication with parents was constructed positively and established an early expectation of engagement, particularly in the social and cultural aspects of the summer school. Program staff noted the benefits of parental and/or family involvement at various times. Before the summer school, family contact supported the establishment of relationships between program staff and participants; while during the summer school, family support was crucial when some students faced personal challenges that greatly affected their wellbeing.

A core component of the nine-day residential activity is to engage with a range of community members, who have the opportunity to share personal and work-related knowledge as well as cultural knowledge and stories of their own journeys. Both ASSETS staff and students found the involvement of Elders to be a highlight and a positive influence on students' career aspirations. STEM professionals and academic providers reported a range of benefits to engaging with groups of young aspiring STEM professionals, including imparting knowledge and lived experiences. Some students were able to identify ways they would continue to engage at a community level after the summer school, especially with local cultural leaders, such as through volunteering, taking on a role-model mindset, and sharing their culture with others.

Bachelor of Science (Extended) Program

Program description

The Bachelor of Science (Extended) program is a four-year degree course which aims to provide a supported pathway for Aboriginal and Torres Strait Islander students to complete a mainstream Bachelor of Science degree at the University of Melbourne (University of Melbourne, 2018). The students selected to participate in the Bachelor of Science (Extended) undertake an additional year of study. The additional subjects are spread across the first three semesters, tapering as students undertake increasing numbers of subjects of the mainstream Bachelor of Science degree at the University of Melbourne. In the additional year, the students are exposed to several science and mathematics subjects, which enable them to refine and consolidate their prior STEM knowledge and ascertain their preferred areas of interest. In this year they also become familiar with the University (e.g. its processes, teaching staff and facilities), and are assisted in the development of their academic skills. The program aim is to provide the students with a strong foundation for entering the Bachelor of Science degree from their second year until completion. Other key program elements include part-subsidy of accommodation costs; a scaffolded approach to learning; and aspects of place-based learning. Incorporation of Indigenous perspectives into the Western science curriculum, in terms of content and approach, is also a major focus of the program.

Program outcomes

Immediate outcomes

- Strong student engagement, retention and results
- Student aspirations, experience of university and support factors including cultural responsiveness
- Areas of curriculum refinement identified to integrate Indigenous science knowledge;

Intermediate outcomes

- Seamless transition into Bachelor of Science with comparable outcomes in retention and results with other students
- Strong engagement with development opportunities, such as study abroad, exchange, scholarships, awards, prizes, volunteering, leadership opportunities
- University building stronger relationships/ partnerships re: Indigenous science knowledge with Indigenous organisations.
- Best practice in science extended courses identified and adopted by other universities.

Research methods: program monitoring and case study research

In addition to ongoing University of Melbourne program monitoring processes, which collected student enrolments, retention, and completion data, a case study methodology was undertaken in Semester 2, 2017 to produce the Bachelor of Science (Extended) Case Study Report (Mudhan, Banks, Gilbert, & Sadler, 2019). The case study aimed to provide a better understanding of the pathways and processes of the program, and the extent to which program goals have been achieved. This includes understanding both the barriers that prevent, and the enablers that lead to increased engagement and aspiration-building, and improved academic results. The core of the case study framework for the programs comprising the Indigenous STEM Education Project is the triangulation of data from the perspectives of key stakeholders in the relevant program element: students, teaching staff, and program/support staff. Table 4 outlines the number of participants from each group.

Table 4 Case Study participants and total program participants, by stakeholder group

PARTICIPANT GROUP	NUMBER PARTICIPATED IN THE CASE STUDY	TOTAL NUMBER IDENTIFIED AND INVITED TO TAKE PART IN THE CASE STUDY	PER CENT PARTICIPATION
Students	6	24	25
Teaching staff	7	8	88
Support staff, including Murrup Barak, ITAS tutors, residential colleges, student support services	11	17	65
Total	24	49	49

The case study methodology consisted of qualitative data collection via interviews and online surveys, and thematic analyses of the resulting transcripts and text responses. A total of 24 people participated in interviews: 18 individual interviews and three group interviews (each with two participants) were conducted in total (see Table 4). Semi-structured questions were asked of each of these stakeholder groups. Semi-structured questions were designed to allow participants to articulate their thoughts and opinions regarding the program on their own terms rather than about preordained response structures (e.g. surveys). The semi-structured approach, along with the broader case study methodology, allowed participants to tell their stories and describe their views of reality (Johnston, 2013). The interview questions are available in the forthcoming Case Study Report.

All students who were currently enrolled or had withdrawn from the course were invited to take part in the research. Six currently enrolled students participated out of a total of 24 students who were invited. These six students provided a rich source of information, but because of the relatively small number of participants involved, some care should be applied in generalising the findings to all participants.

Key findings of the Bachelor of Science (Extended) program

At the time that this case study was conducted, three cohorts of students had entered the Bachelor of Science (Extended) program since it commenced in 2015. Over this period, the program demonstrated success in several key areas (Mudhan et al., 2019). By June 2016, the program had: recruited students from across Australia; developed and delivered a science and mathematics curriculum to the Bachelor of Science (Extended) students; and integrated Indigenous knowledge into the curriculum. Over the same period, the intake of students had gradually increased and challenges for students, particularly in mathematics, were being addressed with individualised support from teaching and support staff. The University of Melbourne was also working closely with the residential colleges to accommodate the students and provide for their individual needs. The following is a review of the key findings related to the five intended outcomes.

Outcomes

Strong student engagement, retention and results

Students reported mixed engagement with the course content. When students reported feeling engaged, they identified the reason to be either the inclusion of Indigenous science knowledge into the curriculum, an interactive format, or a diverse range of class activities. Outside the classroom, connection with support staff such as tutors was perceived to increase attendance and engagement. Due to the small student cohort, teaching staff were able to maintain close relationships with the students, identifying disengaged students early and providing appropriate supports. Student retention was relatively high, with 19 out of the total of 25 students enrolled since 2015 still engaged in the program in 2018 (see Table 5). In the 2018 academic year, the retention rate for the program was 95 per cent (19 out of 20 students still engaged compared to 2017), matching the University of Melbourne average retention rate of 95.6 for all domestic bachelor degree students (Australian Government, 2018), and comparing very favourably to the retention rate of 71.2 for all Aboriginal and Torres Strait Islander university bachelor students in Australia (Universities Australia, 2017).

Table 5. Bachelor of Science (Extended) retention rates

	2016 (9 STILL ENROLLED)	2017 (12 STILL ENROLLED)	2018 (19 STILL ENROLLED)	OVERALL (19 STILL ENROLLED)
2015 cohort (12 enrolled)	75 % (9 out of 12)	78 % (7 out of 9)	100 % (7 out of 7)	58 % (7 out of 12)
2016 cohort (5 enrolled)	n/a	100 % (5 out of 5)	100 % (5 out of 5)	100 % (5 out of 5)
2017 cohort (8 enrolled)	n/a	n/a	88 % (7 out of 8)	88 % (7 out of 8)
All cohorts (12, 17 and 25 enrolled)	75 % (9 out of 12)	86 % (12 out of 14)	95 % (19 out of 20)	76 % (19 out of 25)

Note: Yearly retention rates are based on retention of students from previous year. Overall retention rates are based on retention of students from the original cohort commencement year.

Seamless transition into a Bachelor of Science with comparable outcomes in retention and results with other students

Five out of the six students interviewed moved from interstate to attend the University of Melbourne, and the majority were school-leavers. As a result, some reported a sense of loneliness and isolation from their peers at the start of the course. However, as they settled into the University, the students responded positively to the program’s academic and pastoral support staff, along with their peers, who they described as inclusive and culturally responsive. University teaching staff spoke about strong relationship threads at all levels of the program that were driven by a mutual desire to see the program succeed. Students indicated that they valued their relationships with student peers in the program. Outside their families, their student peers provided support during times of difficulty or loneliness.

At the time the case study was conducted, Murrup Barak (Melbourne Institute for Indigenous Development), which provides student support, education development, and employment assistance to Aboriginal and Torres Strait Islander students, had two student support officers providing support to around 370 Aboriginal and Torres Strait Islander students at the University. Although these support officers did not constantly monitor the progress of individual students, if a student was deemed at risk, they would contact the student to offer consultation and support. Murrup Barak was greatly valued by students and teacher staff for its low student-to-staff ration (compared to support for non-Indigenous students).

Areas of curriculum refinement identified to integrate Indigenous science knowledge

Students indicated that the program and its curriculum was culturally responsive. While the students were generally lifted by the understanding that the ‘stories’ passed down to them by Elders was scientific knowledge, they raised a concern about the assumption of the universal relevance of this knowledge to all Aboriginal and Torres Strait Islander people. The staff varied in their levels of confidence about teaching Indigenous science and acknowledged that it was easier to incorporate Indigenous science perspectives into topics such as Biology, than other subjects such as Mathematics. However, according to some teaching staff, feedback from their students assisted them in developing a more culturally appropriate way of incorporating Indigenous knowledge into the curriculum, and they felt encouraged to do so.

University building stronger relationships/partnerships re: Indigenous science knowledge with Indigenous organisations

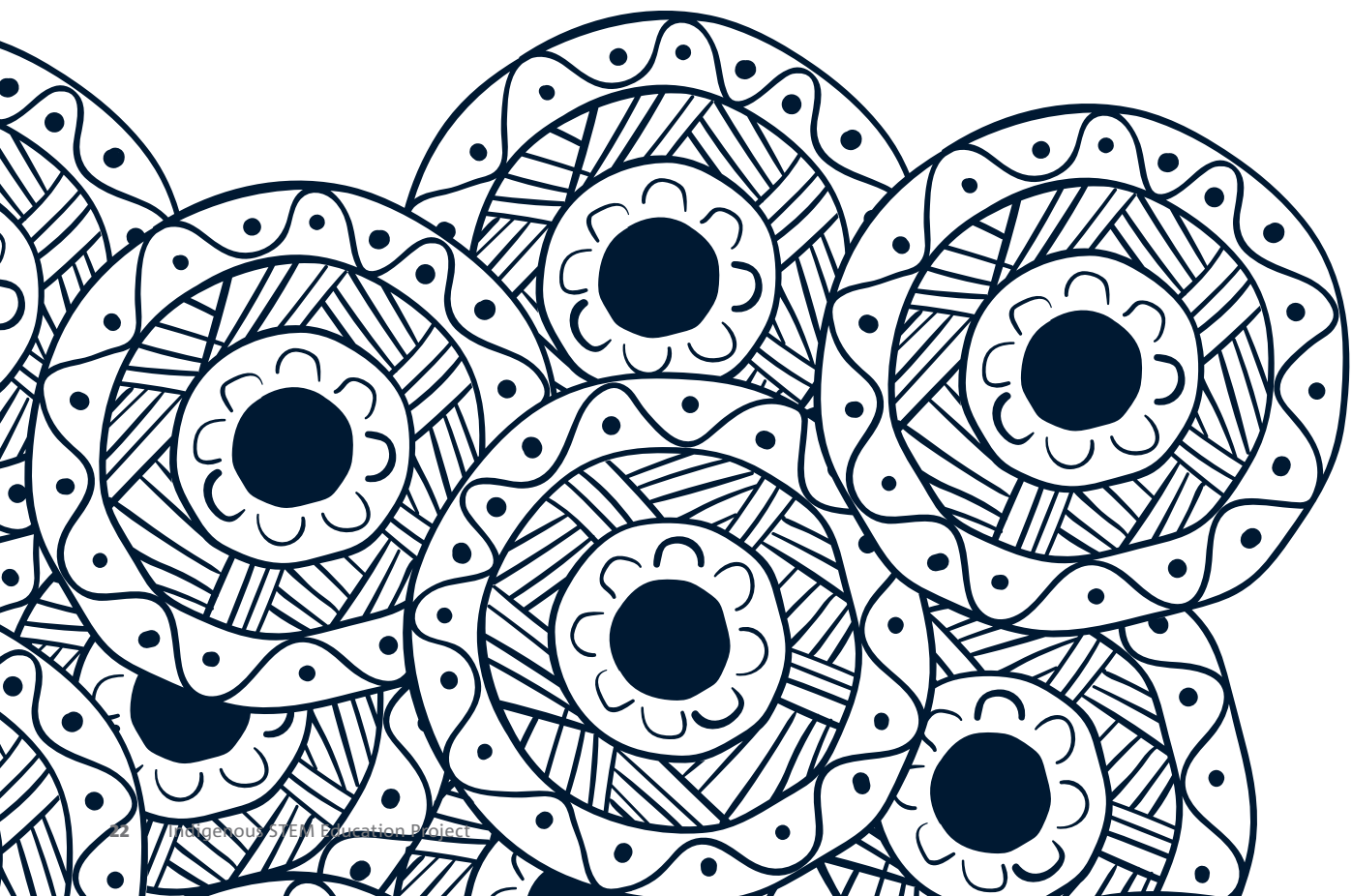
While staff had made considerable progress in incorporating Indigenous-led science knowledges into their programs, they acknowledged that forging closer working relationships with Indigenous organisations was critical to the future success of this part of the program. Students and teachers perceived value in local Indigenous knowledges being taught by local Indigenous Elders; and were especially working towards establishing and maintaining relationships with the communities that the students had come from.

Students revealed that Indigenous scientific knowledge being taught in the classroom with links to what they had learned earlier, either in formal or informal contexts, was more interesting and easier to understand. This was particularly true when students were able to see, through discovery, how previously acquired Indigenous scientific knowledge aligned or complemented global scientific knowledge. Students seemed to discover that some of the ‘stories’ they had been told by immediate and extended family were based on factual evidence, even though the way the stories had been told to them earlier in their lives had led them to believe that they were philosophical or mythological. The realisation that the Indigenous scientific knowledge they had been taught earlier in the community outside the classroom aligned and complemented Western scientific knowledge was highly motivating to students. Having cultural stories and knowledges validated in the university setting likely led to strengthened cultural identities as well.

Student aspirations, experience of university and support factors including cultural responsiveness.

There is evidence from student interviews that the Bachelor of Science (Extended) program supported and reinforced the existing ambitions of the students to build a STEM career. Students reported the course confirmed their intentions or motivated them to continue on this career path. Student experience highlighted that these aspirations originated with effective and engaging high school educators.

Students consistently mentioned that having supportive and inspiring teachers in high school was one of the main motivators for their pursuit of a career in science. Students indicated that their teachers advised them about the requirements that they would need to meet to pursue a STEM career after high school. The students interviewed were able to identify the specific field of STEM they wanted to pursue, such as physiotherapy, geology, or marine biology. The place-based nature of their prior and current learning experiences provided some students with inclinations to follow science careers that would contribute to the welfare of their communities rather than elsewhere.



Science Pathways for Indigenous Communities

Program description

Science Pathways for Indigenous Communities uses on-country projects as the context for learning science for primary and secondary school students in remote Aboriginal communities. Participating communities are located in the Northern Territory and Western Australia. The program supports schools to develop curriculum and education plans that integrate Western science and Indigenous scientific knowledges (specifically Traditional ecological knowledge). These are built around on-country projects developed through strong community partnerships with Elders and, where they exist, Indigenous ranger groups, scientists and land management organisations. Science Pathways for Indigenous Communities is built on Tangentyere Council's 'Land and Learning' project, and is delivered by the CSIRO in Western Australia and Tangentyere Council in the Northern Territory.

Program outcomes

Immediate outcomes

- Strong effective partnerships established with schools and other stakeholders
- Increased student engagement and attendance
- Increased student aspiration, sense of value and school belonging
- Increased community¹⁵, parental engagement
- Increased teacher capacity in science inquiry using on-country contexts
- Increased student results;

Intermediate outcomes

- Education resources developed into a cohesive community-based curriculum and learning resources and embedded in curricula
- School culture of high Traditional ecological knowledge (Indigenous scientific knowledges) and STEM expectations leveraged for literacy and other subjects
- Centres of excellence in two-way STEM education
- University teacher training using teacher professional development and model extended to other remote schools
- Participation in broader STEM initiatives.

Research methods: program monitoring

Data for this report is sourced primarily from general program monitoring and feedback from CSIRO program staff. In-depth case study research will be undertaken in three schools in the Northern Territory and Western Australia in late 2018 and early 2019, and the findings will be included in forthcoming evaluation reports and separate case study report. In addition, jurisdictional administrative data, such as academic achievement and engagement data, will be sought from relevant schools and Departments of Education. Ethical approval has been provided to undertake an evaluation of the program. Case study research has been approved by relevant jurisdictions for Northern Territory and Western Australia.

Implementation of the Science Pathways for Indigenous Communities program

At the time of this report, Science Pathways for Indigenous Communities was working with a total of 60 teachers, 68 Indigenous staff and AIEOs, and 684 Aboriginal and/or Torres Strait Islander students. The cumulative total of participating students was 1,334. Participating communities include Tjuntjuntjarra (self-funded), Warralong, Strelley, Punmu, Kunawarritji, Parnngurr, Wiluna, and Leonora in Western Australia; and Areyonga, Haasts Bluff, and Mount Liebig in the Northern Territory (CSIRO, 2018). Progressive implementation goals have been exceeded, with considerable increases from 2017, as outlined in Table 6.

¹⁵Including Elders, Traditional Owners, and Ranger and other groups.

Table 6 Number of teachers, staff and students engaged in Science Pathways for Indigenous Communities

	2017	2018
Teachers and teacher linguists	45	63
Aboriginal and Torres Strait Islander staff/ teacher assistants	61	68
Aboriginal and Torres Strait Islander students	547	632

Note: Numbers are annual (not cumulative).

Program coordinators in both Western Australia and the Northern Territory report strong engagement in the program by teachers and students, and among school communities. Anecdotal reports from program coordinators indicate that outcomes are being achieved. These reports will be validated in the forthcoming case study report and overall evaluation reports. Feedback from discussions between program staff and principals, teachers and rangers indicates:

- Teachers are embedding Two-way science practice in the development of learning programs and activities with evidence of in-class science and integrated activities preceding and following on-country learning activities.
- Science Pathways for Indigenous Communities in both the Northern Territory and Western Australia are supporting schools to assess science achievement through the development of simple assessment proformas aligned with activities in the education resources.
- Aboriginal people in schools and communities support the planning of learning programs with teachers, the development of local education

resources, and the delivery of educational activities on-country and in the classroom.

- In the Northern Territory, more on-country activities are being linked to the science curriculum and taught in schools, such as bush medicines with chemistry.
- Partnerships have been formed between schools and Indigenous Ranger programs, scientists, and land management organisations in the delivery of two-way science education activities.
- In the Northern Territory, Science Pathways for Indigenous Communities has supported and/or run successful Indigenous Language and Culture planning and training workshops, with a focus on teaching about country, for Indigenous assistant teachers and Elders from up to six schools.

Science Pathways for Indigenous Communities program staff are developing several resources including two-way science education resources, a model of teaching and learning based on school and community partnership, and a program of adult learning for schools and communities to implement a two-way science program. The education resources document successful two-way science practice and can be utilised by additional school communities should further funding become available.

Science Pathways for Indigenous Communities partnered with Australian Curriculum, Assessment and Reporting Authority (ACARA) and four project schools in Western Australia and Northern Territory, in the development series of 'Illustrations of practice' videos (see: <https://www.australiancurriculum.edu.au/resources/aboriginal-and-torres-strait-islander-histories-and-cultures/illustrations-of-practice/>), which reinforce the validity and effectiveness of Indigenous ecological knowledge in the science curriculum.

Indigenous STEM Awards

The Indigenous STEM Awards recognise, reward, and celebrate the achievements of Aboriginal and Torres Strait Islander students and scientists who are studying and working in the STEM field, as well as the integral role schools, teachers, and mentors play in supporting Aboriginal and Torres Strait Islander students in pursuing STEM education and careers.

In 2017, 73 nominations were received, and 12 winners were announced, with an additional five applicants rated as 'highly commended.' The 73 total nominations were below the KPI of 150 nominations. A Winners Gathering was hosted in Sydney on the 23rd-24th February 2018 and ten presentation ceremonies for 12 winners were held throughout Australia in March to May 2018. A communications campaign for the announcement of the winners reached an estimated potential audience of over 4.3 million across social media and traditional media. The 2017 Award finalists and winners were selected by a range of professionals from CSIRO, the BHP Foundation and other organisations. Details on the Award winners and other information can be found at:
www.csiro.au/en/Education/Programs/Indigenous-STEM/AWARDS

The Indigenous STEM Awards has not been prioritised for evaluation. Therefore program data collection targets two of the intended outcomes, with indications they are being met. First, of the 73 nominations, 18 entrants were involved in ASSETS and 24 entrants were involved in I2S2, PRIME Futures, or Science Pathways for Indigenous Communities, which means over 57 per cent of all nominations came from participants in other Indigenous STEM Education programs. The key performance indicator (KPI) for the 2017 Awards was that 10 per cent of nominations would be from other programs. This result provides evidence that there is 'strong engagement in the Awards program by participants of all programs.' Second, the number of nominations has increased by over 160 per cent from the previous year (from 28 in 2016 to 73 in 2017), with nominations from all eight states and territories, demonstrating that the reach of the program is increasing, thereby meeting the goal of creating a national awards program.



Sustainability

As demonstrated in the previous section, each program is contributing to the achievement of expected outcomes. As the current project reaches its latter stages, the evaluation provides a better understanding of project strengths, and opportunities to leverage these for longer-term impact. ‘Sustainability’ is a broad concept, defined by the World Commission on Environment and Development (United Nations, 1987, p. 54) as ‘development that meets the needs of the present generation without compromising the ability of future generations to meet their needs’ and is commonly thought of in economic and environmental terms. For the Indigenous STEM Education Project, ‘sustainability’ is considered in terms of social and cultural development, in particular, how the Project’s social and cultural contribution continues past the current five-year funding period. The Project’s definition of sustainability also seeks to encompass Aboriginal and Torres Strait Islander concepts of sustainability that often emphasise holistically linking relationships to land, language, and knowledge systems (Throsby & Petetskaya, 2016). Within the literature there are several key concepts underpinning this notion of sustainability, including the importance of capacity development (Spencer, Brueckner, Wise, & Marika, 2017), common agendas and cooperation between stakeholders, transformative life-long learning (Kearney & Zuber-Skerrit, 2012), and perspectives of cultural and economic value (George, Grosser, & Jack, 2014; Tsou, Green, Gray, & Thompson, 2018). Drawing upon these principles, the following themes are used to identify the Project’s strengths for longer-term benefit: sharing resources; relationships and networks; new knowledge and practices; place-based solutions; and enablers and barriers to sustainability. Examples are provided from across the six programs to illustrate how the Project’s impact can be sustained in the longer term.

Resources to build skills and ability

Across the six programs, a range of tools, documents, and training programs have been created for longer-term use and continued teacher knowledge and skill development. These resources are targeted to principals and teaching staff, creating an explicit link between Indigenous knowledges and pedagogies and the Australian Curriculum. These resources are designed to improve cultural awareness and responsiveness among teachers, supporting them to better meet the Australian Professional Standards for Teachers (Australian Institute for Teaching and School Leadership, 2016).

For example, PRIME Futures, I2S2, and Science Pathways for Indigenous Communities provide the following:

- Train-the-trainer skills – YuMi Deadly Maths
- Lesson planning and assessment tools
- Mathematics pedagogy and content skills (Foundation to Year 12)
- Science inquiry pedagogy and content skills (Years 5 – 9)
- Two-way science integrated learning program
- Two-way science adult learning program for teachers
- Partnership development tools – between schools and their local community
- Remote travel guide.

The Science Pathways for Indigenous Communities team has worked with remote schools to develop and publish a book of activities, and with ACARA to develop four ‘Illustrations of Practice’ videos. The ASSETS program has also produced a work placement guide and operational framework that can be used by schools, STEM organisations, universities, and businesses.

The utilisation of these practical resources represents just one element of teacher development and confidence to deliver more culturally responsive education. For these resources to be taken up by schools, and to leverage off their potential to deliver longer-term and broader educational change, additional system-level approaches are critical, yet are outside the scope of this project. Jackson-Barrett and Lee-Hammond (2018) argue that systemic changes that support longer-term cultural responsiveness and integration of Indigenous knowledge and learning into the Australian Curriculum are lacking. Part of this system-level change is the recognition of what Rahman (2013) describes as the ‘hidden curriculum’ in schools; acknowledging that school rules and guidelines sometimes do not adequately reflect the lives of some Aboriginal and/or Torres Strait Islander students; and that there are barriers to negotiating cultural identities and school belonging.

Stronger relationships

Strong relationships are critical to the sustainability of program outcomes in a range of ways: by providing information channels, and thereby enabling community participation (Spencer et al., 2017); creating social bonds that provide financial and emotional support and more frequent intergenerational social interaction; cultural continuation; and a sense of belonging (Walter, 2015). These benefits are not only relevant at a family and community level, but also a system level. Tsou et al. (2018) recognise that better partnerships are needed to

improve service delivery in complex but under-resourced environments. Increasingly, corporate-community partnerships aim to achieve improved social or environmental objectives to produce improvements at a community level (Lefroy & Tsarenko, 2012). The relationships developed through the Indigenous STEM Education Project are well placed to support future Indigenous STEM projects, and offer culturally responsive engagement with other education programs outside of Indigenous STEM, as well as supporting a range of other CSIRO programs. However, there are limitations to the longer-term impact they can achieve in the current educational context, which can inhibit the development of stronger relationships by focusing on a prescribed, standardised curriculum that lacks place-based relevance and community-led initiatives within schools (Jackson-Barrett & Lee-Hammond, 2018; McInerney, Smyth, & Down, 2011).

The ASSETS program has multiple impacts on strengthening relationships, including between the participants, and between young people and influential adults such as cultural mentors, Elders, academics, and STEM professionals. Participants saw these relationships as beneficial to strengthen cultural identity, prepare students for future careers, and increase their social and academic confidence. Enduring partnerships have also been formed across the three summer school locations with James Cook University, the Australian Institute of Marine Science (AIMS), the University of Newcastle, South Australian Health and the Medical Research Institute (SAHMRI), University of South Australia (Uni SA), and South Australian Museum, as well as a corporate and government partnerships with Boeing, Origin Energy, Geoscience Australia, and engineering consultant firms, GHD and WSP.

The I2S2 program provides an opportunity for schools within a region to collaborate and share knowledge and experiences, therefore developing or enhancing relationships between teachers and their school communities. This was particularly evident between two communities in a regional area where both schools expressed interest in partnering with each other to conduct the inquiries, share resources and traditional Indigenous knowledges, and develop their cross-cultural awareness. At a broader level, I2S2 and Science Pathways for Indigenous Communities have developed and strengthened partnerships between government Departments of Education, Catholic Education offices, a range of universities, and with the national network of Indigenous rangers. A critical element of the Science Pathways for Indigenous Communities model is the development of partnerships between schools and communities, such as regional and national STEM professionals, Indigenous ranger organisations, land

management and conservation groups, and vocational training providers. Relationships with the network of Indigenous Rangers could also support a range of other CSIRO programs including research business areas.

The Indigenous STEM Education Project has created new relationships and strengthened others. Developing and maintaining purposeful relationships requires time, trust, and reciprocity; which can be challenging. Lowe (2017) argued that authentic relationships could challenge and affect teachers' assumptions and develop the deeper two-way knowledge and understandings that are critical if schools and teachers are to establish an educational environment that supports student engagement and achievement. However, developing authentic relationships at the cultural interface can be challenging (Nakata, 2007), especially in an educational context often characterised by isolation – such as schools isolated from parents, the community, and from each other; and teachers and learners in isolated classrooms (Watterston & Caldwell, 2011). McInerney, Smyth, and Down (2011) reinforced this context, describing an education system shaped by a national curriculum with prescribed outcomes and standardised testing, making it far less accommodating of local contexts, school-based curricula, and community-oriented approaches to learning. To create real change at an individual level, Jackson-Barrett and Lee-Hammond (2018) argue that a cultural immersion experience is beneficial, allowing educators adequate time and support from Aboriginal communities to better know and understand the country on which they teach. At a system level, George et al. (2014) reinforced that for programs and policy to be effective and sustainable, they need to match the internal values of the community.

Sharing knowledge and practice

The Indigenous STEM Education Project aims to enhance the current National Curriculum (ACARA, 2019a), Western scientific knowledge, and teaching pedagogies by integrating Indigenous knowledges and Indigenous teaching pedagogies. Central to all programs is the strength and value of Indigenous knowledges, often drawn from local languages and cultures, strongly place-based and ecological (Yunkaporta & McGinty, 2009), and always renewing their meanings through practice in place (Nakata et al., 2014). Capel (2014) noted that Indigenous knowledge tends to be retained within particular communities due to its origins in the local context, whereas Western science and pedagogy are considered universal in comparison. Therefore, each program provides an opportunity to support the long-term continuation of both areas of knowledge for current and future students, teachers, and communities. Examples of this include:

- PRIME Futures' RAMR (Reality, Application, Maths, Reflection) approach incorporates an Indigenous framework for learning and invites local cultural leaders to participate in student learning activities. PRIME Futures schools have reported their intention to "continue use of resources, expand the coaching and mentoring of other staff across the school" and "continue to embed YuMi in all classrooms and teaching practices" (Principal Exit Survey).
- Schools delivering the I2S2 program are identifying ways to continue their knowledge improvement, especially through professional development events, to share experiences and generate ideas about the upcoming science inquiries. Students at a school in South East Queensland also expressed interest in involving their parents and community with the inquiries; to share resources and traditional Indigenous knowledge; and to develop cross-cultural awareness.
- ASSETS academic and cultural programs have been developed throughout the Project through an action learning approach. Valuable learning and insight into embedding Aboriginal and Torres Strait Islander perspectives into the academic program and delivering culturally responsive programs, particularly in a residential education setting, has been created. This knowledge will be useful for other residential programs. Science Pathways for Indigenous Communities in Western Australia and Northern Territory has documented examples of effective practice in two-way science over the course of the reporting period and is including this in the development of a model of teaching, learning, language, and community development that can be up-scaled to other remote and regional communities where partnerships can be formed with local Indigenous people. This includes publishing two-way science resources and the ACARA 'Illustrations of Practice' videos, which will allow knowledge to be shared with other remote schools and communities; and to inform teaching practice of education institutions delivering remote community school programs. Remote schools and ranger groups in the Goldfields, Pilbara, and Kimberley regions of Western Australia are showing interest in two-way science programs.

Both Science Pathways for Indigenous Communities and ASSETS incorporate elements of a place-based approach¹⁶, in particular, Science Pathways for Indigenous work aims to develop whole-of-school learning plans, led by Aboriginal teachers, community members, Elders, and other cultural mentors on-country. McInerney et al. (2011)

argued that place-based education can provide a hands-on, community-engaged learning experience, providing young people with relevant knowledge and experiences to devise solutions to social and environmental problems.

This approach can align with Indigenous concepts of sustainability, which are predominantly location and society-specific (Throsby & Petetskaya, 2016).

Valuing Indigenous knowledges and cultures is a critical element of this project. However, how cultural knowledge is shared, managed, and integrated, and the subsequent benefits of this, could be strengthened. Baynes (2015) summarises recent research to highlight that at an individual level, some teachers lack the expertise or confidence to integrate Indigenous knowledge and perspectives within their teaching, while Yunkaporta and McGinty (2009) identified that some teachers hold a deficit view of local culture and knowledge. System-level barriers identified in the research include a lack of allocated time and resources, racist attitudes, and lack of support from school administration. Jackson-Barrett and Lee-Hammond (2018) argue that our current national indicators of education success are based solely on a Western knowledge paradigm, failing to consider alternative measures of success that might be more aligned with Indigenous pedagogies. Nakata et al. (2014) also explained that Indigenous knowledge is not static and should not be 'packaged up' for mass consumption, without acknowledgement that part of its intrinsic value is how it is embedded in its local context and can adapt with its people and place.

The Indigenous STEM Education Project is underpinned by some key elements that can provide for the longer-term benefit, including new resources and tools, stronger relationships and partnerships and shared knowledges. The benefits of sustaining some of the positive changes generated by this project are evident at the student, school, and broader community level, including the wider acknowledgement and sharing of Indigenous knowledges as a valuable element of the STEM curriculum in Australian schools. Throughout the Project, factors such as teacher and principal turnover and a lack of opportunity to promote the Project and collaborate more widely have been identified by program leaders as barriers to sustainability. Despite this, the efforts of existing school councils, and the contribution of cultural leaders, teachers, and program ambassadors as champions of the Project has built on the broader community and stakeholder interest and capacity to engage with this project.

¹⁶Place-based education emphasises the significance of local people and Elders, local knowledge, and local places as central to teaching and learning, and often includes 'in the field' experiences and curricula that is responsive to the interests and aspirations of the community (Green, 2016; McInerney et al., 2011).

¹⁷Fully implementing and actively immersed in YDM refers to schools that have implemented YDM pedagogy across the entire school, which is contrasted with YDM-trained schools, in which nominated teachers have completed a minimum of a one-year YDM training program.

Discussion

Summaries of program findings

For I2S2, overall, participating schools observed an increase in student engagement in classrooms and many students demonstrated an increase in academic achievement. These improvements were seen for both Aboriginal and Torres Strait Islander students and non-Indigenous students. However, the largest improvement was seen for students of both groups assessed as 'low-achieving' before the inquiry. Student attendance in I2S2 classrooms was also measured; however no apparent positive influence on student attendance was observed. Taking into consideration that I2S2 lessons constitute only a portion of total class time over a year, and the potential influence of a range of factors on attendance not related to classroom activities, this indicator may not provide the most robust measure of I2S2 success.

Evidence collected in the PRIME Futures program demonstrates positive change at a teacher and whole-school level, including improvements in student engagement and achievement. There are also some encouraging examples of success for student cohorts and the broader school community, particularly through connections with cultural leaders and the application of Aboriginal and Torres Strait Islander knowledges to mathematics pedagogies and content. By design, YDM implementation relies on a cost-effective and sustainable approach to delivering professional development to teacher-trainers (Spina et al., 2017). Teaching pedagogies and frameworks can be very individual and develop over a career. Changing this practice across a school requires strong change management support and strategies to minimise the effects of teacher and principal turnover. Evidence collected from teachers and principals confirms that breaking down existing practices to make changes can require top-down leadership and additional time for planning and execution. This low-intensity and gradual approach to system-level change takes time to fully implement, with success demonstrated more easily for schools that are fully implementing and actively immersed in YDM¹⁷.

The ASSETS program was developed to support the participation and achievement of Aboriginal and Torres Strait Islander students currently taking part in STEM subjects. The program has met all of the intended outcomes (within the scope of this evaluation) to varying degrees. Perhaps one of the most relevant overall indicators of success is that the majority of surveyed participants found the program's impact to be significant, and often life-changing, in terms of their study and career directions. ASSETS has the key factors in place to make the program a success, including a strength-based approach that connects participants to what they already know about

science; being intentional about exploring cultural identity and linking local Indigenous scientific knowledges to Western science, and the critical role of Elders and cultural leaders in connecting them; and well prepared and trained staff and academic providers to deliver the science, inquiry, and cultural components. These factors have been important in making ASSETS a success.

In terms of the Bachelor of Science (Extended), considerable progress has been made towards the overall goal of providing Aboriginal and Torres Strait Islander students with a supported pathway to complete a Bachelor of Science at the University of Melbourne and go on to STEM careers. Although every cohort is, and will be, different, evidence provided in this report suggests that students have had positive experiences in the program and felt supported in a culturally responsive environment. However, some challenges have also been identified, including low attendance at lectures and the timing of subjects over the first two years of the program. Based on feedback from students and staff at the University of Melbourne, the Bachelor of Science (Extended) Evaluation Case Study Outcomes Report (Mudhan et al., 2019) outlined what was working well in the program in each of the outcome areas, and some challenges and ideas to consider for the future. As each cohort of students was different, strategies may need to be tailored and reviewed regularly to maximise success.

At the end of 2018, Science Pathways for Indigenous Communities had exceeded implementation goals, and initial evidence suggests positive progress towards the development of a scalable and transferable model of two-way science teaching and learning, and community development. The model is being developed to support the formation of genuine partnerships between schools and local Indigenous people and groups to create effective practice in two-way science. Examples of this model-in-practice are being documented within schools and communities. This includes a book of two-way science activities that is planned to be distributed by CSIRO, and an adult learning program for teachers and community to implement a two-way science program.

Along with the ACARA's 'Illustrations of Practice' videos, these will allow the learning from the project to be shared with other remote Indigenous schools and communities and inform pedagogy and practice decisions of government and non-government institutions engaged in remote community schools. In-depth case study research will be undertaken in three schools in the Northern Territory and Western Australia from late 2018 to mid-2019, and these findings will be included in a detailed case study report and the forthcoming overall evaluation reports.

The Indigenous STEM Awards recognise inspiring and successful Aboriginal and Torres Strait Islanders in the STEM fields. Program data indicate that there is strong engagement by participants of all Indigenous STEM Education program elements, with over 57 per cent of nominations coming from participants in other Indigenous STEM Education programs, far exceeding the KPI of 10 per cent. The reach of the STEM Awards has also increased by over 160 per cent from 2016 to 2017, with nominations from all eight states and territories, although the total nominations were still below the KPI for the program. Award recipients act as STEM Education ambassadors for 12 months following receipt of their award, supporting awareness and engagement among the broader community.

Progress towards whole-of-project outcomes

This section provides an update on how the Indigenous STEM Education Project is progressing towards its whole-of-project intended outcomes and impacts (see Impact Pathway at www.csiro.au/en/Education/Programs/Indigenous-STEM/Monitoring-and-Evaluation/About). The First Evaluation Report identified positive implementation learnings, as well as the need for stronger evidence, especially to understand better the challenges facing schools to successfully implement the programs. The Second Evaluation report provided early evidence of increased engagement with STEM and STEM achievement of Aboriginal and Torres Strait Islander students across the programs. This Third Evaluation report provides an emerging understanding of how students, schools and their communities are benefiting from the project; and highlights some overall improvement trends relating to student engagement, academic achievement, and teacher and school capacity to deliver Indigenous learning frameworks and culturally responsive pedagogies. Below, a synthesis of immediate and intermediate outcomes from the Indigenous STEM Education Project Impact Statement is discussed. The logic underpinning the Impact Statement is that immediate outcomes need to be achieved in order for intermediate outcomes to occur.

Immediate: Teacher and school outcomes

Teachers and principals have increased capacity and capability in developing and delivering curricula, and inquiry that is place-based and hands-on; and increased experience in teaching in an Indigenous context or participating in inquiry that is Indigenous-led.

The Indigenous STEM Education Project has a substantial focus on activities and outputs that support this outcome; and evidence indicates progress towards realising it. Generally, educators have responded positively to the range of teacher and school resources, and professional development and training, provided as part of the Indigenous STEM Education Project. Interview and survey data indicate that when programs have dedicated staff to provide coaching, modelling and support to teachers and schools, the uptake of these resources and integration to teacher pedagogy and school curriculums has been strong. Project learnings indicate that time and resource constraints, and lack of teacher confidence and experience can affect this outcome, as can the level of commitment required to make a teaching paradigm shift or implement a whole-of-school change.

The ASSETS, Science Pathways for Indigenous Communities, I2S2, and PRIME Futures programs have developed educator resources to improve teacher capacities, such as lesson plans, inquiry booklets and two-way science teaching resources (incorporating local learning on-country); an online learning platform for teaching science inquiries; and a work placement guide and an operational framework that can be used by schools, STEM organisations, universities, and businesses. Initial qualitative data from educators delivering I2S2 indicate that many teachers are feeling better prepared to deliver Indigenous science inquiry lessons. Some teachers have also acknowledged that I2S2 program staff have been critical in developing this competence. Evidence from both I2S2 and Bachelor of Science (Extended) programs have highlighted that non-Indigenous teachers' capability to understand and incorporate Indigenous knowledges into the curriculum has sometimes been improved through their relationships with students, particularly those with a strong connection to culture who share this knowledge with their peers and/or teacher.

PRIME Futures has delivered train-the-trainer courses and support resources to teachers and principals. Overall, an increase in teacher capacity and capability has been reported. PRIME Futures teachers felt, on average, their capacity to incorporate knowledge of culture into their mathematics pedagogy has increased; however, this increase has not been as significant as in other areas of knowledge and skill development. Teachers felt that all PRIME Futures resources improved their capacity to teach mathematics, in particular, workshops were identified as the most useful program component. Further evidence of



progress towards outcomes includes teachers applying the YDM pedagogy in class, using multiple activities or their own YDM lesson plans. Despite these reported benefits, in Survey 3, teachers most commonly noted the high level of preparation required as an obstacle to implementing YDM, which would reduce over time as teachers re-use materials and become more proficient at delivering YDM.

Science Pathways for Indigenous Communities staff worked with remote schools to develop a book of activities and four online videos illustrating practice. These resources are underpinned by a strong place-based, hands-on, whole-of-school approach that is primarily community-led. This program is in the early stages of implementation; however, initial qualitative feedback indicate strong teacher engagement in the two-way science pedagogy and the development of teaching resources and approaches that respond to the specific needs of each community, its teachers, and students.

Immediate: Family and community outcomes

Parents, family and community members are more engaged, including as role models.

Programs within the Indigenous STEM Education Project vary according to their expectations and opportunities for parent, family, and community involvement. In some instances, such as the I2S2, Science Pathways for Indigenous Communities, and PRIME Futures programs, the inclusion of those within the broader school community is an element of each program model that can require concerted time, resourcing, and planning at a whole-of-school level in addition to classroom-related work. For the ASSETS and Bachelor of Science (Extended) programs, parent and family involvement is often targeted for specific purposes when a student might require additional personal support. Project findings across all programs highlighted the involvement of Elders and other cultural leaders and mentors as generally having a significant positive effect on young participants, sometimes inspiring them to become role models for their own families or communities. Also, young people often cited their peers as a valuable area of support.

Project evidence primarily highlights instances where parents, family, and other community members have had a positive influence on young people, especially in areas such as engagement, confidence, aspiration, and confirmation of their existing strengths and goals. In general, lack of parental involvement in some programs was not considered to detract from progressing towards outcomes; however, a lack of engagement with local Aboriginal and/or Torres Strait Islander community members was often referred to by teachers and program staff as a barrier to achieving other project outcomes. For example, within I2S2, the reasons for lack of engagement included unfamiliarity

with the appropriate people to approach; Elders/cultural knowledge holders not being available, often being over-stretched in their demands; and schools not having an identified budget to compensate Elders/cultural knowledge holders for their involvement. Science Pathways for Indigenous Communities demonstrated deep engagement by many Elders, community members, and parents.

Generally, evidence indicates that students and program staff were appreciative of the engagement of family or community members. For the Bachelor of Science (Extended) students, these connections created support structures for them when participating in the program. They felt they were able to develop personal connections with lecturers and support staff, which enabled them to reach out to them when required. In the ASSETS program, having traditional knowledge holders such as Elders and community leaders present at the nine-day residential program was reported to be extremely helpful for students, increasing their engagement and ensuring a discernible Indigenous voice was present. Evidence from the ASSETS program highlighted that for this cohort of young people, support from peers could be sought over engagement from parents or family. ASSETS participants stated their relationships with peers as more than just friendship but 'community'. Each I2S2 school involved in the case study research indicated that there was an opportunity in the future to extend engagement with their community members and generally reported minimal involvement from parents and/or family members in the program, although little effort was made to engage them. Bachelor of Science (Extended) and some I2S2 staff highlighted the role that students played in establishing and maintaining relationships between the Indigenous community/organisations and the education institution. Students occasionally provided the school or university with a family link to the community through Elders, and then benefited from Elders' input into the programs. Outcome evidence from Science Pathways for Indigenous Communities is still emerging; however, qualitative data shows that the engagement of some parents, family, and community members plays a critical role in the success of the learning on-country and in-class activities, and whole-of-school two-way learning plans. Current feedback from Science Pathways for Indigenous Communities staff indicates that Aboriginal community members are taking up leadership roles in the direction and delivery of education programs and activities in their schools.

Immediate: Student outcomes

Students experience increased engagement, attendance, results, recognition, aspiration, sense of value, cultural identity and school belonging.

This outcome was identified as an immediate outcome; however, progress towards it relies heavily on other outcomes such as increased teacher capability and capacity, increased community engagement, especially with cultural leaders and STEM leaders, and the facilitative role of program staff. The voice of young people is an important element of this evaluation and therefore, capturing evidence from students about their experiences and outcomes has been valued as a way to better understand how young people are engaging with, and benefiting from, the programs. All programs, except for PRIME Futures directly involve young people as participants in data collection. Generally, evidence from and about students has been overwhelmingly positive. Overall, interview and survey data indicate gradual yet positive rates of increase for both engagement and academic results across the programs. Some programs also demonstrate progress to outcomes through evidence of meaningful change for individuals, related to their own personal journeys and pathways. These transformative changes are often reflected at various levels within the cohort more broadly and in the context of their connections and experiences with others.

Evidence of increased engagement and academic achievement was common across programs, particularly PRIME Futures and I2S2, where a more significant effect was observed in students considered 'disengaged' or 'low achieving' before the pedagogy changes. Teacher perceptions of student outcomes in YDM, measured through surveys, identified positive indicators of engagement such as their willingness to 'have a go' and their readiness to 'teach and learn from each other' and the most improved being 'students' positive attitude towards learning mathematics'. All student groups increased engagement to a considerable extent with the delivery of the enhanced YDM curriculum. I2S2 findings show that following an inquiry, classroom engagement levels increased across students groups. Forty per cent of Aboriginal and Torres Strait Islander students increased their engagement after the inquiry. An even larger increase was seen among 'low-achieving' students, with just over half of all students in this category demonstrating an increase in academic achievement after the inquiry. Improvements in academic achievement were observed for Aboriginal and Torres Strait Islander and non-Indigenous students following the I2S2 inquiry, with the most significant improvements observed for low-achieving students.

The Bachelor of Science (Extended) program evidence identified strong student attendance and engagement when there was a connection with support staff. Similarly, this concept of connection underpinned findings from the ASSETS program highlighting progress towards indicators such as stronger cultural identity, aspirations, and belonging. Evidence collected from students and the summer school communities demonstrated increased student engagement and identity development when connections were created between Indigenous science and Western science, and through connections with influential adults, including Elders and cultural mentors. Science Pathways for Indigenous Communities coordinators in both Western Australia and the Northern Territory reported strong engagement in the program by students and this will be explored in more detail through the Case Study Report.

The more intensive, ASSETS nine-day residential summer school provided evidence of progress towards a range of student outcome indicators that were not identified in other programs, including high aspirations, confidence, and important life skills. Most students attending the program already held high educational and career aspirations; however, evidence shows the summer schools also assisted young people in developing stronger convictions or direction to achieve STEM-related goals. Evidence collected from participants identified a range of ways that ASSETS improved their confidence, such as the courage to apply for jobs, and feeling informed about, and better prepared for, the future. Some students reported experiencing individual transformations in skill levels such as in public speaking, writing, and leadership. Overall, program evidence indicates that the ASSETS model creates the most impact for students considered 'high achieving'; whereas the hands-on pedagogy included in the I2S2 and PRIME Futures models have most the impact for students considered 'disengaged' or 'low achieving'.

Intermediate: Culturally responsive education

Schools are culturally competent in delivering two-way science in partnership with Elders, families and communities and that there are flow-on benefits to the broader curriculum and approach to teaching within each school

Becoming culturally responsive is an ongoing process and partly relies on teachers having high expectations of students and using inclusive pedagogies (Griffiths, Amosa, Ladwig, & Gore, 2007). The need for approaches that connect teachers and schools with local Aboriginal cultures and opportunities to engage with Aboriginal community members in the educational process is also integral (Burgess & Cavanagh, 2015). Yunkaporta and McGinty (2009) highlighted the importance of culturally responsive education being ecological and place-based.

To date, project evidence indicates some progress towards teachers and schools becoming more culturally responsive across these indicators. This evidence is primarily qualitative; and was highlighted by various participants as they reflect on their experiences in and out of the classroom. Evidence presented in this report is aggregated and reported at a school level. This does not capture the personal reflective work required of individuals to acknowledge how their own culture, values and attitudes affect their pedagogy (Burgess & Cavanagh, 2015); and whether the program has influenced teachers to undertake this kind of paradigm shift in viewing and working with Indigenous Knowledge. This evaluation does not systematically collect evidence against standards of cultural responsiveness in an education setting, such as those identified in Western Australia's Aboriginal Cultural Standards Framework (Department of Education, 2015); however, the following evidence indicates varying levels of progress.

Across the project, qualitative evidence indicates that students participating in the programs have had positive experiences in culturally responsive environments. Some programs such as Science Pathways for Indigenous Communities have been implemented in schools and communities where existing connection to community and culture is very strong, and guided by local cultural leaders, Elders, and Traditional Owners, and in other communities the program has made progress in building these connections. In this context, school work is another way for students to stay connected with culture, and to compare and contrast this with Western Science knowledge. Other programs, such as I2S2 and PRIME Futures, have challenged teachers and schools to improve their confidence in delivering enhanced science and mathematics pedagogies and provided the opportunity to make new connections, or strengthen connections between schools and local Aboriginal and/or Torres Strait Islander leaders. In these contexts, teachers and principals have reported wanting to improve their cultural confidence, but there is not a lot of evidence to date to suggest that this has occurred.

Students in the Bachelor of Science (Extended) program reported the program, curriculum, academic and pastoral support staff operated in a culturally responsive environment. Other programs such as ASSETS have developed and shared practical resources that support cultural responsiveness of schools, universities, and workplaces as well as created valuable learning and insight into embedding Aboriginal and Torres Strait Islander perspectives into the academic program and delivering culturally responsive residential education programs. Evidence from PRIME Futures indicates that overall, participating schools have incorporated a range of strategies to involve the Indigenous community and their perspectives in teaching mathematics and in broader school activities. However, personal reflective work may also be required at an individual teacher and

principal level. According to exit survey results, teachers felt, on average that their knowledge of local Indigenous culture and community had marginally improved.

Intermediate: Increased uptake of STEM education pathways

Indigenous and non-Indigenous students are more likely to pursue STEM education pathways, enrolment in STEM years 10-12 and university, STEM careers and leadership opportunities

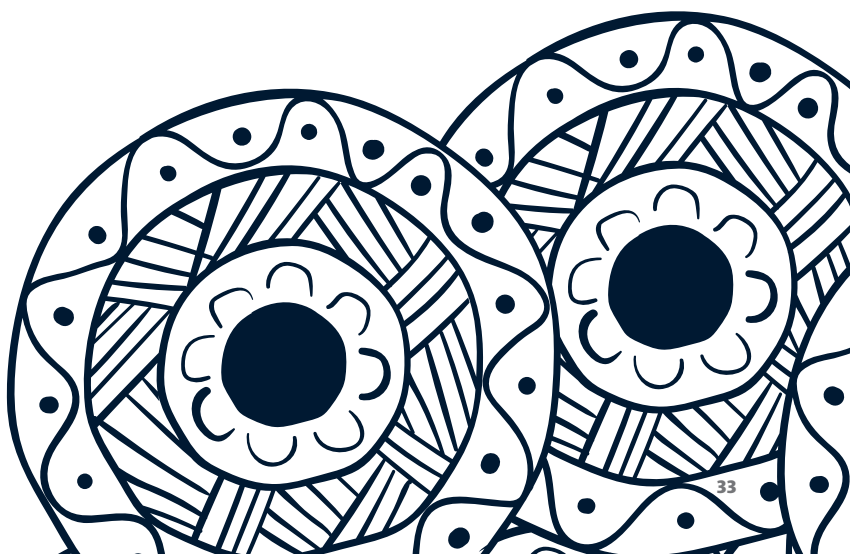
At this stage, there is a paucity of evidence available to discuss progress towards this intermediate outcome. There are indications that ASSETS alumni are taking STEM subjects in years 11 and 12, attending university, and taking STEM courses. However, more longitudinal monitoring of students who have participated in the project is required to understand better if the Indigenous STEM Education Project is having an impact in this area.

Intermediate: STEM Education sector outcomes

Jurisdictions, CSIRO, universities and partners are able to more broadly implement program elements.

Schools adopt good practice standards in high expectation science inquiry and maths education and identify teacher professional development opportunities

This intermediate outcome is measurable at a systems level and requires additional data collection for reporting against in future evaluation reports. Current evidence highlights that making school-level practice changes can involve a collaborative, whole-of-school approach in conjunction with school leadership, and additional time and resources for planning and full implementation. Teacher and principal turnover are also identified as barriers to achieving this. Broader utilisation of the existing project elements will require sector-level planning and may be best placed to occur following the publication of further evaluation reports.



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APPENDIX A

Progress against monitoring and evaluation recommendations

- Recommendation completed ● Recommendation in progress

As part of the Second Evaluation Report, consultancy EEGL made several recommendations for the monitoring and evaluation of the Indigenous STEM Education Project. The table below provides a brief update on progress against these recommendations.

EEGL MONITORING AND EVALUATION RECOMMENDATIONS

EEGL RECOMMENDATIONS (DATED)		PROGRESS AS OF SEPTEMBER 2018
I2S2		
●	As teachers are required to both implement the program and assess students, the viability of other skills and knowledge assessment processes should be explored to confirm current findings e.g. access jurisdictional data.	Supported. Administrative data will be sought for inclusion in the I2S2 Case study report. The following types of administrative data will be considered: student attendance student academic performance - individual students who attend school regularly, and for the year level (literacy, numeracy, science and NAPLAN results) science content taught and science enrolments Data will be requested from jurisdictions for participating schools and non-participating schools with similar demographics and aggregated by Indigeneity, year level, and class level.
●	Further data collection and analysis to be undertaken to better understand variability in the effectiveness of the program by year level, geographical location, and socio-economic disadvantage (ICSEA).	Supported in principle. Planned for inclusion in the I2S2 Case Study Report, as appropriate to the methodology and data availability.
PRIME Futures		
●	As current forms of data collection do not include direct student achievement, engagement or attendance data, it should be triangulated with other data sources that have established validity and reliability (e.g. NAPLAN) in future reports.	Supported. NAPLAN data has been included in the current analysis.
●	Teachers to be encouraged to use online platforms provided by YuMi Deadly Centre to share their lesson plans more broadly with teachers beyond their school.	Supported. A closed YDC PRIME Futures Facebook page has been created where teachers share activities and ideas (rather than lesson plans) beyond their school.

●	Continued monitoring by YuMi Deadly Centre of the teachers' perceived lack of support from school leadership and/or information about local Indigenous resources.	Supported. After an increase of teachers reporting a perceived lack of information about the local Indigenous culture and community, retrospective pre-post data show that teachers' knowledge of the local Indigenous culture and community, as well as teachers' use of Indigenous contexts, has increased. This is supported by teachers providing examples of using Indigenous contexts/ reality in the teaching of mathematics in their reflective journals. Teachers' reporting a lack of support from school leadership has decreased.
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ASSETS

●	The survey of participants would benefit from development to ensure that it focuses on collecting data that is closely linked to Project outcomes.	Supported. The survey instruments have been revised to more closely align with project outcomes.
●	An instrument to be developed to better reflect student variability in their STEM knowledge and skills to replace the PISA questions.	Supported in principle. The survey instrument has been examined but it was decided that, as assessment is not part of the ASSETS program, it should not be explicitly included in the survey instrument. However, grades in STEM subjects will continue to be used as an indicator of long-term STEM knowledge and skills.
●	An instrument to be developed to better reflect student variability in their personal development, including aspects of leadership, knowledge of university and career options, the desirability of STEM, and the desirability of non-STEM courses.	Supported in principle. The current survey instrument elicits information on personal development, leadership, desirability of STEM, both through closed and open-ended questions. The case study methodology explored these areas in depth as well.
●	The Summer School activities could be rated to the extent that they meet the cognitive, social, cultural and aspirational needs of students.	Supported in principle. Planned for inclusion in the ASSETS Case Study Report, as appropriate to the methodology and data availability.
●	A gender and site analysis should be undertaken to establish areas of best practice and areas that require improvement.	Supported in principle. Planned for inclusion in the ASSETS Case Study Report, as appropriate to the methodology and data availability.
●	Further ASSETS data collection and analysis should pay particular attention to attribution.	Supported in principle. Planned for inclusion in the ASSETS Case Study Report, as appropriate to the methodology and data availability.

Bachelor of Science (Extended)

●	Research should focus on the reasons the students chose to study the University of Melbourne Bachelor of Science (Extended), and choose to remain in the course as well as the reasons why they depart. Such research should include data from both students and the teaching staff.	Supported. Included in the Bachelor of Science (Extended) Case Study Report.
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Science Pathways for Indigenous Communities

●	An instrument be developed for students to measure their behavioural, emotional, cognitive and social dimensions of engagement with the materials.	Supported in principle. Planned for inclusion in the Science Pathways for Indigenous Communities Case Study Report, as appropriate to the methodology and data availability.
●	Teacher evaluation of attendance should include school records.	Supported. Planned for inclusion in the Science Pathways for Indigenous Communities Case Study Report, as appropriate to the methodology and data availability.
●	Multimodal opportunities for assessments of student academic achievement should be used to supplement teacher evaluations of academic achievement.	Supported in principle. Planned for inclusion in the Science Pathways for Indigenous Communities Case Study Report, as appropriate to the methodology and data availability.
●	An understanding of student backgrounds such as year level and gender would be useful to establish predictive relationships to determine effect sizes of the program on student outcomes.	Supported in principle. Planned for inclusion in the Science Pathways for Indigenous Communities Case Study Report, as appropriate to the methodology and data availability.

APPENDIX B

Indigenous STEM Education Project Impact Pathway

Impact Pathway for Indigenous

Partici

CSIRO, BHPF, QUT, UoM

ISEP Team, Project partners
Technical Experts

INPUTS What we invest

- BHP Foundation funding \$28m/5 years
- 30-year CSIRO BHPF relationship in science education
- Indigenous leadership
- Relationships with Indigenous communities
- Experienced Indigenous and non-Indigenous staff
- CSIRO experience in science inquiry education – esp. CREST, Land and Learning Program
- CSIRO national infrastructure and university partnerships
- Partner/Stakeholder expertise (e.g. YuMiDeadly Centre, Tangentyere Land and Learning, UoM Bachelor of Science & Arts extended)

Assumptions

- Indigenous leadership is essential
- Importance of high expectations, culture and personalised support
- Importance of working at the cultural interface of two-way science
- Importance of Indigenous curriculum contexts and building teacher and school capacity
- Importance of building strong relationships with community
- Rigorous evaluation is required to demonstrate program effectiveness

ACTIVITIES What we do

- **Innovative curriculum, pedagogy and TPD**
Development of innovative, place-based, high-expectations Indigenous contextualised curriculum, pedagogy, support resources for schools/universities and associated TPD training
- **High expectation extra-curricular opportunities and support**
Development of high-expectations extra-curricular opportunities including summer schools, work placements, awards and leadership programs with personalised support
- **Local and strategic engagement**
Student recruitment and engagement of key stakeholders (esp. schools, universities, CSIRO sites, Aboriginal organisations, Elders and patrons to support the delivery and sustainability of the above)
- **Management, monitoring and evaluation**
Deployment of project management, monitoring and evaluation methodologies to support delivery and sustainability of the above

External factors

- National/Global - Availability of STEM jobs, global and local economy, political environment
- Jurisdictions/School – culture of low expectations, teacher quality, relationship with Indigenous community
- Student – level of family support and understanding of tertiary education context
- CSIRO - Staff recruitment and training essential (need external expertise)

ous STEM Education Project

participation

ISEP team, jurisdictions, Teachers, Principals, CEEdO, Students, Elders, Family, Community, Universities Universities, Community Jurisdictions, Schools, CSIRO

OUTPUTS Our deliverables

Teacher completion of high expectation Indigenous context and pedagogy focused TPD courses and on the job training including train the trainer

Innovative, place based, Indigenous contextualised and/ or led STEM curriculum (inquiry based) delivered in schools and university and documented in school plans

Schools/students engaged in extra-curricular supports and alternate pathways e.g. summer schools, awards, leadership and support programs, BScExt

Partnerships with schools, jurisdictions, universities, mentors, and other key stakeholders

Project Steering Committee (governance), PM tools and databases, skilled staff, M&E frameworks, methods, data, reports and publications

OUTCOMES The uptake, adoption or consumption of or work

Increased student engagement, attendance, results and recognition

Increased student aspiration, sense of value, cultural identity and school belonging

Increased parental, family and community, engagement and recognition of role models

Increased teacher capacity in: inquiry; place based, hands on curriculum development; and delivery in an Indigenous context/ Indigenous led

More Indigenous (and non-Indigenous) students pursuing STEM education pathways, enrolment in STEM years 10-12 and university, STEM careers and leadership

Schools are culturally competent in delivering two-way science in partnership with Elders, families and communities and flow on benefits to broader curriculum/ teaching

Best practice in high expectation science inquiry and maths education programs and TPD identified

Jurisdictions, CSIRO, universities and partners scaling up

M&E input to PE CQI processes

IMPACTS Benefits to economy, environment and society

Indigenous knowledge and culture valued: complementarity to western science and maths demonstrated

Greater under-standing and care of environment

Social cohesion/ reconciliation

More, higher quality and greater workforce diversity of STEM professionals

Schools, students and families increasing high expectations focus contribute to new cultural norm of Indigenous students attending university and having high STEM engagement

Increased innovation and workplace productivity

APPENDIX C

I2S2 Assessment Rubric example

Assessment Rubric for Year 5: Keeping Cool

Strand	Sub-strand	A	B	C	D	E
Science Understanding	Physical sciences	Explains how the different properties of light and material affects usefulness	Explains why the size and direction of the shadow changes	Identifies the change or size of a shadow with reference to light source	Shows how light has travelled from a source to produce a shadow	Shows a shadow
Science as a Human Endeavour	Use and influence of science	Explains how indigenous knowledge of shelters can contributed to decision making	Describes ways knowledge of shelters type and positioning could be applied today	Identifies how knowledge of shelters could be applied today	Identifies a purpose for which a shelter is used	Names a type of shelter
Science Inquiry Skills	Questioning and predicting	Identifies a question that can be investigated scientifically and makes a reasoned prediction linking detailed scientific knowledge cause and effect.	Identifies a question that can be investigated scientifically and makes a plausible prediction with scientific understanding.	Identifies a question and makes a prediction about what might happen with a reason.	Identifies what can be investigated. Makes a prediction.	Uses a given investigation question
	Planning and conducting	Designs a detailed method that makes the test fair which includes variables to be kept the same. Identifies how variables can be accurately measured. Identifies safety considerations and ways to reduce risks. Records and organises accurate data.	Plans and follows a method that identifies variables which need to be changed and measured. Identifies safety considerations and ways to reduce risks. Constructs tables and graphs following conventions to record and organise comprehensive data.	Plans a basic method related to the inquiry question and uses equipment safely. Identifies variables to be changed and measured. Constructs tables and graphs to record and organise relevant data.	Identifies possible steps for a method and uses equipment safely. Identifies a variable to be measured. Records results.	Uses given investigation method and uses equipment safely. Records information.

Strand	Sub-strand	A	B	C	D	E
	Processing and analysing data and information	Constructs graphs following conventions to represent accurate data. Presents a well-reasoned, evidence based finding.	Constructs graphs following conventions to represent comprehensive data. Compares results with prediction using data in explanation.	Constructs graphs to represent data. Refers to data when reporting findings.	Suggests a finding.	Makes a statement about the investigation.
	Evaluating	Justifies how change will improve the investigation.	Suggest a change which will improve the method.	Suggest a change to the method.	Identifies a difficulty/ problem.	Identifies if the test was fair or unfair.
	Communicating	Coherent use of relevant scientific language to communicate ideas.	Uses appropriate everyday and scientific language to communicate ideas.	Uses appropriate everyday language to communicate ideas.	Uses of everyday language.	Fragmented use of language.

Overall result

Comment

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