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Indigenous STEM Education Project

First Evaluation Report

September 2014 – June 2016

BHP Foundation

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Acknowledgements

Acknowledgment of country

Australian 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; through prediction and hypothesis; through testing (designing, making and appraising); and through making generalisations within specific contexts. These scientific methods have been practiced 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. The inter-generational transfer of these knowledges relies on cultural practices including Aboriginal and Torres Strait Islander languages, story, ritual, dance and song.

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

The Indigenous STEM Education Project team acknowledges the Traditional Owners of the Countries and Places with whom this project is collaborating and their vibrant living cultures and knowledge systems. We pay our respects to Elders past and present and 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 believes that Aboriginal and Torres Strait Islander peoples have extraordinary contributions to make in cultural, economic and scientific domains; incorporating Indigenous knowledge of ecological and social systems is vital to the achievement of sustainable development.

Other acknowledgements

The authors would like to thank the Project Steering Committee and the CSIRO Social Research Team for their peer review of this report. Their valuable suggestions have made a significant contribution. We would also like to thank the program element leaders for their research participation and constructive feedback.

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Executive Summary

This report is the first evaluation report for the Indigenous STEM Education Project – a five year science, technology, engineering and mathematics (STEM) project operating from September 2014 to September 2019 for Aboriginal and Torres Strait Islander students across all states and territories funded by the BHP Foundation. 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. The project consists of six program elements. Three are universal programs – Inquiry for Indigenous Science Students (I2S2) and PRIME Futures are science inquiry and mathematics programs implemented in metropolitan and regional communities, while Science Pathways for Indigenous Communities uses Traditional Ecological Knowledge (TEK) as the basis for teaching science in remote communities. Three are targeted programs – Aboriginal Summer School for Excellence in Technology and Science (ASSETS) and the Indigenous STEM Awards which support and extend high achievers; and the Bachelor of Science (Extended), which provides an alternate pathway to a university science degree for students requiring additional assistance.

This evaluation is primarily an implementation evaluation. Three main data sources were used: a literature review of Indigenous STEM education engagement, policy, and practice; interviews with project directors and program element leaders; and program element leaders' program materials and reports. The literature review provides important contextual information on both Indigenous education and STEM education, and where the two intersect. The review highlights the complex and contested socio-political environment in Australia for both STEM and Indigenous education; and seeks to provide an overview of this context for the diverse stakeholders in this project. The interviews were used in conjunction with data from program reports to describe the implementation of the program elements with particular reference to the inputs, outputs, and early outcomes identified in the program logics and the overarching Theory of Change. The interview transcripts were also analysed to identify common themes relating to pedagogical approaches, sustainability, curriculum reform, and policy implications in the Indigenous STEM education field. The findings on the early outcomes are limited; and are based almost exclusively on the perspectives of the program leaders and project directors. Delays in implementing the evaluation component of the program has meant that the mixed methods evaluation methodology that will provide more extensive and rigorous evaluation data has not yet been implemented. Data from this methodology will be presented in subsequent evaluation reports.

A key finding of the evaluation is that, guided by the Theory of Change and individual program logics, the initial implementation of the project is progressing well. Four of the six program elements – I2S2, PRIME Futures and Bachelor of Science (Extended), and ASSETS – have achieved the majority of their initial projected program outputs and short term outcomes. Science Pathways commenced in 2016 and is on track to meet its projected short term outcomes in early 2017; and the awards program will have its first round in December 2016.

Consistent with the best practice literature, the evaluation identifies four principles underpinning all program elements: 1) being place-based; 2) having strong cultural engagement; 3) being strength-based; and 4) being built on high expectations. This contributes to programs that are demonstrating the compatibility of science inquiry with Indigenous pedagogy; the engagement and aspirational benefits of utilising curriculum based on Indigenous knowledge and contexts; methodologies for building teacher and school pedagogical and cultural capacity; and the value for Aboriginal and Torres Strait Islander students of mentoring, personal support and the building of peer and professional networks.

The evaluation also identifies the complex cultural, policy, and institutional contexts in which the project is operating. These contexts necessitate a better understanding of the partnerships required to embed sustainable change; and the importance of Aboriginal and Torres Strait Islander leadership across the project in assisting in the navigation of these contexts, including the appropriate use of Indigenous knowledge. The leadership role that key stakeholders and science organisations like CSIRO can potentially play is a key area to further explore.

The project context is characterised by both positive and negative trends. On the positive side, there are fundamental shifts in the Australian school curriculum towards the integration of Indigenous perspectives; and a greater emphasis on the inquiry pedagogy in science, which is seen as more consistent with Aboriginal and Torres Strait Islander ways of learning than conventional transmission pedagogy. University enrolments are showing an increase in STEM engagement for Indigenous students including a closing in the gap of the proportion of Indigenous students studying STEM compared to non-Indigenous students. This is complemented by the finding that Indigenous students have a higher level of contextualised interest in science compared to their non-Indigenous peers.

Conversely, there are several key contextual challenges for the project. There is concern that the declining participation and achievement in STEM subjects in Australian high schools will mean that the workforce and broader society will not have the necessary STEM literacy to underpin the future workforce needs for a thriving economy. More specifically, the Aboriginal and Torres Strait Islander context is one of a continuing two-and-a-half year gap in student achievement in mathematics, literacy, and science compared with non-Indigenous students. This gap has not improved in the last 10 years. There is also a widening of the gap in the Australian Tertiary Admission Rank (ATAR) achievement. Schools often struggle to implement high expectations pedagogy and to build meaningful relationships with Indigenous families and communities partly owing to a lack of quality professional training in implementing Indigenous engagement and perspectives. While university enrolments are closing the gap, there are significantly lower completion rates for Aboriginal and Torres Strait Islander students compared with non-Indigenous students.

In summary, there are four key implications of these early findings. Firstly, while the initial results are positive, more substantial quantitative and qualitative evidence underpinned by more rigorous evaluation methods are required to establish the extent, impact, and sustainability of outcomes. This will be a key focus of subsequent evaluation reports. Secondly, the project is demonstrating promise in regard to building the evidence base for best practice in Indigenous STEM education, and this, along with program element continuous quality improvement (CQI) processes, should remain a focus for future evaluation reports. Thirdly, a key focus needs to be on understanding and documenting the partnerships necessary to enable project sustainability, including leadership and support roles for organisations such as CSIRO. Finally, while serving the project well in its initial implementation, the program logics and Theory of Change would benefit from further revision and a clearer articulation of their impact pathways.

Acronyms and Glossary of key terms

ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACOLA	Australian Council of Learned Academies
AIG	Australian Industry Group
ASSETS	Aboriginal Summer School for Excellence in Technology and Science – one of the project's six program elements
ATAR	Australian Tertiary Admission Rank
ATSIHEAC	Aboriginal and Torres Strait Islander Higher Education Advisory Council
BHP	BHP Billiton
BHPBF	BHP Foundation
CDEP	Community Development Employment Projects. The Community Development Employment Projects (CDEP) scheme is a program provided by the Federal Government for (primarily) Aboriginal and Torres Strait Islander people. It enables an Indigenous community or organisation to pool the unemployment benefit entitlements of individuals into direct wages for those people who choose to participate in local employment in various community development or organisation programs as an alternative to receiving individual income support payments.
CEdO	CSIRO Education and Outreach
CREST	CREativity in Science and Technology A non-competitive awards program run by CSIRO supporting students to design and carry out their own open-ended science investigation or technology project.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CQI	Continuous Quality Improvement A term adopted by organisations to describe a regular process of reflecting on regularly collected program monitoring data in order to identify and implement strategies to improve program delivery.
Direct Instruction	A general term for the explicit teaching of a skill-set, based on behaviourist learning theory, using lectures or demonstrations of the material to students, breaking each learning task into its smallest component.
EON	A not-for-profit organisation that delivers a food and nutrition focused healthy lifestyle and disease prevention program in remote communities in Western Australia.
I2S2	Inquiry for Indigenous Science Students – one of the project's six program elements
IPA	Indigenous Protected Area These are voluntarily dedicated by Indigenous groups on Indigenous owned or managed land or sea country. They are recognised by the Australian Government as an important part of the National Reserve System, protecting the nation's biodiversity for the benefit of all Australians.
ILC	Indigenous Land and Culture
ILSM	Indigenous Land and Sea Management
NATSIHEC	National Aboriginal and Torres Strait Islander Higher Education Consortium
NCSU	National Center on Scaling Up Effective Schools

NT	Northern Territory
OCS	Office of the Chief Scientist
OECD	Organisation for Economic Cooperation and Development
PD	Professional Development
PISA	Programme for International Student Assessment: A triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students
QUT	Queensland University of Technology
RAMR	Reality Abstraction Mathematics Reflection A mathematics teaching pedagogy developed by Aboriginal mathematician Chris Mathews and used by Queensland University of Technology as part of the PRIME Futures program – one of the project's six program elements.
SAE	Standard Australian English
SCRGSP	Steering Committee for the Review of Government Service Provision
SMiS	Scientists and Mathematicians in School A national volunteer program run by the CSIRO bringing real science, mathematics, and ICT into the classroom through ongoing flexible partnerships between teachers (K-12) and scientists, mathematicians, and ICT professionals.
SSI	Stronger Smarter Institute
STEM	Science, Technology, Engineering and Mathematics
TEK	Traditional Ecological Knowledge: The evolving knowledge acquired by Indigenous peoples through thousands of years of contact and ongoing relationship with their local environment.
TPD	Teacher Professional Development
VET	Vocational education and training: Designed to deliver workplace-specific skills and knowledge, VET covers a wide range of careers and industries, including trade and office work, retail, hospitality and technology
WA	Western Australia
YDM	YuMi Deadly Maths A cohesive mathematics pedagogical framework that covers all strands of the Australian Mathematics Curriculum developed by Queensland University of Technology and delivered by QUT as the PRIME Futures program – one of the elements of the Indigenous STEM Education Project.

1 Introduction

This report is the first evaluation report of the Indigenous STEM Education Project. The project is a partnership between CSIRO, Australia's national research science agency, and the BHP Foundation, an independent charity established by BHP Billiton to provide grants to not-for-profit organisations to deliver large, long-term community projects.

This report has five sections: (a) an introduction which outlines the project and its theory of change, the purpose of the evaluation, its immediate context, and its research methodology; (b) a literature review, which contextualises the project within the broader national and international Indigenous STEM education literature; (c) the evaluation findings; (d) a discussion of these findings; and (e) an overall conclusion.

1.1 Project Theory of Change

The Indigenous STEM Education Project is a five year science, technology, engineering and mathematics (STEM) project for Aboriginal and Torres Strait Islander students across all states and territories in urban, rural, and remote settings. Its overarching goal is to provide supported pathways that improve the participation and achievement of Indigenous students in STEM subjects. It consists of six individual, but mutually reinforcing, program elements emphasising academic excellence and culture, but with differing foci on primary, secondary, and tertiary education. The target groups and methods of these six programs were originally conceived as follows:

- Science Pathways for Indigenous Communities targets primary and middle school students in remote Aboriginal and Torres Strait Islander communities. Its method is to use on-country projects as the context for learning western science linked to language and Traditional Ecological Knowledge (TEK).

- Inquiry for Indigenous Science Students (I2S2) targets primary and middle school students in mainstream metropolitan and regional schools. Its method is to use hands-on, inquiry-based projects using contexts relevant to Indigenous students.

- PRIME Futures targets primary and middle school students in mainstream metropolitan and regional schools, providing tools and support to improve mathematics outcomes. Its method is to use authentic, school-developed approaches that change the culture of the teaching and learning of mathematics for Indigenous students.

- Aboriginal Summer School for Excellence in Technology and Science (ASSETS) targets high-achieving Year 10 students, providing a cultural and academic residential summer school followed by a leadership mentoring program through Years 11 and 12.

- Excellence Awards (renamed in 2016 as the Indigenous STEM Awards) targets primary and secondary school students. Its method is to use a high profile awards program rewarding excellence in STEM achievement.

- Bachelor of Science (Extended) targets Indigenous students who show potential, but who might otherwise not have access to the Bachelor of Science. Its method is to extend the Bachelor of Science by an extra year to provide academic skill development focussing on science and mathematics, and including explicit support for students.

The inter-relationships between the program elements, their high level outputs, outcomes, and how they collectively contribute to the overarching project goal are represented visually in the project's Theory of Change (Figure 1). While established as independent programs the linkages among the programs are expected to increase over time. For example, an increasing proportion of ASSETS participants are anticipated to be sourced through PRIME Futures and I2S2 schools. The Theory of Change was initially developed by the project team with the assistance of an external evaluator in a two-day workshop on 30 March – 1 April 2015 and finalised in August 2015.

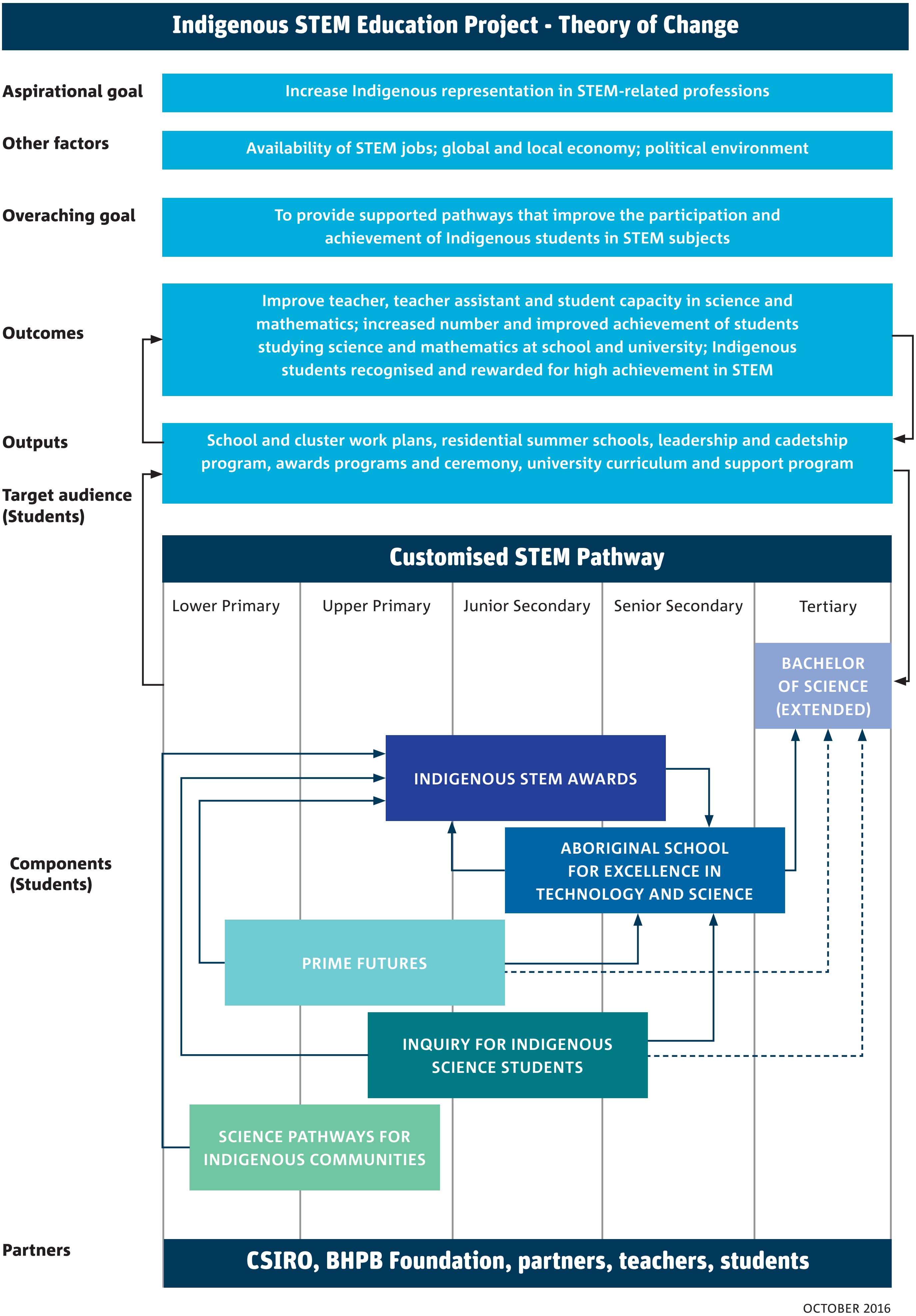

Figure 1: Indigenous STEM Education Project Theory of Change

1.2 Purpose of the evaluation

The Indigenous STEM Education Project constitutes a major investment in Indigenous STEM education by the BHP Foundation of $28m over five years. Both the funder and CSIRO have identified the importance of generating credible evaluation data as to whether the programs funded under the project effectively contribute to the overarching goal. Therefore, in addition to program elements developing and collecting program monitoring data, an evaluation component is being resourced to develop and implement a mixed methods evaluation of the project. CSIRO has agreed to provide to the funder and the project's diverse stakeholders (including schools, jurisdictions, Indigenous organisations, and program partners) with an annual evaluation report documenting the project's progress and the lessons learnt.

The purpose of this first evaluation report is to:

1. **Clearly describe the project's Theory of Change, contextualising this with existing evidence and research;**
2. **Report on the development, implementation, current status, and initial outcomes of each of the program elements and their contribution to the Theory of Change;**
3. **Inform project continuous quality improvement (CQI) processes at both the program element and overall project levels, including any refinements to the Theory of Change; and**
4. **Identify early findings for sustainability, curriculum reform, and policy implications in the Indigenous STEM education field.**

1.3 Context

As Australia's National Science Research Agency, CSIRO has had a long standing commitment to science education in schools, having offered a range of education programs for schools, teachers, and the community for over 30 years (CSIRO 2016a). CSIRO currently offers a range of different education programs focusing on community engagement, and building teacher and student capacity.

CSIRO Education Programs include:

- **CREativity in Science and Technology (CREST)** – which rewards students for successfully conducting open inquiry investigations;
- **Science Bootcamp** – a science camp for secondary students;
- **Inquire to Discover** – an open inquiry teacher professional development program;
- **BHP Billiton Science and Engineering Awards**;
- **Scientists and Mathematicians in Schools (SMiS)** – which partners teachers with STEM professionals;
- **Digital Careers** – which aims to increase the numbers of students taking up digital technologies at school and as a career;
- **Double Helix magazine** – which aims to bring interesting scientific information to young people;
- **Sustainable Futures** – which aims to increase students knowledge of climate science and sustainability; and
- **Pulse@Parkes** – which allows high school students to remotely operate the Parkes radio telescope to find pulsars and contribute to pulsar research.

The Indigenous STEM Education Project (CSIRO, 2016b) builds on an increasing commitment by CSIRO to Indigenous STEM education and research. This commitment includes an Indigenous employment strategy and a substantial engagement of schools with significant proportions of Aboriginal and Torres Strait Islander students through the SMiS program. As of September 2016, there were 29 partnerships in schools with an Aboriginal and Torres Strait Islander student population greater than 50 per cent, and 54 partnerships in schools with an Aboriginal and Torres Strait Islander student population greater than 25 per cent. CSIRO also partnered with Tangentyere Council and Bank Australia in a project in three remote NT schools (Ikuntji, Papunya, Watiyawanu and Ltyentye Apurte) which provided the model for the Science Pathways program. This is one of numerous partnerships with Indigenous communities on a range of projects that recognise and build on Indigenous cultural knowledge including: research into fire management of landscapes in Eastern Arnhem Land (Kakadu); control of pest fish species (Malanbarra Yidinji community); eradication of weeds (Mungalla Station); water flows (Murray-Darling and Daly Rivers catchments); fish stock management (Lobster and sea cucumber in the Torres Strait); and an Indigenous Land use Agreement with the Wadjarri Yamatji Traditional Owners as part of the Australian Square Kilometre Array Project in remote Western Australia.

The 35 year relationship with BHP Billiton through the BHPB Science and Engineering Awards and CSIRO's national science research infrastructure program contributed significantly to the agreement between these two partners to develop and implement the Indigenous STEM Education Project to support Aboriginal and Torres Strait Islander STEM education.

A key aspect of this project which makes it distinct from CSIRO's other education programs is the commitment to embed strong monitoring and evaluation processes within the day-to-day operation of the project. Historically, CSIRO Education and Outreach (CEdO) has gone to external evaluations to measure the effectiveness of its education programs. Further, the significance of the project and the complexities of Indigenous science education led CSIRO to identify the need for external expertise to advise on the project. Consequently, similar to other complex projects, a Steering Committee was established to provide oversight and advice. This committee includes several external Aboriginal and Torres Strait Islander members with expertise in areas such as Indigenous higher education, knowledge and story systems, ecology, health and information, and communications technology, as well as senior CSIRO personnel.

1.4 Research methodology

This evaluation report covers the period from the commencement of the project to June 2016.[1] The Excellence Awards, renamed in 2016 as the Indigenous STEM Awards, is only referred to briefly as the first awards round did not take place until the end of 2016. A key reference point for this evaluation report is the project's Theory of Change and the Monitoring and Evaluation Framework that has been built around it. The workshop which developed the Theory of Change also identified a wide range of indicators and research methods that could be used to evaluate the individual program elements and presented these in a draft Monitoring and Evaluation Framework. This workshop also contributed to the initial ethics application to evaluate the project which was submitted in April 2015 and received final approval in June 2015.

A key distinction affirmed in the ethics approval was that program elements would develop their own independent monitoring frameworks for program monitoring and improvement purposes with the research component operating in addition to these. A Monitoring and Evaluation Framework identifies the data required to monitor and improve the delivery of the individual program elements, the project as a whole, as well as informing the communication and sustainability strategies. It does this in three parts. Firstly, it identifies the headline indicators that will be used to measure progress to the overarching goal and the contributing indicators that measure the key components of the project's Theory of Change. Secondly, it presents logic models developed for each of the program elements to more clearly illustrate the timing of expected changes (short term – 1 year; medium term – 2-4 years; and long term – 5+ years), as well as the underlying Theory of Change for each element. These program logics make an important contribution to understanding the envisioned pathways for the project's Theory of Change. Thirdly, it makes the distinction between routinely collected data for program monitoring and refinement purposes, and additional research processes that allow a deeper understanding of success factors or obstacles to the aims of the project. The summary table of the headline and contributing indicators and their associated research questions is provided in Appendix A; the individual program logics are included in Appendix B; and the table distinguishing between routinely collected data for program monitoring and refinement purposes and additional research processes is contained in Appendix C.

As the key foci of this evaluation report are understanding the effectiveness of the initial implementation of the program elements and contextualising the project's Theory of Change with the existing evidence, three main data sources were identified: a literature review of Indigenous STEM education engagement, policy, and practice; interviews with project directors and program element leaders; and program element leaders' program materials and reports. These sources were supplemented by ethnographic insights of the research coordinator who has been part of the project team since January 2016; PRIME Future's survey data; and feedback from ASSETS participants. This approach was approved by the CSIRO Ethics Committee in June 2016.

With regards to the program leader/project director interviews, a series of questions was asked about the implementation of their program element or the project as a whole, including questions asking them to identify highlights, challenges, uptake, and unique features, as well as asking them to provide their observations as to how their program element/ the project was addressing the Monitoring and Evaluation Framework key research questions (see Appendix D for the interview schedule). In the case where a program leader/the project director had changed (ASSETS and the project director), both the current and former leaders were interviewed. In the case of I2S2, the program leader was on leave at the time of the interviews and delegated the interview participation to the deputy program leader. Interviews were transcribed and provided to interviewees for verification. The interviews were used in conjunction with data from program reports to describe the implementation of the program elements with particular reference to the inputs, outputs, and early outcomes identified in the program logics.

1 The late start of Science Pathways and the conducting of interviews in August 2016 has meant some data is more recent.

The transcripts were also analysed by the two research team members for common themes relating to pedagogical approaches, sustainability, curriculum reform, and policy implications in the Indigenous STEM education field. The subsequent analysis of program elements was provided back to program leaders/project directors for comment, as was a draft of the full report.

While some program elements have developed monitoring processes, consent was not gained for the use of this data for evaluation purposes, and consequently it is not used in this evaluation. Appropriate consent processes are being developed to allow such information to be made available for use in future evaluation reports. As a subcontracted program element with Queensland University of Technology (QUT), PRIME Futures had completed initial teacher and principal surveys of Phase One schools for which they had obtained ethics approval from the QUT ethics committee thus enabling this data to be utilised.

A key limitation of this evaluation report is the lack of external evaluation data to verify the internal program reporting data and perspectives of the program leaders. The resignation of the former research leader and a six month delay in their replacement contributed to a limited timeframe being available to collect data for this report. Delays in the development and implementation of the program element level evaluation methodologies have provided a further limitation. These limitations resulted in the decision to focus the initial evaluation on program implementation against the program logics drawing primarily on the experience of the program leaders. As well as the limitation of not being able to verify program leaders' perspectives with those of key partners or stakeholders, there is also a lack of broader quantitative and qualitative data on each of the program elements. These methodologies are being developed; however, their implementation is still dependent on both jurisdictional and ethical approval. These limitations will be addressed in future evaluation reports with the development and implementation of a range of evaluation methods across each of the program elements including pre, post, and longitudinal surveys of students, parents, and teachers, and case studies to develop a deeper understanding of each of the program elements. Jurisdictions are also being approached to provide data to compare outcomes of students and schools in PRIME Futures, I2S2, and Science Pathways with those not participating in these programs.

2 Indigenous STEM education in Australia: Context

2.1 Overview

Both STEM education and Indigenous education operate in complex and contested socio-political environments in Australia. Discourse in STEM education has a strong focus on international comparisons driven by concerns for Australia's international competitiveness and future economic prosperity. Indigenous education, in contrast, tends to be more internally focussed, particularly on the gap between Indigenous and non-Indigenous outcomes as emphasised by the current dominant policy paradigm of 'Close the Gap'. While there is a wealth of literature identifying relative performance and best practice in both STEM education and Indigenous education in Australia, there has been less of a focus on the intersection of the two – that is, Indigenous STEM education. This is in contrast to those nations with which we usually compare Indigenous outcomes – New Zealand, Canada and USA – where the literature is more extensive.

The literature review presented in this section summarises key elements of Australian STEM performance in an international context, Indigenous education generally, and with particular reference to participation and achievement in STEM. It discusses general principles of best practice in Indigenous education and STEM education; and identifies best practice in Indigenous STEM education in Australia, Canada, and the USA. It does not constitute a comprehensive literature review of these diverse areas; rather it identifies key literature that has helped to inform the focus and practice of the Indigenous STEM Education Project. A reasonably detailed chapter is included for two main reasons. Firstly, it is intended to provide a broad context for the project to stakeholders given the relative paucity of programs and focus on Indigenous STEM education in Australia. Secondly, it will provide a useful reference point for subsequent evaluation reports which will be more focused on the detailed evaluation of the program elements making up the Indigenous STEM Education Project.

2.2 Need for a focus on STEM

2.2.1 INTERNATIONAL COMPARISONS

In many English speaking nations STEM is framed within a discourse of crisis. This is due to declining participation and achievement in STEM subjects in high schools; and concern that the workforce and broader society will not have the necessary STEM literacy to underpin future workforce needs for a thriving economy (Marginson, et al., 2013: 55; OCS, 2013). Further, international research indicates that 75 per cent of the fastest growing occupations now require STEM skills and knowledge (OCS, 2014a: 7).

The Australian Government's Chief Scientist has argued that there is mounting evidence that Australia is falling behind overseas competitors in key performance measures such as converting research innovation into the outputs businesses need. Despite having a significant level of investment in research (in the order of $8.6 billion), Australia is ranked 81st in terms of research conversion to beneficial outputs (OCS, 2014a). Further, the Australian Industry Group (AIG) found that 44 per cent of employers are continuing to experience difficulties in recruiting STEM qualified technicians and trade workers. Subsequently, the AIG has called for the development of a national STEM skills strategy to lift the level of STEM qualified professionals in the workplace. It is also developing a STEM education guide, with support from the Office of the Chief Scientist (AIG, 2015).

The STEM workforce supply concerns are accompanied by a decline in mathematical literacy in schools as measured by the OECD's Programme for International Student Assessment (PISA). Results between 2003 and 2012 have Australia slipping from 6th to 13th, contributed to in part by 40 per cent of Year 7 to 10 mathematics classes not being taught by a qualified mathematics teacher. While scientific literacy has remained unchanged between 2006 and 2012, our relative performance has slipped from 4th to 6th (OCS 2014b: 10-11). When benchmarked against several of Australia's OECD counterparts, the percentage of tertiary student enrolments in science and engineering is 12th out of 15, improving somewhat when looking at the proportion of doctoral candidates to 9th out of 16 (OCS 2014b: 85).

2.2.2 INDIGENOUS EDUCATION CONTEXT

Turning to the Indigenous education context, of significant importance to this project is the 2013 PISA finding that Indigenous students have a level of contextualised interest in science (as opposed to measures of general science interest) slightly higher to that of their non-Indigenous peers (McConney et al. 2011: 2024, Woods-McConney et al., 2013: 241). The Overcoming Indigenous Disadvantage 2014 report (SCRGSP, 2014) also identifies several other positive trends. The proportion of Indigenous 20-24 year olds who have completed Year 12 has increased from 45 per cent in 2008 to 59 per cent in 2012-13, while non-Indigenous completions have remained stable at 86-88 per cent. This has contributed to a 'closing of the gap'. Similarly, the proportion of Aboriginal and Torres Strait Islander 17–24 year olds participating in post-school education, training, or employment has increased from 32 per cent in 2002 to 40 per cent in 2012-13, while the non-Indigenous rate has been stable at 75 per cent (SCRGSP 2014: 43).

However, these changes have occurred in a context of virtually no change in the proportions of students achieving national minimum standards for reading, writing, and numeracy from 2008 to 2013 (SCRPGS 2014: 29), with the levels of disadvantage significantly acerbated in remote and very remote regions (SCRPGS, 2014: 29). As Dreise and Thomson (2014: 1) identify, the PISA results of 2013 in mathematics, scientific, and reading literacy show Indigenous 15 year olds remain two-and-a-half years behind their non-Indigenous peers in school, the same as a decade ago, notwithstanding their higher level of interest in science mentioned above. Further, 62 per cent of the difference in performance is attributable to poor literacy (McConney et al. 2011: 2026).

Of particular interest to the Indigenous STEM Education Project is the proportion of Year 12 students receiving an ATAR of 50 or more, a commonly recognised minimum benchmark for university entrance (Behrendt et al., 2012). As Figure 2 indicates, the rate of improvement is positive, but lower than that of the non-Indigenous population, resulting in an increasing of the gap between the two groups.

Turning to tertiary engagement and outcomes, Australia's Indigenous population (2.2 per cent of the total) is under-represented in the university system. However, the gap in enrolled students is closing slowly, with the participation rate increasing from 1.26 per cent in 2003 to 1.41 per cent in 2013 (Australian Government, 2015). Although working from a low base, Indigenous enrolments in STEM at university are increasing at a rate greater than the overall increase in university enrolments. From 2001 to 2013 this increase has been 146 per cent, (from 473 to 1,163) compared to 101 per cent overall (ATSIHEAC 2015). When compared with overall Australian enrolments (Indigenous and non-Indigenous), science, mathematics and engineering bachelor degrees have seen modest enrolment increases, while agriculture and environment have declined (OCS, 2014a: 80). Overall, university enrolments have increased by 83 per cent in this period.

It is important to note that enrolments are only one indicator. In many regards, retention and completions are more important; and the increase in Indigenous STEM enrolments is being reflected in an increase in completions, with the number doubling from 65 in 2001 to 133 in 2013 (ATSIHEAC 2015). A recent nine-year cohort study of university students commencing in 2005 had overall completion at 73.6 per cent compared to 46.7 per cent for Indigenous students. Low socioeconomic status, regional,

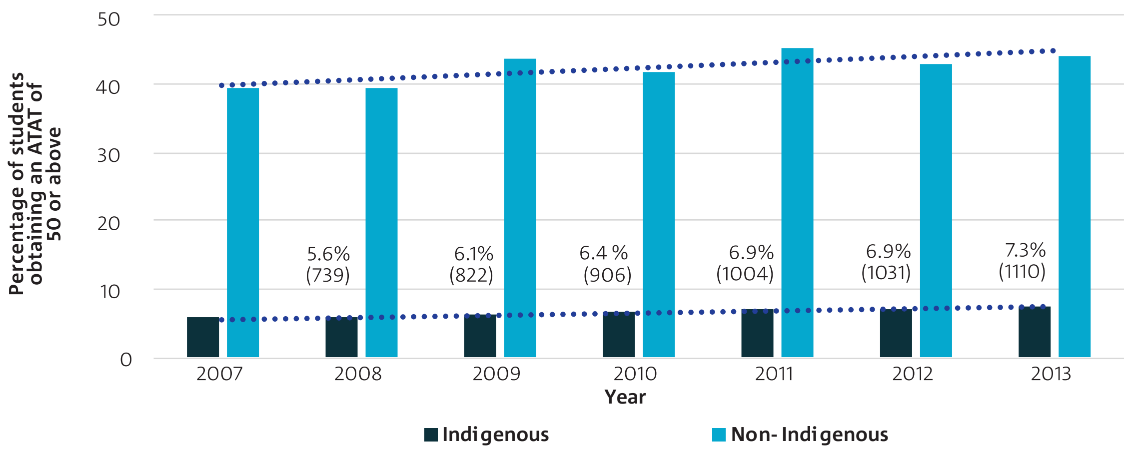

Figure 2: Estimated year 12 students obtaining an ATAR of 50 per cent or above, 2007-2013[2]

2 Data source: SCRPGS (2014). Note that the percentage is of the number of students estimated to be in year 12 and the residential data for Indigenous 15-19 year olds is an estimation based on birth and fertility rates. Possible errors mean this data should be used with caution.

and remote students also had lower completion rates of 68.9 per cent, 69.8 per cent, and 59.5 per cent respectively. More than one in five Indigenous students in this cohort had dropped out of university before their second year; and another quarter had dropped out at some other stage in the nine year period (Edwards & McMillan, 2015: 8).

To provide context to these lower Indigenous completion rates it is important to be aware of other key factors influencing university student completion rates including:

- **Age** – students commencing at nineteen years of age or less had a completion rate of 80.3 per cent; 20-24 years, 70.4 per cent; and 25 years and over, 58.5 per cent;
- **Gender** – women had completion rates of 75.5 per cent compared to 70.9 per cent for men;
- **ATAR** – students with an ATAR of 95-100 had completion rates of 95 per cent, with the rate proportionately declining to 56.1 per cent for those with an ATAR of 50-59 per cent; and
- **Study load** – students studying full time had completion rates of 78 per cent compared to part time students at 49.2 per cent (Edwards & McMillan, 2015: 9).

In summary, both international STEM comparisons and internal analysis of Indigenous education achievement and trends identify substantial challenges that this project's program elements need to address. In regard to STEM, key concerns include the lack of students pursuing STEM studies and the implications for future workforce needs, accompanied by a decline in international student performance, and the lack of conversion of innovation into business outputs. In regard to Indigenous education, the context includes the contradictory situations of no change in 10 years to the two-and-a-half year gap in mathematics, science, and reading literacy, and a widening gap in ATAR achievement offset by increasing enrolments and completions at university. These challenges are central issues in the project's Theory of Change.

2.3 Australian STEM responses

2.3.1 AUSTRALIAN SCIENCE CURRICULUM

A significant development in terms of science education has been the agreement by all state and territory Ministers for Education to a national science curriculum to be taught from Foundation to Year 10 across Australia. The *Australian Curriculum: Science* was the result of consultation with education researchers and practitioners overseen by the Australian Curriculum, Assessment and Reporting Authority (ACARA, 2009a). The curriculum is grounded in an inquiry-based approach to the teaching and learning of science using contexts relevant to students (ACARA, 2016a). This is supported by the development of new teaching methods and materials including "...less emphasis on a transmission model of pedagogy and more emphasis on a model of student engagement and inquiry" (ACARA, 2009a).

To accommodate this new approach of teaching science, recommendations from stakeholders (including government, education authorities, parent bodies, professional educational associations, academics, businesses and industry groups, wider community groups, and interested individuals from the wider community) focus on the availability of professional development for teachers both pre- and in-service (ACARA, 2009b).

The Australian Curriculum has also identified Aboriginal and Torres Strait Islander histories and cultures as one of three cross-curriculum priorities that need to be addressed across the learning areas, including science.

> Students will have opportunities to learn that Aboriginal and Torres Strait Islander Peoples have developed knowledge about the world through observation, using all the senses; through prediction and hypothesis; through testing (trial and error); and through making generalisations within specific contexts. These scientific methods have been practised and transmitted from one generation to the next. Students will develop an understanding that Aboriginal and Torres Strait Islander Peoples have particular ways of knowing the world and continue to be innovative in providing significant contributions to development in science. They will investigate examples of Aboriginal and Torres Strait Islander science and the ways traditional knowledge and western scientific knowledge can be complementary
>
> **(ACARA, 2009b).**

2.3.2 JURISDICTIONAL INITIATIVES

Reflecting the national discourse, most state and territory jurisdictions have identified education initiatives in STEM. A review of their respective education websites identifies numerous initiatives noting the importance of STEM fields to future careers (Government of South Australia, 2012), and the development of STEM knowledge and skills as critical to the prosperity and development of the state (Victorian Government, 2015).

Queensland has released a Strategy for STEM in Queensland State Schools (Queensland Government, 2016a) with three key aims of building teacher capability; increasing student engagement in STEM learning; and achieving excellence in STEM learning. A number of new STEM focussed programs have be instigated, including: Entrepreneurs of Tomorrow, which aims to build student entrepreneurial skills; a STEM Hub documenting online resources on STEM subjects, careers, pathways, opportunities, events, and why STEM is important; a STEM Girl Power Camp; and a review of STEM education in Queensland to determine best practice in STEM education (Queensland Government, 2016b). Other jurisdictions have initiatives such as redeveloping schools into STEM learning hubs; teacher professional learning; and scholarships for mathematics and science education students. Both South Australia and Western Australia support the established STEM outreach programs of CSIRO (Government of South Australia, 2012; Government of Western Australia, 2016b).

2.3.3 AUSTRALIAN UNIVERSITY INDIGENOUS STEM PARTICIPATION

All Australian universities have Indigenous Higher Education units which provide a culturally safe space for all Aboriginal and Torres Strait Islander students on campus (Australian Government 2016a). Many offer diverse and unique opportunities aimed at increasing Indigenous engagement in STEM (e.g. offering scholarships, convening Indigenous STEM camps). There are also several examples of good practice where universities are introducing a range of strategies to support Indigenous students to undertake their studies through to completion. Free tutoring is also provided by the government for all tertiary Indigenous students.

Building on Section 2.2, Section 2.3 has identified the broad policy focus on both STEM and Indigenous education contributing to what would be expected to be a receptive policy and stakeholder environment for initiatives such as the Indigenous STEM Education Project. Section 2.4 deepens this analysis to look specifically at Indigenous STEM education from both Australian and international perspectives.

2.4 Best practice in Indigenous STEM education

2.4.1 KEY LEARNINGS – INDIGENOUS EDUCATION AND STEM EDUCATION

Key learnings on effective Indigenous education practices from the Closing the Gap Clearinghouse (Helme & Lamb, 2011; Mulford, 2011; Dockett, Perry & Kearney, 2010) include school cultures and leadership that acknowledge and support Indigenous students and families, through:

- a shared vision for the school community;
- high expectations of success for both staff and students;
- a learning environment that is responsive to individual needs;
- a drive for continuous improvement;
- involvement of the Indigenous community in planning and providing education; and
- quality career education.

Further, they identify that teachers and school leaders were most effective when they understand the broader environment and organise their schools to respond to this environment, including operating as flexible organisations that focus on developing networks, trust, and resources (social capital) at three levels (Mulford, 2011):

- within the school as a community of professional learners;
- between schools; and
- between the school and its community.

Of particular relevance to the Indigenous STEM Education Project is the conventional expectation that it takes 3-5 years to implement a cycle of reform to generate school level gains. Luke et al. (2013: 7) suggests it actually takes 4-6 years for school improvement in Indigenous education.

One of the key influences in current thinking on Indigenous education is the work of Chris Sarra and the Stronger Smarter Institute (SSI). This work has identified that ‘high-expectations’ needs to be at the forefront of discussions when considering Indigenous education (SSI, 2014: 1). Deficit perceptions can be self-perpetuating as Indigenous children and their families are often so “heavily socialised by this deficit colonial gaze” that they accept negative stereotypes as part of their identity, which fuel low expectations of both self and others, preventing educational engagement and achievement (SSI, 2014: 2).

In promoting a culture of high expectations, they argue that there is a crucial difference between "high-expectation rhetoric" and "high-expectation relationship", with the latter developing relationships that connect teachers and students through their shared humanity. A teacher with high-expectations will use rich and varied tasks, push students, use complex language and tasks, clarify expectations, and direct towards requirements of activities. Critical self-reflection is a key skill teachers need to employ recognising that deficit thinking also impairs the teacher's expectations of themselves as believing that they can educate an Indigenous student. Applied effectively, teachers with high expectations challenge negative behaviours and engage in a conversation with the parents to find out what needs to change to improve education outcomes, thereby replacing blame on student context/circumstance and reflecting it inward on the system/teachers (SSI 2014: 3-8).

The Stronger Smarter Learning Communities (SSLC) Evaluation Report (Luke et al., 2013) provides the first large scale picture of what is occurring in classroom pedagogy for Indigenous students. It describes the operations and analyses the effects of SSLC on a national network of 57 Hub schools and 70 Affiliate schools. A comparison group of 74 non-SSLC schools was also studied. Its major findings confirm the critique of the Stronger Smarter approach that deficit thinking is a major obstacle to improving outcomes for Indigenous students. Unfortunately, even with gains in schools employing Indigenous staff and leadership in the school, and an incorporation of Indigenous perspectives in curriculum, the general feedback from the Indigenous community was that schools continue to operate from deficit assumptions. Of particular relevance to the current project are the findings that the predominant, default modes of pedagogy for Indigenous students are basic skills instruction leading to vocational education; that there is a lack of coherence in approaches to teaching, programs, and curriculum materials; and that lack of school leader and teacher knowledge and engagement with Indigenous communities are major barriers to improved Indigenous student outcomes (Luke et al., 2013: 32).

The ACOLA international comparison report notes that the top performing nations/systems in science and mathematics are Shanghai, Singapore, Hong Kong, Taiwan, Korea, Finland, and Switzerland. These systems also have the smallest proportion of underperformers in PISA; as well all having strong research systems that are rapidly growing scientific output, and having experienced two decades of exceptional economic performance. "What is clear is that all three – science, universal learning, and economic dynamism and prosperity – *form a single interdependent system"* (Marginson, et al., 2013: 14, emphasis in original). Despite the diversity of these countries' economies, political, social, and educational cultures, five common features of their education systems are identified (Marginson, et al., 2013: 15):

1. School teachers enjoy high esteem, are better paid and have more meritocratic career structures;
2. High commitment to disciplinary contents;
3. The institution of major curriculum and pedagogy reforms making science and mathematics more engaged and practical;
4. Innovative policies to lift STEM participation from formerly excluded groups;
5. Development of strong national STEM policy frameworks.

Focusing on how these five characteristics are more specifically manifested at the level of school practice, there is a growing body of international evidence that characterises effective STEM instruction and the characteristics of schools successful in teaching STEM. Of critical importance is capitalising on students' early interests and experiences, as building on what they know provides the experiences necessary to sustain their interest. This needs to be supported by coherent standards, curriculum, and assessment processes, with adequate instructional time and ongoing professional development of teachers. In particular, teachers need content knowledge and expertise in teaching that content; support to address issues that arise in the class and school settings; and sustained opportunities for teacher learning over time (National Research Council 2011: 18-21, 25).

A growing body of international research demonstrates the importance of measuring these school level practices and STEM education characteristics as focussing solely on STEM education outcomes does not provide guidance about the instructional practices and conditions in individual schools necessary to achieve these outcomes. There are also limitations as to the breadth of what quantitative outcomes data (e.g., test results) actually measure; and there is often a time lag between change in practice and the outcomes being achieved. This occurs in a context where there is strong evidence that connects the school level practices and STEM education characteristics with desired STEM education outcomes (National Research Council, 2011: 6).

With regard to student interest and the third and fourth point of the ACOLA comparison, the Aboriginal and Torres Strait Islander Higher Education Advisory Council (2012 – 2015) recommended action be taken to make science and mathematics exciting and relevant in the classroom; and that groups of experts in Indigenous STEM education should be organised to provide advice on strategies to increase Aboriginal and Torres Strait Islander participation in STEM (ATSIHEAC, 2015). This resonates well with the McConney et al. (2011: 2026) finding that, notwithstanding the two-and-a-half year gap compared with non-Indigenous students, Aboriginal and Torres Strait Islander students have a higher contextualised interest is science. They subsequently recommend the greater use of Traditional Ecological Knowledge (TEK) as central to improving science literacy. In doing so they acknowledge the significant implications for the professional learning for teachers to do this effectively.

Non-Indigenous teachers need help in learning how to become culture-brokering science teachers so they can acknowledge students' personal preconceptions and Indigenous worldviews that connect to everyday culture (McConney et al., 2011: 2029).

The challenge of contextual and cultural relevance is further complicated by students who are not necessarily fluent with Standard Australian English (SAE). Working with students from remote Indigenous communities who do not have SAE as their first language, Chizega (2008) demonstrated that two language negotiations occur when learning western science concepts. The first is the negotiation from the student's first language to SAE; and the second is negotiation from their everyday language to scientific language, recognising that Indigenous languages do not necessarily have terminology that directly encapsulates western scientific concepts. Aligning himself with constructivist and contextually based approaches to learning, Chigeza (2008: 96) argues for the development of a "creole science" to empower Aboriginal and Torres Strait Islander students to successfully negotiate the language systems present in science. Recognition of creole languages or supporting Indigenous languages to specifically develop scientific terminology have been policies formally adopted by governments as part of their education policies across the world, including in Haiti, New Zealand, Tahiti, Israel, Tanzania, and Malaysia (Bunting et al., 2013: 7; Chigeza, 2008: 96).

Reflecting on the interaction of Western and Indigenous knowledge systems, Nakata (2010) has written extensively about the "cultural interface" as a way to approach understanding. He explores this in detail with regard to Islanders' relationships with the marine environment and its resources in the Torres Strait. He argues that "[c]hildren learning about both knowledge approaches through the appropriate methods will find their own thoughtful connections if they can come to a conscious awareness of the meanings and conditions of both. For Islander children, what is taught in classrooms and what is learnt in everyday life may be best continued on these different paths" (Nakata, 2010: 56). He posits that education may be better directed at the meta-awareness that Islander children need to "become knowledgeable about the existence of different ways of learning, knowing and doing and to feel their way confidently along both these paths" (Nakata, 2010: 56).

Part of his caution as to the extent of what is "taught in classrooms" lies in the larger context of who is interested in Indigenous knowledge and why. The nature of these competing interests raise questions as to what parts of TEK are valued and by whom; and how documentation by different western scientific disciplines can lead to the fragmentation of a knowledge that is premised on its holistic perspective. "For without a doubt, the collection and documentation of Indigenous knowledge by the development and scientific community is a very partial enterprise, selecting and privileging some Indigenous knowledge while discarding and excluding others" (Nakata, 2002: 283).

The utility of the cultural interface for Nakata (2002) is that it becomes a space of understanding the intersection of Western and Indigenous domains; where underlying principles of reform can be explored and developed; and as a place of Aboriginal and Torres Strait Islander people's agency (Nakata, 2002: 285). The strengths of this approach, for example, include that it challenges a false dichotomy between Western and Indigenous knowledge, acknowledging that there are similarities across the categories, while substantial differences within them. It draws attention to the cultural foundations of all knowledge systems including western science; and highlights how all knowledge systems are constantly developing largely through their interactions with other knowledge systems (Nakata, 2002: 284).

A final area of educational practice that complements this discussion of science content and pedagogy are the more individual characteristics of students that support or inhibit persistence in academic learning, and the policies and practices that schools can employ to support these individual learning styles or characteristics. Local and international literature identifies as important the organisational structures that support meaningful conversations between students and adults at the school including administrators, career counsellors, and support personnel. These include the processes to support relationship development between students and adults over their years at a school; proactive use of data to create targeted and personalised interventions; the creation of small learning communities within the school; support with transition to high schools; and processes to develop student ownership and responsibility (Cannata, M. et al., 2013; Day et al., 2015).

In summary, Section 2.4.1 identifies key evidence on best practice in Indigenous education and STEM education and the intersection of the two. This includes macro level insights such as successful STEM nations having innovative policies to include formerly excluded groups. At the level of effective pedagogical practices it includes evidence such as the potential complementarity of science inquiry pedagogy with high expectations and relevance to students' everyday lives. Further, the work of Nakata, Chigeza and others highlight the complex cultural interactions arising for Aboriginal and Torres Strait Islander students with which effective programs need to engage. This best practice evidence is an essential reference point for the project's Theory of Change, and the individual approaches of each program element as outlined in their program logics. The remainder of Section 2.4 explores examples of how this practice is applied in the Australian and international contexts.

2.4.2 EXAMPLES OF EMERGING GOOD PRACTICE – AUSTRALIA

An example of a major national initiative in building science inquiry practice and skills in Australia is *Primary Connections;* a teacher professional learning program supported with substantial curriculum resources developed by the Australian Academy of Science. Key program principles are: the explicit development of the literacies of science; an inquiry approach to science; and the inclusion of authentic purposeful activities (Hackling & Prain, 2008: 7). Research undertaken on the program has shown improvement in teacher's confidence and enjoyment as well as students' conceptual understandings and enjoyment (Hackling & Prain, 2005). Increased student performance in Primary Connection schools, compared to non-Primary Connection schools, including for Aboriginal and Torres Strait Islander students has also been demonstrated (Hackling & Prain, 2008: 4-5). The development and piloting of an Indigenous perspectives framework for Primary Connections in 2007 saw improved engagement and learning by all students, increased student awareness and teacher confidence in teaching of Indigenous perspectives, and improved relationships between the school with both parents and the community (Bull 2008: 10-15).

In 2011, the Desert Knowledge Cooperative Research Centre published an in-depth look at the Northern Territory Indigenous Land and Culture Program (ILC) and its utilisation of the Tangentyere Council's Land and Learning Program to facilitate two way, on-country learning (Douglas, 2011). (Douglas, 2011) identifies how Aboriginal community members have long requested that schools accord equal value and status to Aboriginal knowledge alongside Western knowledge, and provide education in the language that children speak. This research found that the main entry point for scientific education in remote schools is through local ILC programs. The focus on 'country', its ecosystems, and interrelated cultural knowledge and practices provides a strong connection point to ecological science (Douglas, 2011: 2). Douglas (2011:42) identifies several factors necessary for quality ILC programs, namely: a supportive school principal; the community is engaged in the school; Elders actively engage in the program; Aboriginal teaching staff are employed by the school; non-Aboriginal teachers engage with the program; and resources are available to support country visits.

The *Learning on Country Program: Progress Evaluation Report* (Fogarty, et al., 2015) discusses Indigenous Land and Sea Management (ILSM) programs, Indigenous ranger programs, and natural resource management programs more generally. They note the increased demand for people with both Indigenous and western scientific knowledge, as well as fundamental skills in English literacy and numeracy (Fogarty, et al., 2015: 15). Key findings from their evaluation identify the importance of strong governance mechanisms, a positive trajectory in attendance and retention of students, pathways to employment, intergenerational transfer of knowledge, engaging the wider community in schooling, and supporting the development of young people's Indigenous identity (Fogarty, et al., 2015: 116). They also identify several challenges facing these programs including the lack of ongoing funding, the capacity of teachers to effectively understand and engage with the program, ongoing shifts in the broader policy environment, program governance in the context of high staff turnover, maintaining and building community partnerships, how to effectively integrate with curriculum in the classroom, logistical issues in planning on-country activities, integration into community priorities, and the development of data systems to effectively monitor program impact (Fogarty, et al., 2015: 116-119).

Scitech, a not-for-profit organisation based in Perth, developed an Aboriginal Education Program for rural and remote schools with high Aboriginal student populations. The program consists of a set of lessons for children of different age groups based on the theme of natural and processed materials. Eleven effective pedagogical practices used by the Scitech team are highlighted in Figure 3 and grouped in four categories: (a) engagement - the student's connection with the presenter and other children; (b) a framework for engaging students through hands-on science activities; (c) practical pedagogies that maximise student engagement in classroom discourse; and (d) making links between science activities and students everyday lives (Hackling et al 2015: 36- 38).

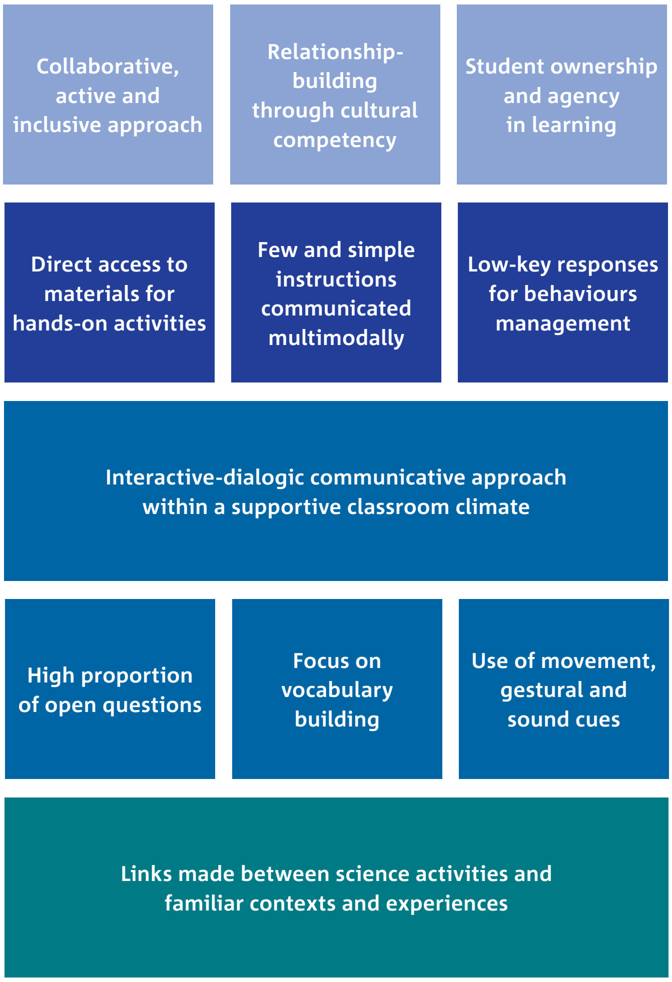

Figure 3: Pedagogical practices engaging Aboriginal students with science learning

A major maths initiative is the YuMi Deadly Maths (YDM); a cohesive mathematics pedagogical framework that covers all strands of the Australian Mathematics Curriculum. It has a focus on "big ideas, an emphasis on connecting mathematics topics and a pedagogy that starts and finishes with the students' reality" (YDM overview, 2014: iv). While the pedagogy is seen as best practice for all students, drawing on the work of Ezeife (2002), it is argued to be particularly relevant for Aboriginal and Torres Strait Islander peoples who have been characterised as belonging to 'high-context' cultures where meaning is 'extracted' from the environment and situation. In contrast, mainstream Australian culture is characterised as a 'low-context' culture using a more linear, sequential building block approach to information processing in which meaning is constructed (YDM overview, 2014: 25).

Central to this pedagogy is the use of Aboriginal mathematician Chris Mathew's Research, Abstraction, Mathematics, Reflection (RAMR) model. The model provides the basis for four different instructional episodes starting and ending with reality (YDM overview: 2014: 29). The reality component is where students use their knowledge of the world and existing mathematics knowledge to identify a new mathematical idea. They then engage in real world activities that act out the idea. Abstraction is the use of representation, action, and language that allow mathematical ideas to be abstracted from their reality. The mathematics component is where students learn the formal language and symbols of Eurocentric mathematics to reinforce the knowledge they have gained in the abstraction and building connections with other related mathematical ideas. Reflection brings these new mathematical ideas back to the students' real world (YDM overview, 2014: 30). In addition to the RAMR cycle there are two other core components of the YDM pedagogy. Firstly, *developing a plan* for teaching across a period of time and secondly, *identifying the central mathematics* to be taught and the ideas to which it should be connected (YDM overview, 2014: 33 emphasis in original).

2.4.3 EXAMPLES OF GOOD PRACTICE – CANADA AND USA

Some Canadian provinces have demonstrated sustained systemic change in both improving Indigenous participation in science and incorporating Indigenous perspectives in the curriculum. For example, the Saskatchewan science curriculum presents students with two cultural knowledge systems: a scientific system based on an intellectual tradition of thinking, and an Indigenous system based on a wisdom tradition of thinking, living, and being.

> **The two coexist; they are not in competition with each other. All students are expected to understand the best of both ways of knowing nature. But students are not necessarily expected to believe what they understand. Their beliefs are personal. (Aikenhead, 2013: 12)**

The curriculum has been supported by research into the development of a culturally responsive science teaching framework that includes the integration of Indigenous knowledge into science classes; culturally appropriate teaching strategies and assessment; and the recognition of cultural styles of interpersonal communication. The success of this approach is evidenced in Indigenous students' enrolments in optional science courses in Grades 11 and 12 between 2002 and 2011 increasing by 80 per cent (from 2,858 to 5,148), substantially greater than the approximately 45 per cent increase in Canada's Indigenous population over the same time period (Aikenhead, 2013: 17). Further, this type of systemic change is not isolated to a single province as evidenced by similar developments in Manitoba (Barnhardt, 2005).

The USA has a strong evidence base for best practice supporting minorities in STEM. A review of 124 US higher education-based programs identified 12 exemplary programs to promote minority participation in STEM fields at the university level. These programs share the following features:

1. institutional leaders being commitment to inclusiveness;
2. targeted investment in the feeder system;
3. engaged faculty;
4. personal attention, through mentoring and tutoring;
5. developing student peer support across cohorts, disciplines, and professions;
6. enriched research experience outside the classroom;
7. building institutional relationships to ensure career pathways; and
8. continuous evaluation of support processes and outcomes (Chubin et al 2005: 78).

Individual examples of best practice include the Math in a Cultural Context (MCC) program in Alaska that connects local linguistic and cultural practices to school knowledge, integrating literacy, geography, and science. Students who experience MCC make statistically significant gains in learning as measured by conventionally designed pre- and post-tests, a finding which holds for students from all backgrounds who engage with this Yup'ik culture-based curriculum compared to peers using conventional curricula (Nelson-Barber, 2013: 13).

Further, the Native Science Connections Research Project is a culturally relevant science curriculum that integrates Native American students' traditional cultural knowledge with western science for fifth grade students in public, contract, and Bureau of Indian Affairs schools on the Navajo, Hopi, San Carlos Apache, and Zuni reservations. Findings from this and STEM programming at several Tribal Colleges and Universities, and the Greater Plains Technical College, identify a key pedagogical difference in that science faculties are more likely to begin teaching at the level of the ecosystem, working their way to the molecular level (whole to part), whereas in a mainstream setting they would begin teaching component parts and sequence material in the opposite direction. Further, evidence demonstrates that: culturally based science curriculum improve student academic achievement and engagement; STEM competencies acquired by students are required for the mainstream workforce but also reinforce competencies within their own place-based knowledge systems; learning is more likely to be seen by students as relevant to their everyday lives, thereby promoting persistence; and science and mathematics class sizes tend to be smaller, creating more supportive community environments that better align with American Indian student comfort zones (Nelson-Barber, 2013: 12-14).

2.5 Summary

This overview of key developments in Indigenous STEM education reveals a complex picture for Aboriginal and Torres Strait Islander students. On the positive side, there is a substantial increase in engagement in STEM at university level, accompanied by fundamental shifts in the Australian school curriculum towards the inquiry pedagogy in science and integration of Indigenous perspectives, including in science. This is accompanied by best practice evidence calling for contextualised place based curriculum relevant to students' everyday lives, with the Primary Connections curriculum providing an example of a key resource that is being used effectively by schools in supporting these changes. More specifically there is also the best practice recognition for the teaching of Indigenous students to be delivered within a high expectations relational framework among the teacher, the student, the school, the family, and the wider community.

However, the evidence also suggests that schools need support in enacting high expectations philosophy, building meaningful relationships with Indigenous families and communities, and identifying strength based, high expectation programs that work. This is necessary to reverse the trends of the widening gap in ATAR achievement between Aboriginal and Torres Strait Islander and non-Indigenous students; and the ongoing two-and-a-half year gap in Indigenous student achievement in mathematics, literacy, and science. While the closing of the gap in Year 12 completions and improved transitions into work or further study is positive this needs to be complemented with greater effort in supporting students' transitions to university.

While working off a significantly more limited evidence base than Canada and the USA, Australian research supporting the value of TEK being integrated into school curricula, coupled with this international evidence, demonstrates the potential for change at the level of education systems resulting in greater engagement and achievement of Indigenous students in STEM. This is supported by international benchmarking exercises such as those undertaken by ACOLA which demonstrate that those countries with the most advanced and dynamic STEM systems have the smallest gaps in STEM performance, and have developed innovative policies to lift STEM participation from formerly under-represented groups.

In summary, the Indigenous STEM Education Project Theory of Change, which is firmly based on methods of academic excellence in curriculum development, cultural relevant pedagogies and content, high expectations extra-curricula engagement, and personalised support, is well supported by the literature. This strength based approach acknowledges the importance of closing the gap on key quantitative indicators such as PISA and ATAR achievement, and parity in enrolment and completions. Nevertheless, it prioritises a focus on building understanding of the pathways and processes of place and strength based interventions that lead to engagement and aspiration building and how these interventions can be scaled.

3 Evaluation findings

This section reports on the initial implementation and current status of each of the program elements and their contribution to the Theory of Change. It starts by looking at the project as a whole, followed by a discussion of each program element, and then finishes with an analysis of how the program elements address the key research questions. In particular, it focuses on the inputs, outputs, and short term outcomes identified in each of the program element program logics and references the KPIs negotiated with the funding body. The analysis draws primarily on the interviews with the current and former project directors and program element leaders as outlined in the research methodology. This then leads into Section 4 which identifies key findings as they relate to improving project CQI processes and implications for sustainability, curriculum reform, and policy implications in the Indigenous STEM education field.

3.1 The project as a whole

The former project director described the overarching project as an ambitious and authentic engagement with both science and mathematics education, and Indigenous education. It is premised on the understanding that there is now a very strong evidence base for what works in the mathematics and science education field that can be matched with what works in Indigenous education. This is important given the major national attention on STEM, and the prevailing view that we are falling behind in the international context. However, it is necessary to acknowledge that in terms of Indigenous education, a focus on STEM is still in its infancy in Australia.

The former project director consulted with a wide range of stakeholders in developing the project and was reassured that the scope and approach was sound. This engagement included the 2014 Aboriginal and Torres Strait Islander Mathematics Alliance Conference in Adelaide; the 2014 Australian Academy of Science Frontiers of Science symposium in Canberra; and the 2015 National Aboriginal and Torres Strait Islander Higher Education Consortium (NATSIHEC) Aboriginal Corporation National Caucus meeting in Brisbane. While these consultations reassured her on the design of the project, she identified numerous challenges to implementation. Firstly, the project's scope and scale – it is very large, goes across many states and territories, and covers many year levels. Secondly, she identified the inherent challenge in both key policy areas it addresses: STEM education and the challenge for Australia to be more competitive in this field; and Aboriginal and Torres Strait Islander education and how to support Aboriginal and Torres Strait Islander students so that they have the skills and inclination to pursue science and mathematics careers.

A further challenge identified by the former project director was attracting Aboriginal and Torres Strait Islander staff to the team. She noted that her initial goal was to have 50 per cent of the team comprised of Aboriginal and Torres Strait Islander people. With skilled Aboriginal and Torres Strait Islander professionals in science education in high demand and short supply, this proved too difficult to achieve. However, the senior Aboriginal leadership present in the I2S2 team, complemented by the depth of experience of the non-Indigenous members, coupled with the cultural mentors, patrons, and Steering Committee has resulted in the Aboriginal and Torres Strait Islander voice being strongly represented in the project.

Supporting this assessment, the current project director identified the key achievements to date as the ability of each of the program elements, particularly those which started as new programs, to become established, develop the resources necessary for implementation, and be well received by the relevant stakeholders. Collectively, this has resulted in the project meeting nearly all of the KPIs identified with the funder; and has set the project up well for its full implementation over the coming years. The two program elements that are behind in KPIs are those which commenced late due to the scale of the project requiring phased implementation – Science Pathways, which began in early 2016; and the Awards program, which commenced in the second half of 2016. The delay in the implementation of these two program elements, coupled with I2S2 requiring several interview rounds over an 18 month period to reach its full complement of staff, is reflected in a 30 per cent underspend in the project as of June 2016 (Project Report, June 2016).

Notwithstanding these challenges, the efficacy of the establishment of the project is captured concisely in the overall assessment of the project's progress in the most recent report to BHP Foundation (June 2016):

As all of the components of the STEM Education Project have been developed and the majority are now operational, there has been project footprint growth and increasing interaction and sharing among each of the project elements over the past three months. The project team is growing in confidence as a result of having established relationships with schools and communities, increased familiarity with the resources and programmes they are delivering, observed teacher performance improvements and increased student engagement, and the positive feedback received from project participants.

The dual focus of strong culture and academic rigour continue to guide the project with essential relationships being established with Aboriginal and Torres Strait Islander stakeholders, STEM professionals, universities and education jurisdictions. Robust systems and processes that will be scalable as the project grows have been, and continue to be, established.

Other key challenges identified by the current project director relate to the future sustainability of the project, and how the team might expand its footprint in the future while maintaining the quality and integrity of the individual program elements.

3.2 Science Pathways

Program Description:
Science Pathways contributes to the overarching goal of the project by using on-country projects as the context for science learning by primary and secondary school children in remote Aboriginal communities in the Northern Territory and Western Australia. The program seeks to increase school engagement and achievement, as well as attendance where it is poor, through supporting schools to develop curriculum and education plans that integrate western science and TEK.

The on-country projects are developed through strong community partnerships with Elders and, where they are active, ranger and mainstream research organisations.

Science Pathways has a substantial history through the Land and Learning Program of Tangentyere Council (see Section 2.4.2). This program has partnered with remote schools in central Australia since 1998, partly through the Northern Territory Department of Education's Indigenous Language and Culture Program (ILC). Science Pathways is using this program in three communities in the Northern Territory (NT) and as a model for six communities in Western Australia (WA) with a program leader in each state. The different jurisdictional contexts between the NT and WA, coupled with the uniqueness of each community, means the application and evolution of the model will have local variations. One of these key differences is the pre-existing nature of the program in the NT and its link to the ILC program, which provides an established entry point for integrating it into the school curriculum.

In contrast, the initial establishment in WA has had a strong focus on brokering formal partnerships between schools, local ranger organisations, and mainstream research organisations that operate on country (for example, Parks and Wildlife, Bush Heritage, EON, scientific researchers, universities, art galleries, and volunteer programs); and developing tailored plans allowing for the local differences between school plans and community aspirations for the education of their children. Another difference in emphasis is the WA program leader's emphasis on the Traditional Owners leading the program.

In contrast, the NT program leader identified that it is more the assistant teachers working in the schools who lead the program development, working with the Elders and other community members with the overarching support of the school principal. So while both emphasise Aboriginal leadership, in WA it is primarily external to the school, while in the NT it is both internal (teacher assistants) and external (working with the Elders).

Achievements: The Science Pathways Program was delayed in implementation, commencing in early 2016 with the employment of two CSIRO staff in WA and subcontracting the Tangentyere Council in the NT to employ the services of the person responsible for the development of the Land and Learning Program for four days a week. Its progress against its output and initial outcomes indicators identified in the program logic (see Appendix B1) is summarised in Table 1.

Table 1: Science Pathways summary progress against program logic and program delivery KPIs

INPUTS	OUTPUTS	EARLY OUTCOMES	KPIS (ACTUAL, YEAR 1, YEAR 2)
Staff – 2.8FTE (2 in WA and 0.8 in NT commencing early 2016) All three staff with remote experience in WA and NT respectively including Tangentyere Council Land & Learning program BHP Billiton relationships with communities I2S2 curriculum resources/ procedures	Development of agreements with 6 schools and key stakeholders Development of activity plans for schools commenced Resource development underway in these 6 schools On the job PD (teachers and teacher assistants) including plans to develop formal TPD program I2S2 curriculum resources/ procedures investigated but not required at this stage 5 on-country activities conducted All on-country activities linked to subsequent class lessons and some included lessons prior to commencement	Strong effective partnerships established with initial schools and other stakeholders Collaborative development of education resources commenced but not yet constituting "a cohesive community based curriculum" Linkage between Western STEM knowledge and cultural knowledge and practice commenced (WA) and extended (NT) Teacher capacity building key focus including assistant teachers Attendance at on-country activities high (some schools already have high attendance) with high engagement and positive anecdotal learning outcomes Some communities prioritising curriculum linkages with Training and Employment pathways	**Actual (June 2016)**: Operating in 6 schools (3xNT and 3xWA), 8 teachers, 12 teacher assistants and 57 students as of 30 June 2016 **KPIs Year 1 (Sep 2014 - Sep 2015)** Operating in Phase One communities (3 communities, 3 schools, 6 teachers, 6 teacher assistants, 75 students) Phase Two & Three communities selected (6 communities) Comment: Achieved except for students **KPIs Year 2 (Sep 2015 - Sep 2016)** Operating in Phase One, Two & Three communities (9 communities, 9 schools, 18 teachers, 18 teacher assistants, 225 students) Evaluation shows improved capacity of teachers and teacher assistants School assessment shows improved student results in science and language At least 3 schools entered in Excellence Awards **Comment**: Phase Three schools due to commence early 2017 and expect teacher and student targets to be met. Program monitoring and evaluation data expected in latter half of 2017 re teacher capacity and student results. Awards program delayed and expect target to be met in 2017. Delays in implementation of Science Pathways, Awards and Evaluation impacting these KPIs.

Due to these delays, this program is still in its establishment phase and the current level of engagement is below the initial targets. With a number of schools yet to undertake specific activities, including three schools in Western Australia that are still negotiating participation in the program, these targets are expected to be reached in early 2017. Not surprisingly, in contrast to the other program elements which have met all or nearly all their initial output indicators, Science Pathways still has significant progress to make in finalising agreements with schools and key stakeholders in WA. Development of activity plans and resources is well underway for initial schools with several examples of on-country activities taking place with preparatory and/or follow up classroom activities. In both states, on-the-job teacher professional development (TPD) is occurring although WA has decided to develop a formal TPD program in 2017 to support the implementation of the model in these schools. While some of the I2S2 support resources (such as assessment rubrics and multimodal assessment techniques) are informing the Science Pathways curriculum development, the richness of the local TEK means that the I2S2 inquiries in themselves are not being used as a significant source for curriculum content.

In regards to short term outcomes, there is positive evidence in the six schools where activities have commenced – Areyonga (NT), Mt Liebig (NT), Haasts Bluff (NT), Warralong (WA), Wiluna Remote Community School (WA), and Leonora (WA) – for nearly all of the identified short term outcomes, specifically: effective partnerships, development of tools and learning resources, building teacher capacity (both teachers and Aboriginal assistant teachers), student attendance and engagement, and articulation with employment pathways.

As an example of effective partnerships, student attendance, engagement and articulation with employment pathways, the WA program leader outlined the partnership building process at Warralong where the project team has been successful in accessing a bilby researcher at the Department of Parks and Wildlife. The main bilby populations largely coincide with Aboriginal-managed lands which is seen by the community as evidence of the effectiveness of Aboriginal traditional land management practices. By brokering the engagement of the Department of Parks and Wildlife, and the Community Development Employment (CDEP) Project in Ashburton, the team are developing a bilby focussed Science Pathways project with strong community engagement.

An excellent example of teacher professional development was the NT Department of Education Western Desert Languages Networking meeting – a two-day workshop attended by an assistant teacher, teacher-linguist, and five Elders from Areyonga; two assistant teachers from Haasts Bluff; five assistant teachers and two elders from Mt Liebig; a Pintupi Luritja linguist; the Languages Consultant officer for NT Department of Education; and the NT program leader. This meeting shared and discussed the ILC teaching resources and practices the teachers have developed. Mt Liebig teachers modelled lessons and resources in the classroom; and the teachers developed new resources with input from the elders present and the linguist. There was a strong focus on learning about country, plants, and animals. The NT program leader noted her attendance at many such workshops over the years; and she identified that this one was particularly effective, partly due to the strong program at Mount Liebig, the modelling of lessons by Mt Liebig assistant teachers contributing to a great exchange of ideas, and the development of new resources.

Both Science Pathways program leaders identified student engagement as a feature of the program, noting that those students who are a lot less engaged in the classroom will sometimes transform when they go 'out bush'. Having worked in schools in remote communities in Central Australia since the late 1980s, the NT program leader noted that students better understand concepts when they are presented in their own language; and are much more likely to listen and understand when Indigenous Elders, rangers, or assistant teachers are talking. Further, schools work better, and attendance is higher, when there is strong community involvement in the school, such as in the Science Pathways program. The NT program leader also identified the uniqueness of the program as being the only program supporting science in remote community schools in Central Australia; and its being beneficial for the classroom teachers as it supports the development of their knowledge of local ecology and the development of resources on the arid zone for schools. Other resources often focus on the forests, woodlands, and the coast.

Other examples included a fish monitoring project in Warralong, which generated a dramatic increase in attendance with students who had not been to school all year participating in the on-country learning part of the program. The WA program leader noted that teachers who had been reserved were now convinced of the value of the approach and are keen to continue with it. Fish anatomy was studied prior to the project using resources developed by the Science Pathways team, and afterwards the class conducted analysis of the data collected. While integration with classroom activities is central to the operation of the ILC program in the NT, the WA program leader acknowledged that there was still a substantial amount of work to be done to better integrate on-country activities with classroom learning.

The WA program leader also highlighted the empowered Traditional Owner group at Wiluna who have, with the support of the Central Desert Native Title Service, strongly engaged with the program and identified TEK projects with which the school can work. A key strength of the community is proximity to an Indigenous Protected Area (IPA), which has many science activities that involve both western science and TEK. In the view of the WA program leader, this is providing the bones of a good program which has identified several different on country projects planned for the rest of the year. An example of this was students viewing a wedge-tailed eagle trap which led to classroom research on the radio tagging of wedge-tailed eagles, including investigating relevant websites which identify where they have flown to, and thereby enable the students to gain an appreciation of their amazing range.

School leadership was identified as critical by both Science Pathways program leaders. Multiple priorities for schools can easily impact on programs. One example is related to a school originally approached in the NT, who had a long history of working with Tangentyere Council, which declined to participate because of its focus on implementing Direct Instruction. In contrast, one of the participating schools is running Science Pathways in the afternoon, having dedicated the morning to the implementation of Direct Instruction. Both Science Pathways program leaders identified the key challenge of staff turnover at schools, particularly in the context of the program being voluntary, with the building of relationships being central to success.

The WA program leader identified that the team has found a lot of goodwill for the concept but also some reluctance from key school personnel such as teachers who have not experienced working remotely before or those who have not considered the value of building curriculum around on-country projects. The WA program leader suggested that program efficacy requires "strategies and a change process, and making time for that to happen… in the classroom, in planning, in getting out to the community, in working out [and in] overcoming barriers… within the community". Science Pathways has engaged the services of a consultant who is working with school leadership teams through a leadership and change management mentoring process as a part of the implementation of a two-way science curriculum.

Summary: Science Pathways was delayed in its implementation resulting in its lagging in meeting initial school, teacher, and student implementation targets (although these look set to be achieved early in 2017). It is well on the way to achieving its initial outputs in accordance with its program logic. Development of agreements and activity plans are completed or well underway for the initial schools engaged, as is initial resource development for on-country activities. In regard to short term outcomes, there is firm evidence of the development of strong effective partnerships established with schools and other stakeholders; however it is too early to demonstrate that these are resulting in the desired development and implementation of a cohesive community based curriculum and associated learning resources. While the Western Desert Language meeting and the Warralong fish project are examples of Science Pathways' development of tools and learning resources for on-country science activities, it is again too early to assess effectively whether this is part of a systemic approach in schools to clearly identify where western STEM knowledge and practice complements traditional cultural knowledge and practice. Similarly, there are initial positive indications that teacher (including Aboriginal assistant teacher) capacity in two-way science content, teaching skills, and attitudes are being positively impacted; however, it is unclear at this stage how the monitoring or evaluation component of the project will seek to systematically measure these changes. A key challenge for the program element will be the establishment of structures and processes for maintaining these partnerships, which are critical for the program element's success, over the long term given the voluntary nature of the program.

3.3 Inquiry for Indigenous Science Students (I2S2)

Program Description:
The Inquiry for Indigenous Science Students (I2S2) contributes to the overarching program goal through the development and implementation of Indigenous inquiry resources targeting middle school students (Years 5-9) 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 to allow Aboriginal and Torres Strait Islander students to demonstrate their cognitive science skills through a diversity of modalities that are not necessarily dependent on literacy skills. An Aboriginal led team has developed the hands-on inquiry-based projects based on traditional Indigenous knowledge and explicitly linked this to the Australian science curriculum through the engagement of a professional curriculum writer as well as being independently reviewed for their Indigenous content. With the inquiries being delivered as part of the school's formal science curriculum, a primary role of the I2S2 team is to train science teachers in its delivery and in broader Indigenous cultural awareness relevant to its implementation. By providing high quality and culturally-relevant Indigenous science inquiry consistently over the middle years of schooling, it is envisaged that the numbers of Aboriginal and Torres Strait Islander students choosing science and mathematics subjects in Years 11 and 12 will increase; their overall performance in these subjects will improve; and the number of students who pursue STEM pathways into university and the workplace will be enhanced.

Achievements: I2S2 was one of the first programs of the Indigenous STEM Education Project to become operational commencing in Term 3 of 2015. Its progress against output and initial outcomes indicators identified in the program logic (see Appendix B) are summarised in Table 2.

Table 2: I2S2 summary progress against program logic and program delivery KPIs

INPUTS	OUTPUTS	EARLY OUTCOMES	KPIS (ACTUAL, YEAR 1, YEAR 2)
I2S2 program leader designed program based on his experience as both a teacher and an Indigenous student, as well as the literature, to address identified gaps in Indigenous education Existing evidence on pedagogy especially science inquiry Indigenous leadership of program development	Three recruitment rounds leading to building of experienced Indigenous (3 FTE) and non-Indigenous (5 FTE) delivery team Series of jurisdictional, regional, and school levels meetings recruited 45 schools into the program Resource development (hands on scientific inquiries with indigenous context) for Years 5, 6, 8 and 9 developed including alternative assessment methodologies TPD program developed and implemented including classroom observation by I2S2 staff Wikispace developed for sharing resources Variable engagement by schools with 'community' (Indigenous education workers, school 'aunties and uncles', parents, and relevant Aboriginal organisations (e.g. land councils)	Program monitoring data showing improved student engagement and results* No data available on student aspirations and plans for subject selection in Years 10 to 12, but improved results a positive indicator for potential increases in participation Program monitoring data showing improved teacher capacity to deliver indigenous focused inquiry units* (*Jurisdictions, schools, and teachers are being asked for permission to make this program monitoring data available to the evaluation; and, if forthcoming, this will be reported on in the next evaluation report)	**Actual (June 2016)**: 45 schools in 10 clusters across three States: Queensland, (Brisbane, Logan, Cairns, Mackay, and Rockhampton); New South Wales (Muswellbrook, Gunnedah, and Quirindi) and Western Australia (Port Hedland and Newman). 156 teachers being trained in the delivery of the inquiry units reaching 1,312 Aboriginal and Torres Strait Islander students across 209 classes. **KPIs Year 1 (Sep 2014 - Sep 2015):** Phase One schools' personnel training undertaken (28 schools, 56 teachers, 700 students) Phase One customised resources and work plans developed for all schools and clusters **KPIs Year 2 (Sep 2015 - Sep 2016):** Operating in Phase One schools (56 schools, 112 teachers, 1400 students) Evaluation shows improved capacity of teachers in science and school assessment shows improved student results in science 10% participation in other program elements **Comment**: School KPIs are slightly lower due to decision from the pilot to stay with the schools for the duration of the program recognising they required ongoing support. Teacher KPIs were exceeded and student KPIS very close to being achieved owing to recruiting more classes within the existing schools.

Secondly, recruiting and training a highly skilled Indigenous and non-Indigenous I2S2 team was not straightforward, taking three recruitment rounds over 18 months to build to its full complement of seven staff. While the I2S2 program leader's networks assisted in the recruitment of several strong Aboriginal staff, he was unable to reach his target of 50 per cent of the team being Aboriginal or Torres Strait Islander. With building teacher capacity a critical success factor, he was clear that his team needed to role-model a good balance of strong Aboriginal leadership and non-Indigenous teachers being confident in the implementation of the program. With the vast majority of teachers of Aboriginal and Torres Strait Islander students being non-Indigenous, both these features are of critical importance. The deputy I2S2 program leader also spoke of the intensive training of the I2S2 staff both in inquiry pedagogy and cultural perspectives, of new staff shadowing established staff, and of her and the program leader's expectations being clearly reflected by their staff in the schools.

Thirdly, the development of the inquiries and supporting resources with four currently completed (Years 5, 6, 8 and 9) and the Year 7 inquiry under development. The Year 5 inquiry, 'What's Cooking', looks at traditional cooking methods of Aboriginal and Torres Strait Islander people, in particular roasting on hot coals; baking in ashes; steaming in a ground oven; and boiling. The science understanding developed using this context is states of matter (solid, liquids and gases), and their observable properties and behaviour (CSIRO 2016a: 2, 7). The Year 6 inquiry, 'Let's Stick it Together', looks at the use of plant resins by Aboriginal and Torres Strait Islander people for making adhesives, waterproofing, burning as a torch, and strengthening joints. The science understanding developed using this context is reversible and irreversible changes including the changes in states of matter (CSIRO 2016b: 8-9). The Year 8 inquiry, 'Fire. A Burning Question', looks at traditional fire starting methods such as the hand drill and fire saw methods. The science understanding developed using this context is energy forms, energy transfer, energy transformation, and energy chains (CSIRO 2016c: 2-5, 9). The Year 9 inquiry, 'Burn and Grow', looks at a subset of the diverse uses of fire by Aboriginal and Torres Strait Islander people namely promoting the growth of particular plants for medicines and food, providing suitable habitat for herbivores, and managing the environment. The science understanding developed using this context is ecosystems, abiotic factors, and matter and energy flow (CSIRO 2016d: 2, 8).

Extensive material was developed to support the inquiries in recognition of how time-poor teachers are. These include suggested learning experience documents, assessment rubrics, enhanced ICT (Student Inquiry eBooks & Vocabulary eBooks), multimodal methods of assessment, teacher supported PowerPoint slides, and the I2S2 Wikispace. In particular, teachers involved in the pilot program have commented very positively about the expansion of the suite of support materials. There are high levels of usage of these resources. For example, the Wikispace platform, designed to deliver all I2S2 resources and materials used for the implementation of the inquiries has 193 registered users, primarily I2S2 teachers and support staff.

A key highlight identified by the I2S2 program leader in a recent program report was how the inquiries are addressing an acknowledged gap in the Australian Curriculum by successfully embedding Aboriginal and Torres Strait Islander people's histories and cultures into the curriculum strand of Science Inquiry Skills. Aboriginal and Torres Strait Islander community feedback has been critical of this gap and the potential perception by non-Indigenous Australians that Aboriginal and Torres Strait Islander people are not capable of science inquiry.

Fourthly, the development and delivery of an I2S2 Teacher Professional Development Program. The deputy I2S2 program leader relates how one of the initial challenges of implementation was the quantity of TPD. On one hand the I2S2 program leader was coming from the perspective of the demands on teachers in doing out of hours PD (usually after school) and proposed four one-hour sessions. In contrast, the deputy leader's previous role saw the creation of a four day professional development module addressing Indigenous education issues including the incorporation of Indigenous perspectives into the curriculum. In the end they compromised at eight hours, while also instigating additional teacher supports including class visits, where I2S2 coordinators support teachers by modelling, team teaching, observing, and providing feedback or planning with the teachers. After the initial eight hours, teachers receive a further four hours support when learning a new inquiry.

Critical to both the I2S2 program leader and deputy's assessment of successfully implementing the program was the learnings from the initial pilot and acting on these learnings. The pilot showed that eight hours of PD is not sufficient to expect that teachers will deliver the inquiry as demonstrated. Given the curriculum was written by a professional curriculum writer, it was initially believed that teachers should be able to effectively deliver the inquiries. In many cases this was not the case, as teachers did not fully understand the inquiry. The pilot also revealed a number of related challenges which are often exacerbated in regional areas. Issues affecting teacher capacity include: many teachers are not science specialists; do not understand Indigenous Australia; do not have Indigenous science content knowledge; do not have ICT expertise; and do not have familiarity with alternative assessment modalities. On the positive side, the pilot confirmed the value of the inquiry pedagogy and the Indigenous curriculum, as well as the key focus on building teacher capacity.

This led to an early critical change in the model to commit to ongoing TPD over the duration of the program rather than a primary focus in the initial year. As outlined by the deputy I2S2 program leader this allows incremental skill development and building capacity over successive years, including the development of additional resources to allow two inquiries per year rather than one, effectively doubling the students' exposure to Indigenous inquiry each year. The deputy I2S2 program leader identified that this, in combination with the program focusing on a specific subject and class range, is providing a substantial opportunity for I2S2 to demonstrate the 'natural fit' between science and Aboriginal and Torres Strait Islander perspectives, allowing a truly authentic product.

In addition to these four program outputs, I2S2 initial outcomes are also encouraging. I2S2 has developed a robust monitoring process of collecting student engagement, attendance, and results pre- and post- the implementation of the inquiries with the agreement of the schools involved in the program, as well as pre- and post- teacher data prior to the TPD and after the implementation of the inquiry. While initial analysis of this data is promising, delays in establishing the evaluation processes for the Indigenous STEM Education Project has meant that the appropriate consents (CSIRO ethics committee, jurisdictional, principal, and teacher) have not yet been gained for such program monitoring data to be made available to the evaluation.

In addition to this quantitative data there is also some strong anecdotal evidence from teachers for the effectiveness of the PD in building teacher confidence and skills. The deputy I2S2 program leader related the story of a nervous teacher at the beginning of the PD training saying "… it's Indigenous… I don't want to offend people", as well as expressing her concern over her mastery of inquiry. However, after the training she went back to her class and conducted the inquiry effectively and was thrilled with the engagement of her students. The deputy I2S2 program leader also spoke broadly of I2S2 staff talking about the realisation by teachers of the value of Indigenous content in engaging their students, and gaining the confidence to deliver this and the inquiry methodology effectively.

Similarly, the feedback is positive with regard to the pride and self-confidence experienced by Aboriginal and Torres Strait Islander students seeing their culture strongly valued and central to the curriculum. For example, one student spoke of his pride in the content of the inquiry being from his culture, and his belief that he could be a scientist when he grows up.

Another key factor that is central to the program logic is the aim that over time teacher capacity will be built in the ability to form relationships with the local Aboriginal and Torres Strait Islander community in order to provide a local context for the inquiries. Further, it is hoped this will extend beyond the I2S2 inquiries and into other science curriculum content at participating schools (and potentially into other subject areas). While the deputy I2S2 program leader related examples of this already happening, it is unclear as to the extent of schools achieving this objective at this stage. While this is identified in the program logic as an 'output', its importance in contributing to the local contextualisation of the inquiries coupled with its dependence on the effectiveness of the PD in building this capacity and commitment of teachers would be better conceived as an outcome rather than an output.

The other short term outcome of students thinking about subject choice in Year 10 for Years 11 and 12 seems overly ambitious to measure at this early stage, with only a small cohort having moved into Year 10 and only having experienced one inquiry in the previous year. Data collection methods will be developed to effectively quantify this impact.

Summary: I2S2 commenced with a successful pilot and is now in its implementation phase. The pilot resulted in some key changes to implementation, in particular the decision to commit to ongoing capacity building within recruited schools for the duration of the project. This change recognises that the challenges of delivering effective Indigenous inquiry requires capacity building of teachers over a longer timeframe. All program outputs have been achieved with the exception of the schools localising inquires through the building of relationships with local Aboriginal communities which, as discussed above, would fit better in the outcomes part of the program logic. A key highlight has been the acknowledgement by the Indigenous Committee of ACARA and others of how the inquiries address an important gap in the Australian Curriculum. Initial outcomes are encouraging although they demonstrate the need for the implementation of consent processes to allow monitoring data to be made available to the evaluation as well as the development of more in-depth evaluation methods.

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

Program Description: ASSETS contributes to the overarching project goal by supporting high achieving and/or aspirational Year 10 students with an interest in science and mathematics to explore the study and career options available to them in STEM fields. This is achieved through participation in a nine-day residential summer school at the end of Year 10, followed by a two year leadership and support program in Years 11 and 12. The three key components of the summer school are a rigorous academic program prioritising inquiry approaches to learning; a strong focus on personal development, including raising aspiration and self-belief and building an understanding of the diversity of, and pathways to, STEM careers; and an integrated overarching cultural program. During the summer school, STEM professionals share their experiences and discuss study and career possibilities. Students complete a group inquiry project and present their findings at the closing ceremony. Students experience a rich cultural environment allowing them to reflect on their cultural identity, guided by a strong cultural program overseen by a local cultural patron, with Aboriginal and Torres Strait Islander mentors and leaders acting as role models throughout the school. After the summer school, the leadership and support program supports students through Years 11 and 12 to develop leadership skills, access work placements, and tertiary education opportunities.

Achievements: ASSETS is a long running program which was established by the University of South Australia in the early 1990's and ran intermittently in Adelaide (subject to funding) between 1992 and 2013 with various partners including the Australian Science and Mathematics School. In 2014, the management of the ASSETS program was integrated into the Indigenous STEM Education Project. The 2014 ASSETS program was a transitional year with CSIRO staff involved for the first time, learning about the existing model – a single residential summer school in Adelaide. In 2015, it was expanded into three summer schools and a two year leadership program for alumni of ASSETS. Its progress against output and initial outcomes indicators identified in the program logic (see Appendix B.3) are summarised in Table 3.

Table 3: ASSETS summary progress against program logic and program delivery KPIs

INPUTS	OUTPUTS	EARLY OUTCOMES	KPIS (ACTUAL, YEAR 1, YEAR 2)
Staff (3FTE) Pre-existing model for summer school Academic providers, CSIRO, and university STEM professionals University support resources at summer school sites (e.g. cultural patrons and Indigenous units) Accommodation providers Regional BHP Billiton careers experience	CSIRO staff inducted into ASSETS model in Adelaide Dec 2014 with 28 participants Model further developed and expanded to 3 sites in Townsville, Newcastle, and Adelaide with local universities as academic partners in Dec 2015/Jan 2016 with 98 participants Strong academic, cultural, and personal development components with 47 STEM professionals attending the 'Meet a STEM Professional' sessions, an additional 40 interacting with students through academic activities, and the cultural program overseen by a senior cultural mentor from the partner university Leadership program delayed in development due to resourcing issues but includes Facebook page, networking opportunities, and development of work placements through the SMiS program arranged for 10 students and 20 more under development.	Strong anecdotal evidence for high levels of engagement in ASSETS summer schools, increases in aspiration and confidence in pursuing STEM career, as well as better understanding of STEM career pathways Strong anecdotal evidence for greater confidence in cultural identity and the relevance of culture for STEM career Leadership and support program still in development Awards program delayed and lack of data to measure participation in other science programs	**Actual (June 2016)**: 28 participants at inaugural ASSETS summer school in Adelaide in Dec 2014 and 98 participants attending 2015/16 ASSETS summer schools in Adelaide, Newcastle and Townsville, representing schools from all states and territories **KPIs Year 1 (Sep 2014 - Sep 2015):** Summer schools 3 locations confirmed Leadership program commenced (5 mentors, 90% of summer school students participating) **KPIs Year 2 (Sep 2015 - Sep 2016):** Summer schools held in 3 locations (100 students) Leadership program operating (20 mentors, 90% of eligible students participating) 60% of students in placements and 10% student participation in other program elements School assessment shows improved student results in science and mathematics **Comment**: Core KPI of summer school participation met. Delays in establishing leadership program result in placement targets not being met. Delay in Awards prevent participation until late 2016. Absence of monitoring framework and delays in evaluation mean no data available re improved results.

The critical initial implementation outputs were developing a sound understanding of the summer school in the transitional year, expanding this from one to three sites including the engagement of multiple partners required to run a successful summer school, and the development of the leadership and support program. The former ASSETS program leader described the magnitude of these first two tasks:

Recruiting so many students, working with so many venues, STEM professionals and cultural providers, working with local cultural patrons, with the mentors, dealing with 100 families, negotiating travel and all the related logistics, and then the additional layer of working with all of the CSIRO systems – the sheer complexity of it all gave a great sense of accomplishment.

One hundred and nineteen applications were received for the 105 places in the 2015/16 summer school. Late withdrawals due to personal issues resulted in 98 participants attending ASSETS summer schools, representing schools from all states and territories.[3]

3 Note that the 1 ACT school participant in 2015/16 resides in NSW hence the zero for ACT in Table 4 for 2015/16.

There was strong engagement from STEM professionals across the three summer schools and all three camps appeared to have a strong locally based academic and cultural program. In Adelaide, the academic program was provided by the University of Adelaide and CSIRO Food and Nutrition at the South Australian Health and Medical Research Institute. The cultural program was developed in conjunction with cultural patron, Professor Peter Buckskin from the University of South Australia, and Wiltja Boarding (an experienced Indigenous accommodation centre that has worked closely with ASSETS in its previous operations) where the students were accommodated. As CSIRO staff were impressed with the quality of student support provided by Wiltja Boarding, the services of one of their youth workers was secured to provide individual student support in the two other summer schools. In Newcastle, the academic program was provided by the University of Newcastle and the CSIRO Energy Centre. The cultural program was developed in conjunction with cultural patron, Professor Peter Radoll from the University of Newcastle, and the Wollotuka Institute at the University. In Townsville, the academic program was provided by James Cook University and CSIRO Land and Water, and was hosted at Mungalla Station. The cultural program was developed in conjunction with cultural patron, Professor Yvonne Cadet-James from James Cook University, and the School of Indigenous Australian Studies at the University.

Table 4: Gender & state of residence of ASSETS participants

	2015/16 PERCENT (N=98)	2016/17* PERCENT (N=105)	NATIONAL PERCENT (ABS, 2013)
Female	53	66	
Male	47	34	
ACT	0	2	1
NSW	19	27	31
NT	4	5	10
QLD	46	39	28
SA	4	4	6
TAS	5	1	4
VIC	3	6	7
WA	18	17	13

It is worth noting this expansion of the program is quite impressive in the context of the numbers indicated in Section 2.2.2. Using the 2014 figures of Year 12 students receiving an ATAR of 50 or greater (1,110) and applying the 9.5 per cent of Indigenous students choosing STEM subjects at university, gives a figure of 105 students.

Assuming a similar cohort size coming through in subsequent years, ASSETS notionally needs to attract every Aboriginal and Torres Strait Islander student that is on track for a 50+ ATAR score and likely to be considering studying STEM to fill its places. Evidently, ASSETS is also attractive to medical students; but the challenge to fill the vacancies is indicative of the enthusiasm of the student cohort and the effectiveness of the ASSETS team in their promotion of the program across the country. This is reinforced in the application figures for the 2016-17 summer schools which have seen an increase from 119 to 175. Analysis of the student applicant data shows the program is also meeting its participation outputs of being a national program with participation from all states and geographic areas (see Table 4), although an overrepresentation of students from Queensland, and to a lesser extent Western Australia, is evident in both years, as is a corresponding underrepresentation from New South Wales in 2015/16 and Northern Territory in both years. What is encouraging is the robust representation from remote and very remote regions given the disproportionally poor education outcomes from these areas (see Table 5).

Table 5: Geographical region of ASSET participants

	2015/16 PERCENT (N=98)	2016/17* PERCENT (N=105)	NATIONAL PERCENT (ABS, 2013)
Major Cities	25	20	35
Inner Regional	18	42	22
Outer Regional	34	21	22
Remote	5	9	8
Very Remote	18	9	14

The workload required of the three ASSETS staff to expand from one to three summer schools has meant that the third key output of the leadership program was not fully developed for the 2015/16 cohort. In particular, the development of the work placement program has been ongoing with a particular highlight being its development in partnership with SMiS. Other leadership and support program activities include a Facebook group that has been used to continue to engage with students regarding opportunities, and information and in person catch up events for Townsville in June in conjunction with James Cook University. Wikispaces for students, support teachers, and families is being developed to provide access to useful information and opportunities, including a calendar of events and key dates.

Turning to short term outcomes, both ASSETS program leaders felt the summer schools delivered successfully on the academic, cultural and personal development components; and this was confirmed in their discussions with other staff, mentors, cultural patrons, and STEM professionals. They identified the depth of the academic component including that all the students were engaged in hands on, Indigenous knowledge-based science inquiries including utilising 'Fire – A Burning Question' developed by I2S2, as well as conducting their own science inquiry projects with the academic partners of each summer school. This culminated in small groups giving a formal presentation about these projects at the end of the summer school. Similarly, the current ASSETS program leader identified that in all three summer schools the "cultural components were always the first aspect of the program that students would refer to and the fact that they're proud Aboriginal, Torres Strait Islander students".

In regard to personal development, both ASSETS program leaders identified the intense nature of ASSETS having deep effects on student self-belief and self-esteem. In particular, the development of an Aboriginal and Torres Strait Islander peer network who have an interest in both traditional Indigenous and western science knowledges was seen as particularly valuable. Similarly, the students' experience of the group presentation, their appreciation that, 'Wow, we actually did that!', and the affirmation of a cultural patron saying they "look like first year university students" had a visible impact on the students' sense of self-belief and aspiration.

These positive assessments on academic, cultural and personal development is confirmed by student feedback, including the following posts on the ASSETS Facebook page:

"The best 9 days. I recommend this trip to anyone and everyone eligible. You meet the absolute greatest people, make the best friends and learn things about yourself and culture you had no idea existed. These people made my week the best week of my life so far and I am forever grateful…."

"I will be forever thankful to everyone who was involved with the ASSETS program as it has changed me for the better. Just thought I would let you know that I talked to my parents about going to uni on the mainland and we are already looking at different options so thank you for making me realise that I was limiting myself by not looking at all of the options I have."

Similarly parental feedback indicates enhanced academic, cultural and personal development outcomes:

"[My daughter] was blown away by the strong bonds she formed in such a short time and felt she gained valuable cultural knowledge that she will be able to build on in the future."

"Just watching him be himself academically and socially with his 'new' brothers and sisters from the summer school filled my heart with excitement and awe that he's on his way to finding his purpose in life…. I am pleased with the guidance of people like Aunty Bronwyn and Uncle Peter that were able to get in touch with their inner elders to help them discover who they are…. "

The other short term outcomes in the ASSETS program logic are success in STEM subjects in Years 11-12, and participation in the Awards program, CREST, BHPB Science and Engineering Awards. The demands of organising the second ASSETS summer schools and the evolution of the leadership and support program, have meant monitoring student success in Year 11 and encouraging participation in the Awards, CREST and the BHPB Science and Engineering awards has not yet been prioritised. With the delay in the establishment of the Awards program, it is also too early to measure ASSETS students' engagement in it.

In summary, there is abundant anecdotal evidence supporting the effectiveness of ASSETS in regard to the three key strands of academic, cultural, and personal development. However, the key challenge for ASSETS is the development of monitoring and evaluation methodologies that quantify these benefits for their future study and career trajectories. This is particularly challenging in the absence of a clear baseline or comparative cohort, although mapping their pathways through Years 11 and 12 (including their participation in external science programs) is an important component.

A challenge for the team was their self-identified lack of evaluation expertise, and while they developed a pre- and post- questionnaire for the 2015/16 summer school they subsequently identified several design flaws. With the delay in the establishment of the evaluation component of the program, the appropriate consents have not been obtained for this information to be included in this report. In order to help establish a monitoring framework for ASSETS, the former program leader tapped into a partnership that CSIRO has with the United States Worcester Polytechnic Institute. Four students, spent three months with the ASSETS team identifying similar residential programs for minority populations across Australia, the US, and New Zealand. From the 30 programs identified, staff from 16 were interviewed and they determined the five most common aims were to:

- increase student awareness of Indigenous culture and STEM career options;
- develop students abilities in STEM;
- heighten student STEM career aspirations;

- increase students' self-confidence in cultural identity and STEM ability; and
- aid students in the development of a social community of Indigenous STEM students (Adie, Bozzuto, Laudage & Pachucki 2016: iv).

The ASSETS team are now working with the research coordinator to develop evaluation methods which will include techniques to quantify the impact of ASSETS being cognisant of these five common aims. However, this will not be able to alter the missed opportunity for more rigorous monitoring data from the 2015/16 summer school.

Another key challenge identified by the current ASSETS program leader is the differences in regard to the approach to the cultural component in the summer school that has emerged in recent discussions with the Indigenous units at the partner universities. While Aboriginal staff from I2S2 provided support and attended ASSETS, the cultural program is highly reliant on the cultural patrons and providers in each location. Following the principle of developing a program based on local leadership, the Indigenous units from the three partner universities have provided the leadership for the cultural program at each summer school. The significant restructure of these units has increased the likelihood of a significant change in approach in at least one of the sites, creating potential challenges for non-Indigenous ASSETS staff to negotiate. Some of these challenges include how to explore cultural identity in a safe manner, particularly given the diversity of Aboriginal and Torres Strait Islander peoples across Australia; the skills required of staff to manage issues that may arise from these discussions; and the implications for ongoing support that students may require. This is expected to see a differing emphasis in the summer schools on the degree of emphasis in the cultural program on 'cultural engagement' activities on the one hand and exploring the epistemological similarities and differences between Aboriginal and Torres Strait Islander and Western approaches to knowledge on the other.

Summary: The successful expansion of the ASSETS Summer School from one to three sites more than tripling the number of participants is a significant result. All program logic outputs were met in relation to the summer school; however, the leadership and support program is still being developed, and the program is yet to develop a credible monitoring framework. Anecdotal evidence for the success of the summer camp is abundant, but the key challenge is to develop a more rigorous monitoring and evaluation process to include quantitative measures of the program.

3.5 PRIME Futures

Program Description: PRIME Futures contributes to the overarching goal through the delivery of YuMi Deadly Maths (YDM), a cohesive mathematics pedagogical framework covering all strands of the Australian Mathematics Curriculum developed and delivered by the YuMi Deadly Centre (YDC) at the Queensland University of Technology. It adopts a systemic approach to changing the whole school, working with the principal, or other senior leader, and a core of teachers in a train-the-trainer model. Each semester, over a period of two-and-a-half years, the program runs a three-day Teacher Professional Development session (five in total) for selected teachers, identified as trainers, skilling them in the YDM pedagogy.

As outlined in Section 2.4.2, a key part of the YuMi Deadly Maths approach is for teachers to apply the Reality, Abstraction, Mathematics, Reflection (RAMR) model developed by Aboriginal mathematician Chris Matthews. Another key part is the focus on deep learning of powerful mathematics ideas, which requires a focus on training teachers to see connections between mathematics ideas, to sequence from one idea to the next, and to focus (where possible) on 'big' ideas as part of a high expectations methodology. Schools are grouped together in clusters with the selected teachers from each school undergoing the TPD together and forming a community of practice. This community of practice is supported through an online learning platform for teachers to share lessons and insights, and an annual two-day face-to-face sharing forum.

Teachers first implement the program in their own classroom and then train other teachers in their school in the pedagogy. In addition to the TPD, the program includes a community visit at the beginning of the program to assist in building the relationship between the Aboriginal community and the school, with the TPD emphasising the importance for teachers to use that relationship with community members to develop curricula that is relevant to their students' everyday lives. Each semester also includes a visit to each school in the cluster focused primarily on engaging the principal and key staff to set up a school plan that facilitates the implementation of the YDM model, in particular supporting the teacher-trainers with training their colleagues in the pedagogy and identifying the structures and processes to build the relationship with the local Aboriginal community to develop localised curriculum content.

Achievements: Phase One of the program has successfully implemented the outputs identified in its program logic (see Appendix B.4) with positive data for its initial outcomes, as summarised in Table 6.

This implementation includes the engagement of schools, teacher trainers and Aboriginal and Torres Strait Islander students across two Queensland clusters of schools located in the Emerald/Blackwater region and Townsville. Local community Elders have been engaged to support the Indigenous perspectives and cultural workshop sessions in the first two PD sessions.

Phase Two schools have been confirmed, with two new clusters in Queensland (Clusters 3 and 4) and two in South Australia (Clusters 5 and 6) comprising of 30 schools with approximately 2,054 Aboriginal and Torres Strait Islander students.

Clusters 3 and 4 have completed their first TPD, with Clusters 5 and 6 to complete their first TPD in Term 4 2016. Planning has commenced for the initial school visits for the Phase Two schools.

The first sharing summit which the PRIME Futures schools can attend is scheduled for late October 2016.

A substantial innovation with the implementation of PRIME Futures is an increase in emphasis on the cluster remaining after the two-year program. The team has introduced a fifth, three-day TPD at the end of the two years to develop strategies as to how the school will keep the program going. It is also the first time that they have been resourced to undertake research into the effectiveness of the model resulting in regular teacher and principal surveys generating valuable data.

Table 6: PRIME Futures summary progress against program logic and program delivery KPIs

INPUTS	OUTPUTS	EARLY OUTCOMES	KPIS (ACTUAL, YEAR 1, YEAR 2)
Staff – this element is subcontracted to Queensland University of Technology who have 15 staff working across PRIME Futures and other YuMi Deadly programs at 10 FTE of which an estimated 7 FTE is PRIME Futures YuMi Deadly Maths Resources Professional Development program	Fourteen schools across two Queensland clusters engaged including 60 teacher trainers and 1,822 Aboriginal and Torres Strait Islander students. Community visits and two TPD sessions completed Two new clusters in each of Qld and SA totalling 30 Phase Two schools recruited with approximately 2054 Aboriginal and Torres Strait Islander students. The Qld clusters have completed their first TPD Principal and Teacher surveys from Phase One schools completed (n=46) *Blackboard* (web based resource) utilised for resources and informal discussion Cluster meetings held Significant use of reflective journals by teachers	Program leader interview and teacher and principal questionnaires support that teacher capacity – both curriculum content, pedagogy and attitudinal - have improved and teacher trainers are sharing the methods with other staff Teachers and principals also report positive impact on student engagement	**Actual (June 2016)**: Operating in 14 schools, 60 teachers and 1,822 students. A further 30 schools with approximately 2054 Indigenous students recruited **KPIs Year 1 (Sep 2014 - Sep 2015)** Phase One personnel training undertaken and customised resources developed (12 schools, 24 teachers, 300 students) Phase One work plans developed for all schools and clusters **Comment**: All KPIs achieved **KPIs Year 2 (Sep 2015 - Sep 2016):** Operating in all Phase One schools (12 schools, 24 teachers, 300 students) Evaluation shows improved capacity of teachers in mathematics School assessment shows improved student results in mathematics 10% participation in other program elements **Comment**: Teacher and student targets well exceeded. Survey data indicating increased teacher capacity. As per the Monitoring and Evaluation Framework and program logic no systematic data is being collected on student results – seeking jurisdictional data to address this. No data on participation in other program elements

As well as these outputs, surveys of Phase One principals (n=11) and teachers (n=35) have provided progress evidence. In contrast to the other program elements, PRIME Futures has been quite explicit in their program logic that the nature of the train-the-trainer methodology requires a minimum of two years to see substantial changes in student results. Therefore, their short-term outcomes are focused explicitly on teacher capacity in terms of curriculum content, pedagogy, and attitudes (e.g. high expectations). However, an assessment of student engagement and outcomes is also made.

PRIME Futures staff have developed comprehensive teacher and principal questionnaires to measure progress in these areas (approved by the QUT ethics committee). This data is, therefore, able to be discussed in this evaluation.

These surveys show that teachers and teacher assistants who attended the first TPD have self-assessed as improving their capacity to teach with respect to the content covered. They also report that students in their classrooms are increasing in engagement and confidence, and improving their learning. For example, they have identified:

- increased student engagement (77 per cent);
- improved learning and understanding (63 per cent);
- students having a positive attitude to learning mathematics (83 per cent);
- students are able to verbalise their thoughts and strategies mathematically (71 per cent); and
- that they have shared the methodology with their colleagues (94 per cent)

The PRIME Futures team's belief that the TPD is going well is supported by the initial teacher self-assessments where 83 per cent have identified using one or more YDM activities in their class and only nine per cent (n=3) have not yet tried using it. Forty three per cent reported reducing the use of textbooks and worksheets; and 49 per cent are using their own YDM lesson plans. However, there are significantly lower positive responses to more ambitious targets, such as changing to a RAMR pedagogical approach in most or all lessons only occurring with 14 per cent of teachers at this stage; and a better but still modest 29 per cent reporting using Indigenous contexts as part of their lessons.

Also encouraging for the PRIME Futures team is the level of sharing with other teachers in the school. Only six per cent reported not sharing with anyone; 49 per cent shared with 1-2 colleagues; 26 per cent with 3-5 colleagues; three per cent with 6-10 colleagues; and 17 percent with all teachers in the school/department. Further, these colleagues are well spread across all year levels from Prep to Year 10. The level of response from their colleagues has also been encouraging, with 71 per cent reporting their colleagues have some interest, 21 per cent reporting a lot of interest, and only nine per cent reporting no interest.

Importantly, these teacher self-reports of effectively using YDM are supported by principal assessments (n=11) of the program, with two-thirds to three-quarters of principals identifying that the program either moderately or extensively has improved capacity of mathematics teachers in confidence in mathematics teaching; mathematical knowledge; pedagogical skills; Indigenous knowledge; and expectations of students.

The survey results are also supported by qualitative data. The PRIME Futures program leader related how the team is constantly assured of the value of its pedagogy, in particular the RAMR model, through the wide adoption of participant teachers of the phrase 'to RAMRise a lesson'. He also referred to a particular primary school where one of the three teachers receiving training related " 'I've now changed…Every day we have maths in the last lesson of the day … because that's the subject that they love, they'll stay for it and they want to.' And that's all been done because [she's] changed to the methods that we've [PRIME Futures] advocated, which is starting from where they are, being very active, … if you only take your learning and try and fit it to the child instead of taking the child and trying to fit it to the learning" (PRIME Futures program leader).

These are positive initial results. However, given the early stages on implementation, it is too early to predict the impact against the overarching goal, with only 9 per cent identifying better test results and 6 per cent that students are expressing more interest in STEM pathways/careers. Further, the teacher surveys also reveal several challenges to embedding the YDM approach, with 31 per cent of teachers identifying conflicting school priorities; 56 per cent being too busy; and 38 per cent the lack of suitable classroom resources as obstacles to sharing the YDM approach with colleagues. Similarly, 56 per cent of teachers identified the time required for preparation and 44 per cent the lack of suitable classroom resources as key obstacles to the implementation of the YDM approach in their own classroom.

In terms of the model's aim to be a whole of school approach, only six per cent of staff identified lack of support from senior leadership as a key obstacle. The level of sharing with their colleagues outlined in the previous section is also indicative of a supportive environment. However, a significantly larger minority (18 per cent) have identified that their school's mathematics program is not suited to YDM methods. Principals identified several strategies that they were using in supporting their school's implementation of YDM with 'trained teachers supporting other teachers in YDM', extra professional development in YDM with time provided at staff meetings/student free days, and peer support in the classroom/informal discussions each utilised moderately or extensively in almost half of the schools. In regard to school planning, nearly half the principals (n=5) indicated PRIME Futures as influencing school planning to a moderate or extensive degree, nearly half (n=5) as 'somewhat', and only one principal as 'very little'.

At the level of parental, community, and Indigenous community engagement the results are less encouraging. In these early stages, only one principal identified a moderate engagement with the Indigenous community; and two principals (18 per cent) identified 'somewhat engaging' all three of these communities. Essentially, 70 per cent of the schools identified little-to-no engagement with these three groups as a result of the PRIME Futures program to date. Somewhat counterintuitive to these findings is that half of the principals feel the program has positively influenced the support of the local Aboriginal and Torres Strait Islander community through support for increased attendance, support for the schools mathematics program, and support for teaching Aboriginal and Torres Strait Islander knowledge to students. The other half of principals stated either 'very little', 'none', or that they 'didn't know' in regard to these three areas of Aboriginal and Torres Strait Islander community support.

Key obstacles identified by the principals (approximately half identifying either moderately or extensively) in the implementation of YDM included the length of time required for planning and implementation; loss/transfer of trained staff; conflicting priorities; cost of replacing teachers attending PD; and preparation of materials. These challenges are acknowledged by the PRIME Futures team particularly in regard to the significant cost for the school of the TRS (teaching relief support) for the three days of TPD per semester, and the internal arrangements for the trainers to train other staff. So while the TRS for the TPD can be in the vicinity of $25,000, teachers also need to commit to changing the way they teach, to meet, to talk, and to redevelop their mathematics curriculum.

Summary: As an already well-established program, PRIME Futures has successfully met all of its initial program outputs and developed a quantitative survey methodology with its teachers and principals that is generating initial evidence that it is meeting its short term outcomes of improved teacher capacity across curriculum content development, pedagogy, and teacher attitudes, as well as their assessments of student engagement and performance. While this approach will provide important baseline data to measure progress over time there is no systematic approach to quantify changes in student results over the life of the program – an issue that the Indigenous STEM Education Project evaluation may wish to pursue in more detail such as through seeking access to jurisdictional data.

3.6 Bachelor of Science (Extended)

Program Description: The Bachelor of Science (Extended) contributes to the overarching goal through the development and implementation of a supported pathway to complete the University of Melbourne Bachelor of Science. This is achieved through the program having a year-and-a-half tapering program of highly supported teaching in foundational mathematics and science that students may not have chosen in Years 11 and 12 or that they did not develop with sufficient strength to prepare them for the Bachelor of Science. As those particular subjects taper, the proportion of general Bachelor of Science subjects increase; and ultimately, students complete the Bachelor of Science.

The model is based on the university's Bachelor of Arts (Extended) program which the university has been operating since 2009. A key feature of this degree is that it is a four year program, which sets it apart from typical transitional programs in that the University commits to the students for four years, in contrast to many one year transitional programs that students complete and then have to apply to enter the degree in question.

The program also has a strong emphasis on student support with all students living for their first year in one of four colleges that surround the University. These colleges have a strong commitment to supporting Aboriginal and Torres Strait Islander students to be successful at the University. In addition to the colleges, they have been provided with support from Murrup Barak, the University of Melbourne Institute for Indigenous Development; the Faculty of Science; and other central services, such as the Academic Skills service.

Achievements: The program inputs, outputs and early outcomes of the Bachelor of Science (Extended) are in line with their program logic (see appendix B.5), and are summarised in Table 7.

Table 7: Bachelor of Science (Extended) - Summary progress against program logic and program delivery KPIs

INPUTS	OUTPUTS	EARLY OUTCOMES	KPIS (ACTUAL, YEAR 1, YEAR 2)
Staff – this element is subcontracted to University of Melbourne and involves teaching staff from the Faculties of Science, Engineering, Veterinary and Agricultural Sciences and coordinator (5 in total at estimated 0.7FTE) Bachelor of Science curriculum University professional staff (student support) through Murrup Barak (Melbourne Institute for Indigenous Development), Faculty of Science, student services, and university residential colleges	The first student cohort commenced in semester 1, 2015 with 12 students and another 5 in 2016. Residential component for 1st year Science curriculum, with embedded scientific literacy, plus additional core units in mathematics and communication developed and taught Ongoing development of BSc(Ext) science and mathematics subject curriculum Extensive support for student engagement and resilience	7 of 12 students in the 1st cohort made satisfactory progress in year 1, overall pass rate of subjects for all students 72% 3 students repeating mathematics with additional support 1 student took leave of absence in semester 1 of the second year, 2016 3 students progressed to other STEM-related degrees, 1 at University of Melbourne, and 2 at universities in Queensland leaving 14 students enrolled in the BSc (Extended) at the end of semester 1 2016	**Actual (June 2016)**: Of 12 students in 1st cohort 7 complete year 1, 3 move to other STEM degrees, 1 leave of absence. 5 students recruited in 2nd cohort **KPIs Year 1 (Sep 2014 - Sep 2015)** Second year curriculum developed First cohort of students commenced (5 students enrolled) **KPIs Year 2 (Sep 2015 - Sep 2016):** first cohort of students complete Year 1 Second cohort of students commence (10 students enrolled) **Comment**: 1st year targets exceeded and make up for missing 2nd year target

The 2015 cohort included students from Queensland (including Thursday Island), New South Wales, South Australia, Victoria (one regional and three metropolitan), Tasmania, and Western Australia (Perth). In 2016, students were recruited from Queensland, New South Wales, Western Australia, and the Northern Territory. While the target for year 2 fell short of the 10 students predicted, the cumulative total of 17 commencements across the two cohorts is on track. Note also that the Bachelor of Science increased Aboriginal and Torres Strait Islander student enrolments from five in 2015 to nine in 2016. Fluctuation in the size of the commencing cohort has been the case with the Bachelor of Arts (Extended) which, in the years from 2009 to 2016, has welcomed between six and 20 commencing students.

Implementation of the first-year subjects was completed in 2015. In each semester the students have participated in subjects that develop their mathematics, and science knowledge and skills. The science subjects have integrated biology, chemistry, geography, and physics in Semester 1, with the addition of agriculture and engineering in Semester 2 in place of geography. Their science and mathematics development has been complemented by completing subjects with students in the Bachelor of Arts (Extended) cohort in communication and performance; and a subject designed to introduce the complexity, challenges and richness of Australian Aboriginal and Torres Strait Islander life and cultures. Teaching staff have used student evaluation (conducted by Murrup Barak) to refine their approach for 2016 with these refinements delivered in the initial mathematics and science subjects offered in Semester 1 to the second cohort.

In 2016 the final foundation science subject, ***Science: Supporting Health and Wellbeing***, was developed and taught for the first time, completing the phase of initial curriculum development. A key feature of the small cohorts with a dedicated team of teachers is that the students' personal as well as academic needs were well known, allowing the teaching team to be confident that they were being offered tailored support.

Three students have now progressed to other STEM-related degrees, one at the University of Melbourne, and two at universities in Queensland in more specialised degrees in forensic science and oral health. This resulted in a total of 14 students enrolled in the Bachelor of Science (Extended) at the end of Semester 1 2016.

Pursuing opportunities for development of Aboriginal and Torres Strait Islander content has progressed slowly. The program leader noted the value of learning from the Bachelor Arts (Extended). In particular, one of the lecturers teaches across both programs and brought invaluable knowledge into the Bachelor of Science (Extended). The three science lecturers, a mathematics lecturer, and the Bachelor of Science (Extended) program leader meet fortnightly which the program leader identified as "a key highlight because that becomes a meeting where we talk about curriculum". These meetings have included ongoing discussions about how to improve the incorporation of Indigenous perspectives in the curriculum which has resulted in, for example, the identification of an elder from the Gunditjmara people from Western Victoria who is going to spend time with the students during second semester talking about Gunditjmara traditional practices (including eel and fish trapping). Another example is that the Bachelor of Science (Extended) program leader has initiated contact with the Science Pathways program to explore the possibility of integrating data from their on-country projects into the Bachelor of Science (Extended) Curriculum. However, this remains an area of challenge in which more work is required, including learning from others who are achieving this development and integration successfully.

Two closely related short term outcomes which were not articulated in the program logic relate to the development of the teaching team and their relationship with the students. The program leader spoke of the melding together of people in the teaching team and their unified vision for the course to be successful. As well as learning from each other, they are all working to increase their understanding of traditional Aboriginal and Torres Strait Islander practices and perspectives and how they are complementary to western science. The corresponding building of relationships with the students was identified as a highlight, facilitated by the small size of the cohort, with the Bachelor of Science (Extended) program leader meeting them individually approximately twice a semester for half an hour to an hour. Further, the teaching staff develop a depth of relationship due to the 18 month extended program, an opportunity unlikely to be repeated in the larger Bachelor of Science classes, allowing a close monitoring of their aspiration and support needs, thereby supporting the third of the identified short term outcomes.

This third outcome area has been a particular challenge in that the students have a range of different learning and wellbeing needs. A key part of the model is that for the first year they live on campus at Trinity College, or one of three other University of Melbourne affiliated student residences, which allows a significant pastoral care role. The move into private rental in the second year along with other issues such as the distance from family, particularly in the case of students with ill parents or grandparents, means the Indigenous unit at University of Melbourne is a critical resource, and acts as a single point of contact for a whole range of services provision issues.

Summary: The Bachelor of Science (Extended) has successfully developed and delivered the science and mathematics curriculum to the Bachelor of Science (Extended) students. While the second year target for student recruitment was not met, the cumulative total over two years has met the target. The team has worked closely with Murrup Barak in refining the recruitment processes for 2017, while noting that the experience from the Bachelor of Arts (Extended) is that cohort numbers fluctuate from year to year.

Initial program outcomes are encouraging with strong retention at this early stage. The level of successful completion of subjects has demonstrated that a number of students are finding the mathematics particularly challenging. However, with additional support, the three students who failed subjects in 2015 have embarked upon the Semester 1 subjects in 2016.

There is strong qualitative evidence that the small student cohort and commitment of the lecturer team has resulted in both individualised support and interpersonal relationships developing that are contributing to student engagement and achievement, and the staff understanding the particular challenges Aboriginal and Torres Strait Islander students can experience. Initial steps have been taken by the team to integrate Indigenous knowledge into the curriculum, although this is acknowledged to be in its early stages. With the internal monitoring processes confidential, the evaluation is currently developing a case study methodology to provide more in-depth material as to the operation of Bachelor of Science (Extended).

3.7 Indigenous STEM Awards

As mentioned in the introduction this evaluation does not assess the effectiveness of this program element as the first round of awards will not take place until December 2016. It does, however, note that the awards play an important role in the project’s Theory of Change, contributing to the overarching goal through a high profile awards program to reward excellence in STEM achievement. In contrast to its original conception of solely targeting primary and secondary students, the development of individual awards has seen the scope expanded in two important ways. Firstly, it now includes Indigenous STEM professionals consistent with the project's focus on aspiration raising by identifying Aboriginal and Torres Strait Islander role models. Secondly, it includes awards for schools and teachers that are delivering innovative curriculum consistent with the best practice literature identifying the critical roles of teachers and schools.

3.8 Progress against the research questions

Section 3 has provided an overview of each program element's initial implementation, with particular reference to the initial program outputs and short term outcomes. There has been a high level of initial achievement of these short term outcomes from the perspective of the program element leaders and (in some cases) more quantitative data sources such as the PRIME Futures teacher and principal surveys and Bachelor of Science (Extended) results. While this is promising, the data is currently largely anecdotal and requires the ongoing development and implementation of robust monitoring and evaluation processes to establish and report on the extent of these outcomes. This will be the key focus of future evaluation reports. To assist in developing a deeper understanding of these initial successes to better inform monitoring and evaluation, an analysis of the program elements' responses to each of the ten key research questions (see Appendix A) has been undertaken.

Increasing Aboriginal and Torres Strait Islander students' participation and achievement in STEM (Research questions 1 and 2): At this early stage of the Indigenous STEM Education Project only the Bachelor of Science (Extended) and I2S2 have collected quantitative data of student achievement, although the latter is unable to be made available to the evaluation until appropriate consents have been secured. However, all program elements have reported extensively on student participation, including the relevance and richness of content of on-country activities using TEK and Indigenous inquiries; the high expectations environment explicit in all program elements; the benefits of effective pedagogy made relevant to students' everyday lives; and personalised social and wellbeing support and mentoring.

This approach to identifying and implementing science best practice is consistent with the ACOLA finding that ***the institution of major curriculum and pedagogy reforms making science and mathematics more engaged and practical*** is one of the five defining features of high performing STEM countries, as well as the motivation for ACARA in making inquiry central to the new Australian Science Curriculum. Likewise, Indigenous pedagogies are strongly aligned with the best practice identified by the Closing the Gap Clearinghouse and Stronger Smarter Institute, with the use of TEK as best practice particularly affirmed in the Canadian and US Indigenous STEM literature.

Increasing Aboriginal and Torres Strait Islander students' aspiration and self-belief in engaging in STEM and supporting their cultural identity and its link to science knowledge (Research questions 3-5): Building aspiration, self-belief, and affirming the two-way relevance of STEM learning and Aboriginal and Torres Strait Islander culture is central to all of the program elements. The practical role modelling of Indigenous knowledge and ingenuity provides a clear anchor for Aboriginal and Torres Strait Islander students to have pride in their culture and history. Coupled with strength based pedagogy that aligns with Indigenous learning styles, including content that is contextually relevant and hands on inquiry approaches, all elements actively promote these three goals. ASSETS combines a challenging academic environment with mentoring, explicit targeting of information about careers including through engagement with STEM professionals, and experience of a university campus within the supportive context of similar-minded Indigenous peers. The Bachelor of Science (Extended)'s 18 month tapering academic program, accompanied by the first year residential component and other personal support, constitutes a systemic approach to supporting students' aspiration to completing a STEM degree. The University of Melbourne is doing more to do to integrate Aboriginal and Torres Strait Islander contributions into the curriculum such as their understanding and care of the environment and the depth of history in such practices.

Increasing teacher capacity (Research questions 6 and 7): The skill development of teachers is a fundamental and explicit strategy being employed in I2S2, PRIME Futures, and Science Pathways. The Bachelor of Science (Extended) also indicated significant improvement in the capacity of teachers to teach science and mathematics to Indigenous students, both academically and from a cultural perspective, as well as being more aware of their personal development needs. In contrast, ASSETS is the only program element that does not have an explicit focus on teachers.

The critical role of teacher capacity is essential for the success of all the school-based program elements which accords well with the ACOLA finding that the status and capacity of teachers is one of the five common features of leading STEM countries. More specifically, it accords with the Indigenous education best practice summarised by the Closing the Gap Clearinghouse, in particular the focus on teachers and school leaders needing to be community-minded, supportive of differences, and having a capacity for change, as well as the call by ACARA and the stakeholders consulted in the implementation of the new Australian science curriculum for effective teacher training in inquiry pedagogy.

This appears to be a central challenge to the project in the context of recent research which demonstrates that Indigenous education is still predominantly dominated by models of deficit thinking. Teachers have established 'default pedagogies' as to how Indigenous students are predominantly taught. This default emphasises basic skills of literacy and numeracy taught through highly variable modes of Direct Instruction and then appear to transition into vocational education pathways for many Indigenous students (Luke et al 2013: 18).

Building supportive environments: families, communities and schools (Research questions 8 and 9): Both PRIME Futures and Science Pathways are explicit in their approach to engage the whole school in the delivery of the program and the implementation of their pedagogy. PRIME Futures specifically built into its model that part of the role of the teachers trained is to train all mathematics teaching staff at their schools. The challenging extension of this is the building of relationships with families and communities (which is central to Science Pathways), and while an important part of both PRIME Futures and I2S2, the onus is very much on the teachers and the schools to make this happen in a sustainable fashion. The three program leaders noted how challenging a shift this can be for teachers. This is supported further by the initial PRIME Futures survey data. ASSETS is also seeking to foster this supportive school and family environment through activities in its leadership program, such as work placements and encouraging interactions with universities (e.g. attending information days).

The importance of relationships are very evident in the best practice literature as summarised by the Closing the Gap Clearinghouse, which highlights the importance of contextually literate and leadership-smart school teachers and leaders; and which emphasises the importance for schools building networks, trust and resources at the level of the school community of practice, with other schools and with the community. However, the SSLC research shows that "…deficit thinking by teachers and principals remains a major challenge and impediment for systems that have ambitions to 'close the gap' in conventional educational achievement" (Luke et al 2013: 18); that overall levels of knowledge about Indigenous issues is low; and that previous training and preparation for Indigenous education is poor (Luke et al 2013: 14).

Contribution to Reconciliation (Research questions 10): While not conceived as an explicit goal in the development of the program, all program leaders (with the exception of PRIME Futures) spoke explicitly about the contribution their program elements seem to be making toward reconciliation. ASSETS staff identified the high level of non-Indigenous volunteers, mainly STEM professionals, who were involved in the summer school. Science Pathways identified the non-Indigenous scientists working alongside traditional owners and the schools being in the middle of this makes it a "great reconciliation project". The Bachelor of Science (Extended) program leader is looking to bring Indigenous knowledge from the program into the standard Bachelor of Science degree. In these early stages this dimension of the project has not been explicitly built into the individual program element monitoring processes; and it will be a role for the broader evaluation to develop ways to assess this outcome more effectively.

3.9 Summary

The program leader and project director interviews indicate that initial implementation is going well overall with major delays occurring only in those elements that were significantly delayed in their implementation (i.e. Science Pathways and the Awards). The reliance at this stage of the project on interview data with program leaders point to the importance of the implementation of broader evaluation methodologies. Work is underway developing the mixed-methods approach and is planned to include:

- access to program monitoring data;
- development of questionnaires to collect quantitative data from student, teacher and stakeholder perspectives;
- development of case study methodologies to better understand the mechanisms of program elements effectiveness;
- access to jurisdictional data.

All these methods will be submitted to the CSIRO Human Research Ethics Committee and the school based research and use of jurisdictional data will be subject to jurisdictional approvals. Results from these methods will be reported on in subsequent evaluation reports.

However, the rich implementation data from the program leaders also intersects with, and provide insights into, some of the key education issues identified in the literature review and brought into focus by the project's key research questions. Consistent with the thematic analysis method outlined in Section 2, the following section discusses some of these issues and identifies key findings of this evaluation report, with a particular focus on implications for the project's future directions, as well as Indigenous STEM education policy and practice more generally.

4 Discussion

Based on the literature review, and the analysis of the program elements and their engagement with the key research questions, the overarching finding of this evaluation is as follows:

KEY FINDING 1: Initial results of the implementation of the Indigenous Education project are positive. However, more substantial quantitative and qualitative evidence is required as to the extent, effectiveness and sustainability of outcomes.

As noted Section 3.9 summarises future research methodologies intended to generate this evidence while the following sections elaborates on these initial results with further key findings.

4.1 Diversity of principles and methods

A striking feature of the program elements is the commonality of methods and principles underlying their approaches, yet the diversity of ways in which they are operationalised. Considering the progress of the program elements to date, Table 8 identifies four common principles that emerge across all program elements and describes how each program operationalises these principles. All program elements: 1) are place-based; 2) have strong cultural engagement; 3) are strength-based; and 4) are built on high expectations. Table 8 also describes the key methods employed by each program element, separating them into methods that have a particular focus in these early stages of implementation and methods that are likely to increase in focus into the future.

Table 8: Principles and Methods of Program Elements

	COMMON PRINCIPLES ACROSS PROGRAM ELEMENTS				
PROGRAM ELEMENTS	PLACE-BASED (CONTEXTUAL)	CULTURAL ENGAGEMENT	STRENGTH-BASED	HIGH EXPECTATIONS	METHODOLOGIES
Science Pathways	Local Aboriginal nation partnering with school	Traditional Owners/ Aboriginal assistant teachers lead development of curriculum and/or on-country activities Uses TEK as basis for learning western science	Hand on, on-country projects Classroom learning integrated with on country projects	Schools commit to development of integrated curriculum Students will increase/ maintain attendance, and increase engagement and performance Clear articulation to employment and possibly university (e.g. via ASSETS)	**Target:** Broad based, whole of cohort **Initial foci:** Local Indigenous knowledge based curriculum, work plans and activities highlighting on country activities and privileging traditional language Partnerships essential to deliver Assistant teacher Professional development (NT) **Subsequent foci:** Teacher Professional development (WA)
I2S2	Aboriginal 'generic' knowledges/ technologies applied in local context through partnership between school and local Aboriginal 'community' (Aboriginal teachers, families, elders, organisations - e.g. land councils/ Traditional Owner bodies) NB. Regional schools more likely to have significant Traditional Owner populations	Explicit use of traditional practices as a basis for inquiries (common to all Aboriginal and Torres Strait Islander communities) Aboriginal led team	Hands on Inquiries - methodology consistent with Aboriginal pedagogy Multimodal assessment methods to allow students to demonstrate their cognitive grasp of science	I2S2 will help transform the pathway of students in middle school with an interest in science to choose appropriate mathematics and science subjects in Years 11 and 12 to enable ATAR and prerequisites for university courses School will be become exemplars in use of inquiry pedagogy	**Target:** Broad based, whole of cohort **Initial foci:** Development of new broad based non-sacred Indigenous knowledge based curriculum Teacher Professional development Innovative assessment modalities **Subsequent foci:** Partnership development to localise curriculum Fostering communities of practice

PROGRAM ELEMENTS	COMMON PRINCIPLES ACROSS PROGRAM ELEMENTS PLACE-BASED (CONTEXTUAL)	CULTURAL ENGAGEMENT	STRENGTH-BASED	HIGH EXPECTATIONS	METHODOLOGIES
ASSETS	Explicit university interface for Aboriginal students from all over Australia	100 per cent Indigenous cohort Local cultural program led by university Indigenous unit Indigenous role models and cultural mentors	Inquiry, mentoring, networking, aspiration-raising	All ASSETS students can go to university and pursue a STEM career	**Target:** Self-identified high performing and/or high aspirational Indigenous cohort **Initial foci:** Supplementary inquiry focused curriculum (Summer School) Individualised professional development - mentoring, networking, Partnerships essential to deliver **Subsequent foci:** Individualised professional development - work placements
PRIME Futures	Schools working in partnership with local Aboriginal community in development of place based mathematics curriculum	Indigenous perspectives to be built into curriculum	RAMR - starting and ending with students everyday reality (Indigenous cultures tend to be 'high-context) Inquiry pedagogy Sequencing, connections and big ideas	PRIME Futures will help transform the pathway of students in middle school with an interest in mathematics or science to choose appropriate mathematics and science subjects in years 11 and 12 to enable ATAR and prerequisites for university courses Transformation of school mathematical teaching practice	**Target:** Broad based, whole of cohort **Initial foci:** Teacher Professional development Fostering community of practice Innovative contextualised, high expectations pedagogy Train the trainer model to effect whole of school transformation in mathematics teaching Aboriginal community partnerships essential to indigenise curriculum **Subsequent foci:** School plans to structurally embed approach
Bachelor of Science (Extended)	Explicit university interface with Aboriginal students from all over Australia and integrated into the mainstream degree While starting point is traditional academic curriculum increasing efforts to integrate with Indigenous notions of place	100 per cent Indigenous cohort Increasing incorporation of Indigenous perspectives	Small group, peer support, strong teacher-student relationships	To complete the University of Melbourne Bachelor of Science in preparation for a STEM career	**Target:** High aspirational Indigenous cohort requiring additional foundation support **Initial foci:** Supplementary 18 month foundation mathematics and science curriculum Individualised support – small group teaching, mentoring, social support **Subsequent foci:** Development of Indigenous content into curriculum
Indigenous STEM Awards	Proposed to develop local (rather than centralised) award ceremonies	Cultural engagement part of awards criteria	Identification and recognition of strengths of individuals and schools	Recognition of excellence	**Target:** High performing students, schools and STEM professionals **Initial foci:** High performing students, schools and STEM professionals **Subsequent foci:** To be developed

A key point to note about these principles is how inter-related they are. Place and local cultural engagement are critical to all program elements in informing curriculum development using strength-based, culturally relevant pedagogies. For the school based elements this means schools are expected to engage with their local Aboriginal and Torres Strait Islander communities to develop student centred, culturally relevant curriculum or work plans (in the case of Science Pathways and PRIME Futures) or to contextualise 'generic' inquiries (in the case of I2S2). In the case of I2S2, the development of Indigenous inquiry curriculum addresses a major gap in the Australian science curriculum and the implementation of the Aboriginal and Torres Strait Islander cross curriculum priorities. With only 12 points identified in the science curriculum for the embedding of Indigenous perspectives the majority of these are in the field of ***Science as a Human Endeavour*** with none identified for ***Science Inquiry Skills***.

The focus on place in ASSETS and Bachelor of Science (Extended) is twofold. Firstly, the university – demystifying and clarifying pathways to it in the case of ASSETS, and providing a highly supported pathway (both academic and personal support) into it for Bachelor of Science (Extended). Secondly, the explicit acknowledgement of the cultural strength of the students and the relevance of culture in pursuing a STEM degree (and career), using the methods of the other elements of showing the complementarity and intersections of two different knowledge systems, is an affirmation of the students' sense of place as informed by their cultural identity.

In the somewhat more abstract world of mathematics the PRIME Futures program leader reflected on western and Aboriginal and Torres Strait Islander cultures and described that the established approach in western mathematics was to focus on the parts rather than the whole. In contrast, Aboriginal and Torres Strait Islander cultures tend to focus on the whole rather than the parts. Elaborating on the story of Aboriginal mathematician, Chris Matthews, who developed the RAMR method, the PRIME Futures program leader explained that Chris had found mathematics difficult until he was taught algebra. Algebra, as the generalisation of arithmetic, enabled him to understand mathematics as a whole and to go on to do a doctorate in applied mathematics. Similarly, the PRIME Futures program leader outlined that the student-focused pedagogy is in contrast to what often happens in the traditional teaching of mathematics, where there is a tendency to celebrate western culture in mathematics teaching. He used the example that mathematics promotes the idea that bigger numbers are better, leading to an undue focus on technological development. He stated that the YuMi Deadly Maths approach was to "teach the maths and not the western culture behind it".

KEY FINDING 2: Four common principles were identified as being central to all program elements: 1) being place-based; 2) having strong cultural engagement; 3) being strength-based and 4) being built on high expectations. A deeper understanding of how each program element enacts these principles should be a priority for future monitoring and evaluation as well as enriching the individual program element program logics and the overall project Theory of Change.

4.2 Aboriginal and Torres Strait Islander leadership

Aboriginal and Torres Strait Islander leadership, a key constituent of the cultural engagement principle, is central to all the program elements. At the project level, senior Aboriginal and Torres Strait Islander experts are members of the Project Steering Committee with a recent decision to expand this membership further.

This leadership is explicitly articulated across all aspects of the I2S2 program development and delivery as both the I2S2 program leader and deputy are Aboriginal; as a critical benchmark for ensuring authenticity in the development of the content for the curriculum materials and the cultural awareness training; in role modelling high expectations both within the I2S2 team and with the teachers implementing the program; and in the importance for schools to engage with their local Aboriginal and Torres Strait Islander communities in contextualising the curriculum to their local area.

Science Pathways also has a central focus on Indigenous leadership with the program predicated on the engagement and leadership of Elders and Traditional Owners, Aboriginal assistant-teachers, and Aboriginal organisations such as the Ranger organisations, and their respective central roles in the development and delivery of the curriculum.

PRIME Futures focus on Indigenous leadership is threefold. Firstly, a fundamental component of their pedagogy is the RAMR model developed by Aboriginal mathematician Chris Mathews. Further, the engagement of local Aboriginal and Torres Strait Islander community in order to incorporate Indigenous perspectives in their curriculum content and the cultural content of their TPD is an essential element of the program, as is the input of the senior Aboriginal staff in the team.

In contrast, ASSETS explicitly has the cultural element of the program as important as the academic component, and relies on the cultural patrons, university Indigenous units, and Indigenous STEM Education Project Indigenous staff from other elements to lead this aspect. The academic program also draws on the I2S2 Indigenous inquiries to provide a strong Indigenous context to the academic side of the program.

With the Bachelor of Science (Extended), the University of Melbourne has strong Indigenous leadership that contributed to the development of the model (based on the Bachelor of Arts (Extended)) with Murrup Barak, which is an important source of support for the students, as well as managing the evaluation processes of the extended subjects. Further, the program is actively seeking to build their links with local Aboriginal elders and strengthen the Indigenous knowledge and content in their curriculum.

Notwithstanding this commitment to Aboriginal and Torres Strait Islander leadership across the project, four key concerns were identified in the interviews:

The challenge of recruiting Indigenous staff to the program: As outlined in Section 3.1, the former project director had an initial aim of recruiting 50 per cent Indigenous staff into the project. While she quickly discovered how difficult that was going to be, she believed that having several senior Indigenous staff, primarily in the I2S2 program, excellent Aboriginal and Torres Strait Islander mentors, cultural patrons and critical friends, and the Indigenous membership on the Steering Committee, had resulted in a very strong Aboriginal and Torres Strait Islander voice in the project – a view shared by the incoming program director. It is worth noting that even after three rounds of interviewing, the Aboriginal I2S2 program leader still fell slightly short of his ideal of a team that was at least 50 per cent Aboriginal or Torres Strait Islander people.

Challenges for non-Indigenous staff: A close corollary of the above was the strong awareness across both Aboriginal and Torres Strait Islander and non-Indigenous staff of the challenges for non-Indigenous staff in effectively developing and implementing the cultural components of their programs. Numerous strategies were employed including employment of staff with extensive experience working with Aboriginal and Torres Strait Islander communities; recognition of the leadership and advisory roles played by Aboriginal and Torres Strait Islander staff across the project; identification of cultural patrons, advisors and mentors; and the prioritisation of cultural awareness training for both non-Indigenous and Aboriginal and Torres Strait Islander staff. Some interviewees suggested that there was room for improvement in this area, such as through the use of a systematic approach to cultural awareness training rather than it being at the discretion of program elements. The agreement of the leadership team to develop a cultural framework for the project at their team meeting in October 2016 is recognition of the importance of this issue.

Diversity in local leadership and approaches to culture: The interviews all identified the importance of Aboriginal and Torres Strait Islander leadership and, in particular, the importance of local leadership (the place based principle), and how there is a diversity of approaches to engaging with culture. When coupled with the fact that there can be high turnover of individuals in these local leadership roles flexibility and adaptability of staff is required to protect against developing simplistic or formulaic understandings of culture and how to best integrate this into the project. For example, the ASSETS cultural program is being developed with different emphases in different settings with some programs including traditional cultural engagement activities (such as dancing and digeridoo playing) while others are preferring to keep the emphasis on the cultural content embedded in the science inquiries focussed on the interface between traditional and western science knowledges.

Institutional capacity of CSIRO: Concern was also identified as to how external stakeholders, including Aboriginal communities, viewed the credibility of the project in terms of CSIRO's expertise in leading Indigenous education. This links closely with the issues identified above, particularly in regard to the project needing to bring in substantial expertise, especially people who have been assessed as understanding and having experience in managing the complexities of the Indigenous policy and education space. While this has helped build credibility and gain traction for this project, it also opens up new possibilities for CEdO and CSIRO to benefit from this increased diversity. The development of the cultural framework could prove a useful tool for addressing these issues not only at the project level but also for CEdO and CSIRO more broadly.

KEY FINDING 3: The Indigenous STEM Education Project is operating in a complex cultural, policy, and institutional interface which has required the development of support structures and recruitment strategies that explicitly acknowledge the value of, and engagement with, Aboriginal and Torres Strait Islander leadership. This leadership should be supported and developed not only for the benefit of the project and project partners, but also to build the institutional capacity of CEdO and CSIRO.

4.3 Teacher and school capacity

A critical finding across the school-based and university program elements has been the importance of teacher professional development. I2S2 instituted a major change in its model to stay with a smaller number of schools for longer after recognising the complexities of the inquiry methodology and navigating Indigenous contexts required ongoing investment. As an established program, PRIME Futures has already embedded substantial TPD in its train-the-trainer model; and identified the value of an additional three day PD dedicated to the sustainability of the program. Likewise, the Bachelor of Science (Extended) identified how important the fortnightly curriculum meetings of the lecturing team were in providing critical insights into how to improve delivery and student support. The Science Pathways program will be prioritising the development of a TPD package in 2017. Given the significantly higher teacher turnover in remote community schools, this highlights the benefits of TPD for Aboriginal teachers and assistant teachers who are more likely to stay. It also highlights the importance of integrating Science Pathways TPD into the induction for new teachers for remote community schools.

This emphasis is strongly in accord with the best practice literature and is underlined by the challenging context of existing practice (as discussed in Section 2.4.1) which indicates that dominant beliefs and practices are often inconsistent with high expectations and strength-based approaches. This evidence includes that as the proportion of Aboriginal and Torres Strait Islander students increases above certain thresholds (11-15 per cent) so does the likelihood of pedagogies emphasising basic skills and vocational education with the important exception of those teachers with 10 years or more experience (Luke et al 2013: 18-19).

Given the diversity of program element approaches across the Indigenous STEM Education Project, including their approaches to professional development, the dedicated resourcing to the monitoring and evaluation process, as well as the five year program duration, the project is well placed to contribute to building the evidence for effective teacher and school capacity building, including the incorporation of Indigenous knowledge and contexts in curriculum as exemplified in Science Pathways and I2S2. This is particularly important in the context of program elements effectively competing with numerous other science programs that are currently offered to schools (OCS, 2016).

KEY FINDING 4: The Indigenous STEM Education Project is well placed to contribute to building the evidence base for high expectation, strength-based Indigenous STEM programs, in particular a better understanding of the pathways for effective teacher professional development, school capacity building, and the integration of Indigenous-focused curriculum content.

4.4 Consideration for remote contexts

The previous key finding, while equally relevant to the urban, regional, and remote school contexts, highlights some of the specific challenges and opportunities in remote contexts. As outlined in the literature review, remote communities and schools are engaging with a disproportionate share of Aboriginal and Torres Strait Islander educational disadvantage. They also have their own place based strengths, as the fundamental premise of Science Pathways shows. In particular, the privileging of traditional cultural knowledge and language in the development of a two-way science curriculum, including using local language and culture as a motivation to improve English literacy.

As outlined in Section 3.2.1, the initial establishment of Science Pathways in WA has had a strong focus on brokering formal partnerships between schools, local ranger organisations, and mainstream organisations that operate on-country, with the community engagement outcomes a real highlight. In contrast, many of these relationships have been more established in the NT schools, partly facilitated by the established nature of the program in the NT and its link to the NT Department of Education's Indigenous Land and Culture program, which provides an established entry point for integrating the program into the school curriculum. What both the WA and NT experiences emphasise is the importance of relationships and partnerships in ensuring the effective operation of the program. This importance is further emphasised by the literature that highlights the policy complexity around funding (Fogarty et al., 2015); the high staff turnover in remote schools (Luke et al 2013); and the additional challenges for science education, and education in general, for students who are not fluent in Standard Australian English (Chigeza, 2008; Wilkins, 2008).

Given this complexity, a fundamental building block would appear to be the foundational partnerships that enable the effective integration of TEK into curriculum, and the sustainability of these partnerships underpinned by community ownership and leadership in the process. Developing a better evidence base of how partnerships are made and maintained may prove critical to the sustainability of the Science Pathways model.

KEY FINDING 5: The complex issues and policy environment in remote communities, including high turnover of non-Indigenous school staff, requires particular attention to the partnerships required at all levels of the system, from the community to schools to policy makers to maximise the chances of developing a sustainable model or models.

4.5 Reflection on Theory of Change

As outlined in Section 3, the initial qualitative and quantitative evidence is highly supportive of the effective implementation of the program element initial outputs and outcomes as articulated in the individual program logics. Overall, this is an endorsement of the project's overarching Theory of Change. As shown in Section 2, this is also based in the best practice literature.

A particular strength of the Indigenous STEM Education Project is the planned and unplanned benefits from the program elements maintaining a relationship with each other through the leadership team and accessing the STEM education infrastructure across CEdO and CSIRO more broadly. Effectively, the six discrete and largely independent program elements are connected in a community of practice which allows mutual learning, resource sharing, insights to be shared, and problem solving facilitated with other program elements' and broader CEdO and CSIRO expertise. Some key examples of these benefits include the value of the Indigenous leadership in I2S2 being available for the other program elements; I2S2 staff delivering inquiry and cultural leadership at ASSETS; the Bachelor of Science (Extended) consulting with PRIME Futures about alternatives to written assessment processes when lecturers recognise these are not a true assessment of students' ability; and the potential for PRIME Futures to use I2S2 inquiries as a rich source of mathematical exercises and processes. Examples of the wider community of practice with CEdO and CSIRO are the ASSETS program use of the SMiS infrastructure to develop a national work placement program and the identification of STEM professionals and academic providers to contribute to the summer schools. Such benefits are highly consistent with the conception of the Theory of Change as an integrated pathway among program elements. Further, these benefits extend the Theory of Change to include the building of linkages with mainstream STEM programs. Over time it is expected these linkages among programs will deepen further as indicated by the exploration of opportunities for I2S2 and PRIME Futures in the same schools; school based program elements strengthening their links with CEdO programs and wider CSIRO Indigenous research initiatives; and the Bachelor of Science (Extended) looking to draw on content of other program elements to enrich its integration of Indigenous perspectives; and the establishment of the Awards.

However, a key weakness identified with the Theory of Change by the peer reviewers was its lack of clarity in effectively identifying the key drivers of change at the project level. This led one reviewer to describe it more as a program framework rather than a theory of change with clearly defined impact pathways. In addition a few points relating to specific program elements are:

- The current pathway of ASSETS to Bachelor of Science (Extended) is possible, but, as discussed in the interview with the former project director, is not intended to be exclusive. In particular it will be interesting to monitor the number of students that choose one of the universities that partner with ASSETS to see whether that experience supports a pathway to the ASSETS partner universities.
- There is some further work to be done to effectively articulate the Science Pathways program element pathways with the Theory of Change. A prevailing aspiration in remote communities is to be able to live on and care for country. This community aspiration is resulting in a strong emphasis on employment pathways in ranger programs and land management through VET courses. So while it is important for the project to support potential pathways to university, it is also critical to support wider community aspirations. A possible pathway that may develop over time may result from working closely with scientists involved with a community's two way science curriculum. This could lead from employment as a ranger or other land management role onto studying STEM at university.
- In addition to these points, key finding 2 and the analysis of program elements in Section 3 have suggested the value of reviewing aspects of the individual program element logics.

KEY FINDING 6: The Project's Theory of Change is well grounded in the literature and the individual program element logics have provided a robust conceptual base for assessing the implementation phase of the program elements, notwithstanding their diverse contexts and approaches. There are, however, revisions needed to more clearly identify the project Theory of Change impact pathways and refine the individual program element logics as discussed in the relevant parts of Sections 3 and 4.

5 Conclusion

The evidence presented by the program element leaders, their regular reporting processes, observations of the research coordinator, and some limited quantitative data for some program elements point towards successful initial implementation of all program elements (except the Indigenous STEM Awards which has been delayed until the latter half of 2016). The four program elements that commenced at the beginning of the project (I2S2, PRIME Futures, ASSETS and Bachelor of Science (Extended)) have all met, or substantially met, their contracted engagement targets with two exceptions: ASSETS has not yet met its targets for summer school participants' engagement in the ongoing leadership program work placements; and fluctuations in small cohort programs such as Bachelor of Science (Extended) has meant a failure to reach its second year target has been offset by their exceeding the target in the initial year. Further, delays in the establishment of the Awards program have prevented participation KPIs from being met by ASSETS, PRIME Futures and I2S2; and delays in establishing monitoring and evaluation processes have also meant KPIs relating to student progress have not been measured by ASSETS and PRIME Futures. Science Pathways, which was delayed to the beginning of 2016, is on track to meet its engagement targets in early 2017, and its student progress targets by the end of 2017. Notwithstanding these delays, by making academic excellence, high expectations and culture central to all elements and having a combination of universal and targeted programs, the team has developed, and is implementing, a credible Theory of Change.

In support of this, there is a substantial body of anecdotal evidence, complemented by some preliminary quantitative data, that initial outcomes are being achieved: teachers in I2S2 and PRIME Futures are responding positively to professional development; students, parents and teachers have enthusiastically embraced the experience of ASSETS; exciting and engaging on-country experiences are being chronicled by Science Pathways; and strong engagement and first year results are being demonstrated by the initial cohorts of the Bachelor of Science (Extended).

While this initial implementation is promising, the primary reliance in this initial report on program leader self-report data means that it is too early to provide conclusive evidence as to the extent to which any of the program elements will contribute to the overarching goal of providing supported pathways that improve the participation and achievement of Indigenous students in STEM subjects. The need for stronger evidence is further highlighted by the current evidence pointing to the challenges facing schools in enacting high expectations pedagogy and meaningful cultural engagement, and the ongoing and widening gap between Aboriginal and Torres Strait Islander and non-Indigenous students in PISA and ATAR achievement respectively.

This indicates the importance for the ongoing development of the overarching evaluation methodology which was itself delayed due to time it took to replace the research coordinator after the original incumbent resigned. This will include obtaining the appropriate consents from schools in order to be able to access the I2S2 program monitoring data; and working closely with ASSETS and Science Pathways who are still developing their monitoring frameworks. In addition, the judicious use of case studies and survey tools across the program elements should contribute significantly to a more systematic understanding of the development and implementation of best practice in Indigenous STEM for both students and teachers.

The further development of these research methodologies should also be strongly informed by the relevant key findings of this evaluation. In particular, deepening our understanding of how the four principles guiding all the program elements of being place-based, having strong cultural engagement, being strength-based and built on high expectations are differentially enacted in their contribution to the development of supported STEM pathways. This is especially pertinent at three levels – teacher professional development, school capacity building, and student aspiration and academic persistence. While the current program logics and Theory of Change have served the project well, these too require reviewing and updating to better articulate the impact pathways of the individual program elements and the project as a whole.

The report also identifies the ACOLA findings that dynamic STEM nations have innovative policies to increase STEM participation of formerly excluded groups and point to the centrality of STEM for Australia's future prosperity. In light of this, it is important that CSIRO continues to foster and support leadership in the complex cultural, social, and political interface that is Indigenous STEM education. The unique contribution of TEK, the contribution of I2S2 to filling a gap in the Australian Curriculum, and the recognition that inquiry and RAMR pedagogies are themselves more conducive to Aboriginal and Torres Strait Islander ways of learning, all have the potential to make a major contribution to the nation, including in regard to reconciliation. This is conditional on the development of sustainable models of partnership and delivery that respect and enhance the four principles including the fostering of Aboriginal leadership at the levels of communities, program implementation, and within CSIRO.

In closing, the project is well positioned to further develop comprehensive monitoring and evaluation research methodologies to build quantitative and qualitative evidence of the impact of the program elements. Alongside this is the need to build understanding of jurisdictional policy contexts and build partnerships to explore alignment with respective program elements in order to support sustainability. It is this data and focus that will be central to subsequent yearly evaluation reports.

References

Aboriginal and Torres Strait Islander Higher Education Advisory Council (2015) Indigenous participation in science, technology, engineering and mathematics disciplines. Viewed 15 August 2016, <https://docs.education.gov.au/node/39021>.

ACARA, National Curriculum Board (2009a) Shape of the Australian Curriculum: Science. Viewed 17 August 2016, <http://www.acara.edu.au/_resources/Australian_Curriculum_-_Science.pdf>.

ACARA, National Curriculum Board (2009b) Framing Paper Consultation Report: The Sciences. Viewed 17 August 2016, < http://www.acara.edu.au/_resources/Consultation_report_-_Science.pdf>.

ACARA, Australian Curriculum (2016a) Science: Overview. Viewed 17 August 2016, <http://v7-5.australiancurriculum.edu.au/science/implications-for-teaching-assessment-and-reporting>.

ACARA, Australian Curriculum (2016b) Cross-Curriculum Priorities: Overview. Viewed 17 August 2016, <http://v7-5.australiancurriculum.edu.au/science/cross-curriculum-priorities>.

ACT Government (2015) Annual Report 2014–15 Volume 1. Viewed 12 August 2016,<http://www.cmd.act.gov.au/__data/assets/pdf_file/0004/782050/CMTEDD-AR-Vol-1.pdf>.

Adie, B., Bozzuto, D., Laudage, S., Pachucki, B. (2016). Parallel Pathways: A Comparison of STEM and Culture Programs for Underrepresented Students and Associated Program Evaluation Methods. Worcester Polytechnic Institute, Massachusetts.

Aikenhead, G. S. (2001). Students' ease in crossing cultural borders into school science. Science Education, 85, 180–188.<https://www.usask.ca/education/documents/profiles/aikenhead/borders.pdf>.

Aikenhead, G and Michell, H (2011) Bridging Cultures: Indigenous and Scientific Ways of Knowing Nature. Toronto, ON: Pearson Canada Inc. ISBN13: 9780132105576

Aikenhead, G (2013) Science, Technology, Engineering and Mathematics Education and Related Employment for Indigenous Students and Citizens of Saskatchewan. Australian Council of Learned Academies <http://www.acola.org.au/PDF/SAF02Consultants/Consultant per cent20Report per cent20- per cent20Canada per cent20Indigenous.pdf>.

Australian Bureau of Statistics (2008) Australian Social Trends: Population Distribution. <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Chapter3002008>.

Australian Bureau of Statistics (2013) 3238.0.55.001 - Estimates of Aboriginal and Torres Strait Islander Australians, June 2011. Viewed 31 October 2016, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/3238.0.55.001>.

Australian Government-Department of Education and Training (2015a) Aboriginal and Torres Strait Islander Higher Education. Viewed 15 August 2016,<https://www.education.gov.au/aboriginal-and-torres-strait-islander-higher-education>.

Australian Government, Department of Education and Training (2015b) ATSIHEAC Background Paper: Indigenous Science, Technology, Engineering, and Mathematics (STEM). <https://docs.education.gov.au/node/39021>.

Australian Government (2016a) Department of the Prime Minister and Cabinet. Indigenous Affairs: Higher Education. Viewed 15 August 2016,<https://www.dpmc.gov.au/indigenous-affairs/education/higher-education>.

Australian Government (2016b), Department of Education and Training Higher Education Statistics: Student Data. Viewed 17 August 2016< https://www.education.gov.au/student-data>.

Australian Industry Group (2015) Progressing STEM Skills in Australia. Viewed 12 August 2016,<www.aigroup.com.au/portal/binary/../14571_STEM%20Skills%20Report%20Final%20-.pdf>.

Barnhardt, R (2005) Creating a Place for Indigenous Knowledge in Education: The Alaska Native Knowledge Network. Local Diversity: Place-Based Education in the Global Age, Greg Smith and David Gruenewald, eds., Hillsdale, NJ: Lawrence Erlbaum Associates. Viewed 19 August 2016, <http://www.ankn.uaf.edu/curriculum/articles/raybarnhardt/pbe_ankn_chapter.html>.

Behrendt, L, Larkin, S, Griew, R, Kelly, P (2012) Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People Final Report. Viewed 17 August 2016, <https://docs.education.gov.au/system/files/doc/other/

Bowers, C A (2001) Educating for Eco-justice and community. Athens: The University of Georgia Press

British Columbia Ministry of Education and First Nations Education Steering Committee (2008) Poster First Peoples Principles of Learning. Viewed 19 August 2016, <http://www.fnesc.ca/wordpress/wp-content/uploads/2015/05/PUB-LFP-POSTER-Principles-of-Learning-First-Peoples-poster-11x17.pdf>.

Bull, R (2008) Small Study – Big Success Story Primary Connections Incorporating Indigenous Perspectives Pilot Study Report. Australian Academy of Science.<file:///C:/Users/noo025/Downloads/Small per cent20Study per cent20- per cent20Big per cent20Success per cent20Story.pdf>.

Buntting, C, Jones, A, McKinley, L, Gan, M (2013) Consultant Report Securing Australia's Future STEM: Country Comparisons: STEM initiatives and issues in New Zealand. Report to the Australian Council of Learned Academies. Hamilton: University of Waikato. Viewed 19 August 2016, <http://www.acola.org.au/PDF/SAF02Consultants/Consultant per cent20Report per cent20- per cent20New per cent20Zealand.pdf>.

Cannata, M., Taylor Haynes, K., & Smith, T. M. (2013). Reaching for Rigor: Identifying Practices of Effective High Schools. Nashville, TN: National Center on Scaling Up Effective Schools.

Chigeza, P (2008) Language negotiations Indigenous students navigate when learning science. The Australian Journal of Indigenous Education, 37(1).91-97.

Chubin, D., May, G., and Babco, E. (2005). Diversifying the engineering workforce. Journal of Engineering Education, 73-86.

Collins, B, & Lea, T (1999) Learning lessons: An independent review of Indigenous education in the Northern Territory. <http://www.det.nt.gov.au/__data/assets/pdf_file/0005/7475/learning_lessons_review.pdf>.

Cowie, B & Jones, A, (2010) The history and influences on curriculum development in New Zealand. In J.D. Kirylo & A. Nauman (Eds.), Curriculum development: Perspectives from around the world (pp. 237-248). Washington, DC: Association for Childhood Education International.

CSIRO (2016a), Education. Viewed 15 August 2016, <http://www.csiro.au/en/Education>.

CSIRO (2016b), Education Programs. Viewed 15 August 2016,<http://www.csiro.au/en/Education/Programs>.

CSIRO (2016c) I2S2-Current Inquiries: Year 6- Let's Stick it Together. Viewed 19 October 2016,<http://www.csiro.au/en/Education/Programs/Indigenous-STEM/I2S2/I2S2-Inquiries-Current/I2S2-Inquiry-Year6-LetsStickItTogether>.

CSIRO (2016d) I2S2-Current Inquiries: Year 8 - Fire: A Burning Question. Viewed 19 October 2016,<http://www.csiro.au/en/Education/Programs/Indigenous-STEM/I2S2/I2S2-Inquiries-Current/I2S2-Inquiry-Year8-Fire-ABurningQuestion>.

CSIRO (2016e) I2S2-Current Inquiries: Year 9 – Burn and Grow. Viewed 19 October 2016,<http://www.csiro.au/en/Education/Programs/Indigenous-STEM/I2S2/I2S2-Inquiries-Current/I2S2-Inquiry-Year9-BurnAndGrow >.

Department of Education (2011) Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People - Context Paper and Call for Submissions. Viewed 17 August 2016, <https://docs.education.gov.au/node/36853>.

Dockett S, Perry B & Kearney E (2010) School readiness: what does it mean for Indigenous children, families, schools and communities? Issues paper no. 2. Produced for the Closing the Gap Clearinghouse. AIHW Cat. no. IHW 36.Canberra: Australian Institute of Health and Welfare & Melbourne: Australian Institute of Family Studies. <http://www.aihw.gov.au/uploadedFiles/ClosingTheGap/Content/Publications/2010/ctg-ip02.pdf>.

Douglas, J (2008) Learning from country: the value of country visits in remote schools for community engagement and natural and cultural resource management. DKCRC Report 69. Ninti One Limited, Alice Springs.<http://www.nintione.com.au/resource/NintiOneResearchReport_69_Thevalueofcountryvisitsinremoteschools.pdf>.

Dreise, T and Thomson, S (2014) Unfinished business : PISA shows Indigenous youth are being left behind.<http://research.acer.edu.au/indigenous_education/37>

Edwards, D and McMillan, J (2015) Completing university in a growing sector: Is equity an issue? Melbourne, Australian Council for Educational Research (ACER)<http://research.acer.edu.au/higher_education/43>.

Ezeife AN (2002) Mathematics and culture nexus: The interactions of culture and mathematics in an Aboriginal classroom. Int Educ J. 3(2):176–187.

Fogarty, W, Schwab RG and Lovell, M, Australian National University (2015) Learning on Country Program: Progress Evaluation Report. <https://www.dpmc.gov.au/sites/default/files/publications/LoCP per cent20progress per cent20evaluation per cent20report per cent20- per cent20Final per cent20for per cent20public per cent20release per cent20- per cent2015 per cent20October per cent202015.pdf>.

Government of South Australia (2012) A Science, Technology, Engineering and Mathematics (STEM) Skills Strategy for South Australia. Viewed 12 August 2016,<http://www.statedevelopment.sa.gov.au/upload/science/STEM per cent20Skills per cent20Strategy per cent20for

per cent20South per cent20Australia per cent20- per cent20Jan per cent202012.pdf?t=1471227772522>.

Government of Western Australia a (2015) A Science Statement for Western Australia - Growing Western Australia. Viewed 12 August 2016,<https://www.dpc.wa.gov.au/science/Documents/DPC.statement.web.pdf>.

Government of Western Australia b (2016) Snapshots of Science in Western Australia-Education and Engagement. Viewed 12 August 2016<https://www.dpc.wa.gov.au/science/Documents/education.and.engagement.web.pdf>.

Hackling, MW, Prain, V (2005) Primary Connections: Stage 2 trial - Research report. Australian Academy of Science.

Hackling, MW, Prain, V (2008) Impact of Primary Connections on students' science processes, literacies of science and attitudes towards science. Australian Academy of Science.

Hackling, MW, Byrne, M, Gower, GC, Anderson, K (2015) A pedagogical model for engaging Aboriginal children with science learning. Teaching Science: The Journal of the Australian Science Teachers Association, 61(1).27-39.

Helme S & Lamb S (2011) Closing the school completion gap for Indigenous students. Resource sheet no. 6. Produced for the Closing the Gap Clearinghouse. AIHW Cat. no. IHW 38. Canberra: Australian Institute of Health and Welfare & Melbourne: Australian Institute of Family Studies. <http://www.aihw.gov.au/uploadedFiles/ClosingTheGap/Content/Publications/2011/ctgc-rs06.pdf>.

Hoogenraad, R (2001) Critical Reflections on the history of bilingual education in Central Australia. In Forty years on: Ken Hale and Australian Languages, edited by Jane Simpson, et. al. Canberra: Pacific Linguistics, p. 123-150

Johnson, S (2006) Indigenous Ecological Knowledge: A Northern Territory scoping study. Report for NT Natural Resource Management Board. Tropical Savanna CRC.

Luke, A, Cazden, C, Coopes, R, Klenowski, V, Ladwig, J, Lester, J MacDonald, S Phillips, J, Shield, P, Spina, N, Theroux, P, Tones, M, Villegas, M, &Woods, A (2013) A Summative Evaluation of the Stronger Smarter Learning Communities Project : Vol 1 and Vol 2. Abridged Version. Queensland University of Technology, Brisbane, QLD. <http://eprints.qut.edu.au/59535/27/SSLC_Evaluation_2013_Abridged_Version.pdf >

Marginson, S, Tytler, R, Freeman, B and Roberts, K (2013). STEM: Country comparisons. Report for the Australian Council of Learned Academies, www.acola.org.au<http://www.acola.org.au/PDF/SAF02Consultants/SAF02_STEM_ per cent20FINAL.pdf >

McConney, A, Oliver, M, Woods-McConney, A, & Schibeci, R (2011) Bridging the Gap? A Comparative, Retrospective Analysis of Science Literacy and Interest in Science for Indigenous and Non-Indigenous Australian Students. International Journal of Science Education, 33(14), 2017–2035.

Mulford B (2011) Teacher and school leader quality and sustainability. Resource sheet no. 5. Produced for the Closing the Gap Clearinghouse. AIHW Cat. no. IHW 39. Canberra: Australian Institute of Health and Welfare & Melbourne: Australian Institute of Family Studies. <http://www.aihw.gov.au/uploadedFiles/ClosingTheGap/Content/Publications/2011/ctgc-rs05.pdf>.

Nakata, M. (2002) Indigenous knowledge and the cultural interface. A. Hickling-Hudson, J. Matthews, & A. Woods, A.(Eds.), Disrupting preconceptions: Postcolonialism and education, 19-38.

Nakata, M. (2007) The Cultural Interface. The Australian Journal of Indigenous Education. Vol. 36. ISBN 9781864998856.

Nakata, M. (2010) The cultural interface of Islander and scientific knowledge. The Australian Journal of Indigenous Education, 39(S1), 53-57.

Nelson-Barber, S. (2013) US Indigenous STEM. Contributing paper to Marginson, Tytler, R., Freeman, B. & Roberts, K. STEM Country Comparisons. Melbourne, Australia: Australian Council of Learned Academies,<http://www.acola.org.au/PDF/ SAF02Consultants/Consultant Report - US Indigenous.pdf>.

New South Wales Government (2016) Encouraging Maths and Science at School. Viewed 12 August 2016, <https://www.nsw.gov.au/media-releases-premier/encouraging-maths-and-science-school>.

Northern Territory Government (2016) Agency Budget Statements 2016-2017. Viewed 15 August 2016,<https://budget.nt.gov.au/__data/assets/pdf_file/0008/277604/BP3-2016-17-book.pdf>.

Northern Territory Government (2002) Indigenous Languages and Culture. Viewed 15 August 2016,<https://education.nt.gov.au/__data/assets/pdf_file/0004/270337/indigenous_lang_cult.pdf>.

Office of the Chief Scientist (OCS) (2013) Science, Technology, Engineering and Mathematics in the National Interest: A strategic Approach. Viewed 12 August 2016,<http://www.chiefscientist.gov.au/wp-content/uploads/STEMstrategy290713FINALweb.pdf >

Office of the Chief Scientist (OCS) (2014a) Science, Technology, Engineering and Mathematics: Australia's Future. Viewed 12 August 2016,<http://

www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf>.

Office of the Chief Scientist (2014b) Benchmarking Australian Science, Technology, Engineering & Mathematics. Viewed 12 August 2016,<http://www.chiefscientist.gov.au/wp-content/uploads/BenchmarkingAustralianSTEM_Web_Nov2014.pdf>.

Office of the Chief Scientist (2016) Commonwealth of Australia, STEM Programme Index 2016. Compiled by the AiGroup with funding provided by the Office of the Chief Scientist.

Project Report March 2015, 6-monthly project report to BHP Foundation.

Project Report June 2016, quarterly project report to BHP Foundation

Queensland Government, Department of Education and Training (2016a) A strategy for STEM in Queensland state schools. Viewed 12 August 2016, <http://advancingeducation.qld.gov.au/SiteCollectionDocuments/schools-of-the-future-stem-strategy.pdf>.

Queensland Government (2016b) Science, Technology, Engineering and Mathematics (STEM). Viewed 12 August 2016, <http://www.education.qld.gov.au/stem/>.

Reconciliation Australia (2016) Reconciling the Nation: 2016 Federal Election Statement. Viewed 19 August 2016, <https://www.reconciliation.org.au/wp-content/uploads/2016/06/Reconciliation-Australia-2016-Federal-Election-Statement.pdf>.

Robinson, N (2008) Furniture please, says bush school at Hermannsburg. The Australian, Viewed 18 August 2016<http://www.theaustralian.com.au/news/furniture-please-says-bushschool/story-e6frg6po-1111116586817>.

Rushton, G, The Australian (2015) Indigenous graduation rate less than 50 per cent. Viewed 18 August 2016, <http://www.theaustralian.com.au/higher-education/disadvantaged-students-have-low-university-completion-rates/news-story/3e8501806124c5096a483b068f41d372>.

Sarra, G (2011) Indigenous mathematics: Creating an equitable learning environment. <http://research.acer.edu.au/cgi/viewcontent.cgi?arti cle=1118&context=research_conference>.

Steering Committee for the Review of Government Service Provision (SCRGSP) (2014) Overcoming Indigenous Disadvantage- Key Indicators 2014: Overview. Viewed 31 August 2016, <http://www.pc.gov.au/research/ongoing/overcoming-indigenous-disadvantage/key-indicators-2014/key-indicators-2014-overviewbooklet.pdf>.

Stronger Smarter Institute Limited (SSI) (2014). High-Expectations Relationships: a foundation for quality learning environments in all Australian schools. Stronger Smarter Institute Limited Position Paper.

Suntherland, D and Swayze, N (2011) The Importance of Place in Indigenous Science Education. Springer Science+Business Media B.V.

Tasmanian Government (2016) Budget 2016. Viewed 12 August 2016,<https://www.education.tas.gov.au/documentcentre/Documents/047_16_Factsheet_Overview_FA_Web.pdf>.

University of New South Wales (2016) Indigenous Students: Future Students. Viewed 12 August 2016,<http://www.nuragili.unsw.edu.au/future-students>.

University of Newcastle (2016) Closing the Gap on Indigenous STEM Education. Viewed 12 August 2016, <https://www.newcastle.edu.au/newsroom/featured-news/closing-the-gap-on-indigenous-stem-education>.

University of Queensland, Indigenous Australian Science and Infrastructure Development Winter School. Viewed 12 August 2016,<https://www.qut.edu.au/about/oodgeroo/indigenous-australian-science-and-infrastructure-development-winter-school>.

Victoria State Government (2015) Science, Technology, Engineering and Mathematics (STEM). Viewed 12 August 2016, <http://www.education.vic.gov.au/school/teachers/support/Pages/stem.aspx>.

Wellington, J and Osborne, J (2011) Language and Literacy in Science Education. Open University Press. Buckingham, Philadelphia.

Wilkins, D. (2008) W(h)ither language, culture and education in remote Indigenous communities of the Northern Territory? Viewed 19 October 2016,<http://www.australianreview.net/digest/2008/10/wilkins.html>.

Woods-McConney, A, Oliver, M, McConney, A, Schibeci, R and Maor, D (2013) Science Engagement and Literacy: A retrospective analysis for students in Canada and Australia. International Journal of Science Education, 36 (10). pp. 1588-1608. doi:10.1007/s11165-011-9265-y

YuMi Deadly Centre 2014. Overview: Philosophy, Pedagogy, Change and Culture, Version 2 29/04/2014. Brisbane: YuMi Deadly Centre, Queensland University of Techology.

Appendix A — Indicators and Research Questions

INDICATOR LEVEL	OUTCOME INDICATORS	RESEARCH QUESTIONS
Aspirational Goal*	Project participants employed in STEM professions	Has the project contributed to increased participation and achievement of Indigenous students in STEM careers?
Headline Indicators (overarching goal)	• Student enrolment in STEM subjects • Student engagement • Student attendance • Student results	1. Has the project contributed to increased participation of Indigenous students in STEM subjects? 2. Has the project contributed to increased achievement of Indigenous students in STEM subjects?
Supporting indicators (that contribute to overarching and aspirational goal)	• Student strength of cultural identity • Student aspiration and self-belief • Teacher capacity (professional & cultural) • High expectations (teacher, school, parents, community • Parent/Caregiver engagement • Community engagement	3. Has the project supported students in being strong in their cultural identity? 4. Have students a stronger connection between their cultural identity and their interest in science? 5. Has the project impacted on Indigenous students' attitudes, self-belief and aspirational goals towards science and science-related careers? 6. Has the project improved the capacity of teachers and Indigenous teacher assistants to teach science and mathematics to Indigenous students? 7. Has the project improved the capacity of teachers, Indigenous teacher assistants and schools to nurture the cultural identity of Indigenous students? 8. Has the project effectively engaged with families and communities to create a more supportive environment for students to pursue their STEM interests? 9. How has school leadership contributed to the achievement of the program elements goals?
Additional (unintended?) outcomes**	• Increased understanding of Indigenous people, their culture and Australian history by non-Indigenous students, teachers and schools • Better Indigenous/non-Indigenous relations (students, teacher, school, community)	10. Has the project contributed to reconciliation?

* The aspirational goal is beyond the timeframe of this project to be able to measure but is included for context
** As the program has developed reconciliation outcomes have been identified as an 'unintended consequence' of the project.

Appendix B — Program Element Program Logics

B.1 Science Pathways Logic Model

INPUTS	OUTPUTS: ACTIVITIES	OUTPUTS: PARTICIPATION
Staff Existing relationships with remote communities Tangentyere Council Land & Learning program and resources BHP Billiton relationships with communities I2S2 curriculum resources/procedures	Development of agreements with schools and key stakeholders Development of activity plans for schools (workplans) Development of resources On the job PD (teachers and teacher assistants) I2S2 curriculum resources/ procedures investigated and, if relevant, adapted for use On country activities Classroom activities	No. of agreements with schools. No. of partnerships developed in each site (e.g. ranger groups, elders, BHP Billiton, Parks and Wildlife) No. of schools with plans No. of partners involved in resource development Teacher/teacher assistant numbers No. of teachers using Student numbers Elders/ community member numbers No. of classes including observation and support by science pathways staff

ASSUMPTIONS

Local communities have rich cultural practices that can provide the content for STEM education.

The diversity of communities and jurisdictional differences mean that approaches will be customised to the specific circumstances of the communities. They include different histories and resources such as:

- the existence of local Indigenous ranger groups;
- presence of nearby national parks, reserves and IPAs;
- levels of involvement of Elders and other community members in teaching students about country.

There are many intricacies with engaging with communities and TEK. Therefore a substantial investment in partnership development is essential.

A key aim of the program is to identify localised pathways to support students to stay on country.

EXTERNAL FACTORS

NT has a strong emphasis on the Indigenous Land and Culture Program.

WA has a strong focus on partnering with ranger groups and other organisations (e.g. Parks and Wildlife, Greening Australia, EON Foundation)

In some communities literacy and numeracy are very low. Many communities are committed to Direct Instruction.

	OUTCOMES/IMPACT	
SHORT (1 YEAR)	**MEDIUM (2-4YEAR)**	**LONG (5+ YEARS)**
Strong effective partnerships established with schools and other stakeholders (e.g. Ranger organisations, Elders, Parks and Wildlife, Greening Australia, local BHP Billiton sites) These stakeholders supported to collaborate on the development of education resources into a cohesive community based curriculum and associated learning resources (WA) Development of tools and learning resources for on-country science activities – for example: • App/i-book template for collecting local data for school use • Learning Resources developed for bush foods & medicines, animal survey, waterhole monitoring activities These tools and resources to include clear identification where Western STEM knowledge and practice complements traditional cultural knowledge and practice Teacher capacity – both two-way science content, teaching skills and attitudinal (e.g. high expectations) Assistant teachers develop learning goals and progress to meeting these (e.g. lesson planning, confidence in presenting) (NT) Student attendance and engagement Training and employment pathways clearly articulated (e.g. certificate 1 and 2 Indigenous land management or Conservation Land Management; on to rangers, Parks and Wildlife, mining and/or tourism)(WA) Identification of factors affecting success of Science Pathways activities, based on previous experience (NT)	Increased capacity of schools to implement country specific culture and language programs rich in two-way science • Aboriginal Assistant Teachers, Elders, Rangers and other community members: - provide clear direction in learning program focus - regularly accompany students on-country - regularly engage in the school and modelling learning to students - impart cultural knowledge that complements STEM learning • Further resources developed and used (e.g. rationale; units of work; activities; assessment), with articulated links to the Australian Curriculum (WA) • Generic learning resources and PD program developed from culture specific resource (WA) Associated outcomes of increase in ranger and education assistants literacy/numeracy skills involved in the program (WA) Schools committed to science pathways actively supporting students applying to awards program and entering the teacher and school categories Teacher and Assistant Teacher (TA) capacity increasing including use of developed resources & training at biannual workshops for ATs (NT) Student attendance and engagement and results continue to improve • Students' self-esteem, confidence, aspirations and interest in science increasing; students' experience of school and understanding of its connections to Indigenous culture improved • Literacy and numeracy improvements in English and Indigenous language (WA) • Regional gatherings of highly engaged students – e.g. at SciTech (and linked to Awards) • Articulation into certificate programs deepening and students graduating and moving into employment (WA)	Schools using and developing integrated two way knowledge STEM learning programs that can be continued once the program finishes Documentation of the SP model(s) of engagement [promote to relevant stakeholders such as university teacher training; Departments of Education] Uptake by Departments of Education and other stakeholders Students transition into alternative STEM career pathways such as rangers, parks and wildlife, CSIRO cadet

B.2 I2S2 Logic Model

INPUTS
Staff • Experience as teacher • Experience as Indigenous student Conception of the program in response to identified gaps in Indigenous education Existing evidence on pedagogy Indigenous leadership of program development

OUTPUTS	
ACTIVITIES	PARTICIPATION
Recruitment of experienced Indigenous and non-Indigenous delivery team Meet jurisdictional, regional and school levels • Information sessions in respective areas Development of inquiries (hands on scientific inquiries with indigenous context) Alternative assessment methodologies development Development and implementation of TPD program Delivery of Indigenous Inquiry (1 per year during 1 term) Classroom observation by I2S2 staff Wikispace for resources Schools engagement with 'community' (Indigenous education workers, school 'aunties and uncles', parents and guardian of students, relevant Aboriginal organisations (e.g. land councils))	Gradual increase in I2S2 staff numbers Schools recruited: • No. of clusters • No. of schools • No. of classes • No. of students Number of teachers and Indigenous teacher assistant participation in PD, delivering inquiries and utilising alternative assessment methods No. of teachers using Number of community members engaged in schools

ASSUMPTIONS

Indigenous leadership is critical to program success including the development of Indigenous based inquiry.

Indigenous Assistant Teachers know the cultural context so are important partners. They may need capacity building in western science context.

Using multi-modal ways to demonstrate and improve success in science will encourage students to improve their literacy and encourage schools and teachers to raise their expectations.

To improve pathways to university we need to work with students through middle school and into year 10.

Both VET and university STEM pathways should be supported, tailored to individual student skills and aspirations.

EXTERNAL FACTORS

The Aboriginal and Torres Strait Islander cross curriculum priority is an important support for the program's focus on Indigenous context.

The level of non-Indigenous parental support for Indigenous content in schools is untested.

There is a lack of curriculum demonstrating Indigenous scientific inquiry skills.

Most teachers of Indigenous students are non-Indigenous so role modelling of high expectation STEM programs by non-Indigenous teachers is important.

Family support for education achievement varies.

There are systemic pressures that channel Indigenous students to VET.

OUTCOMES/IMPACT		
SHORT (1 YEAR)	MEDIUM (2-4YEAR)	LONG (5+ YEARS)
Student attendance engagement and results Students aspiration to do science Teacher capacity to deliver indigenous focused inquiry units – both curriculum content, pedagogy and attitudinal	Student attendance engagement and results Student thinking about subject selection in year 10 for year 11 and 12 (upper secondary) • In particular maths, physics, chemistry and biology • Need to be aware about prerequisites to get to university. • Significant numbers of I2S2 students applying for ASSETS • ASSETS deepen conversation of different career prerequisites Student aspirations, experience of school and support factors including culture Schools committed to I2S2 actively supporting students applying to awards program and entering the teacher and school categories Schools committed to I2S2 becoming more involved in other CSIRO programs (CREST, SMiS) Schools demonstrating stronger relationships with community Parental engagement increased	Increased enrolments in university STEM degrees Alternative STEM career options?

B.3 ASSETS Logic Model

INPUTS	OUTPUTS: ACTIVITIES	OUTPUTS: PARTICIPATION
Staff Pre-existing model for summer camp Academic providers – STEM professionals Accommodation providers Cultural providers (patrons) University and CSIRO resources at summer school sites (e.g. Wollotuka) Regional BHP Billiton careers experience	Summer Schools • Cultural program • STEM program including Indigenous science activities • Personal development • Leadership and support program materials Ongoing leadership and support program • Work experience placements • Networking events • Facebook engagement	Student numbers STEM professional numbers Cultural provider numbers (mentors, patrons) No. of applications Community and family involvement (in application process) Student numbers STEM professional numbers No. of schools represented (characteristics of schools – geography, %indigenous, SES) Student numbers in program, work experience placements, networking events and Facebook engagement

ASSUMPTIONS

Integrating academic high expectations with culture and personal development is the best pathway to success.

This program's focus on university pathways for STEM careers needs to accommodate possible alternate pathways.

EXTERNAL FACTORS

Students may wish to do science in years 11 and 12 but the classes may be unavailable

Some schools may not offer certain subjects

Importance of school experience in influencing education outcomes

OUTCOMES/IMPACT		
SHORT (1 YEAR)	MEDIUM (2-4YEAR)	LONG (5+ YEARS)
High levels of engagement in ASSETS summer schools High levels of engagement in ongoing leadership and support program High aspiration for STEM career Greater confidence in pursuing STEM career Greater confidence in cultural identity and the relevance of culture for STEM career (also medium outcome) Growth in cultural confidence Better understanding of career pathways Success in STEM subjects in Years 11-12 (also medium outcome) Participation in Awards program, CREST, BHP Science Awards (also medium outcome)	Increased enrolments in university STEM degrees • Alternative STEM career options? High aspiration for STEM career maintained (over time) Greater confidence maintained over time Growth in student networks Organisational networks growing Linking in with other STEM initiatives from partner organisations Completions of yr 11 and 12 STEM subjects with reference to prerequisites for university STEM courses (e.g. Maths B is a prerequisite for many sciences) Increasing participation in Awards program, CREST, BHP Science Awards, SMiS Increased school involvement in ASSETS/ awards programs and CREST, BHP Science awards, SMiS	High completion levels of university STEM courses Graduate jobs in STEM

B.4 BSc (Extended) Logic Model

INPUTS
Teaching staff from Faculties of Science, Engineering and Veterinary and Agricultural Sciences Science curriculum, with embedded scientific literacy, plus additional core units in mathematics and communication BA (Extended) experience University professional staff (student support): • Murrup Barak (Melbourne Institute for Indigenous Development) – also supports recruitment, and partnerships with local Indigenous organisations • Faculty of Science professional staff • Staff of other university student services • University's residential colleges

OUTPUTS	
ACTIVITIES	PARTICIPATION
• Student Recruitment • Residential component for 1st year • Teaching of BSc (extended) units (first two years) • Ongoing development of BSc(Ext) science and mathematics subject curriculum • Teaching of regular BSc units • Support for student engagement and resilience.	Student numbers Residential component engagement No. of teachers No. of teachers engaged in curriculum development No. of teachers Staff involved in student support Support activities

ASSUMPTIONS

The additional year of the BSc (extended) emphasises practical workshops and tailored academic support to provide a strong science foundation within a number of science, mathematics and communication subjects unique to the extended programs.

Cultural identity is supported through Murrup Barak, living in residence and through an increasing identification of relevant local Indigenous science knowledge experiences being incorporated into the curriculum.

EXTERNAL FACTORS

The BSc (Extended) caters for Indigenous students who do not meet current entry requirements for the standard, three-year Bachelor of Science program. Their interest in science or technology may have emerged later in their schooling, or their educational opportunities may have limited their capacity to be well-prepared to enter the BSc.

OUTCOMES/IMPACT		
SHORT (1 YEAR)	**MEDIUM (2-4YEAR)**	**LONG (5+ YEARS)**
Student attendance, engagement, progression and retention in STEM pathways Areas of curriculum refinement identified to integrate Indigenous science knowledge Student aspirations, experience of university and support factors including culture	Student attendance, engagement, progression and retention in STEM pathways (comparison with BSc students) Strong engagement with related opportunities (study abroad and exchange; scholarships, awards and prizes; volunteering and leadership opportunities) Curriculum refinement to integrate Indigenous science knowledge Students supported to apply to awards program University building stronger relationships/ partnerships re Indigenous science knowledge with local Indigenous organisations Student aspirations, experience of university and support factors including culture	Employment in STEM profession Further graduate study in STEM

B.5 PRIME Futures Logic Model

INPUTS
Staff YuMi Deadly Maths Resources Professional Development program

OUTPUTS	
ACTIVITIES	PARTICIPATION
Teacher professional development	No. teachers
Community Visits	No. community members
Principal surveys	% completion
Teacher surveys	% completion
Blackboard for resources and informal discussion	Number of teachers accessed
Cluster meetings	No. schools attend
Reflective journals	No. teachers submitting

ASSUMPTIONS

The PRIME Futures model is based on training a select group of teachers in the PRIME Futures methodology and for these individuals to train other teachers in their school. PRIME Futures data collection is likewise targeted at teachers and direct engagement of students is not undertaken by PRIME Futures staff. Any data provided about student performance, parental and community engagement will be based on teacher's reflections and presentations at the annual forum, voluntary reflective journals and postings to the on-line forum. CSIRO may however, work with PRIME Futures schools (supported by PRIME Futures staff) to recruit students into interviews, focus groups or surveys as part of the CSIRO led evaluation of the Indigenous STEM Education Project.

Similarly, student engagement in ASSETS and other CSIRO programs are not an outcome of the PRIME Futures program per se but will be monitored by CSIRO as part of evaluating the integration of the Indigenous STEM Education Project.

EXTERNAL FACTORS

NAPLAN: Evidence of improved numeracy in NAPLAN is a long term outcome for several reasons: (a) students are tested only once every two years; (b) point in time tests are unreliable unless the data shows that the change is sustained; (c) it takes almost a year for the data to be published after each test (for example, the data for the tests held in May 2015 was not published in the "My School" website until March 2016). Evidence of improvement is possible only between Years 3 to 5 and Years 7 to 9 because students change schools between Years 5 and 7.

<table>
<tr><th colspan="3">OUTCOMES/IMPACT</th></tr>
<tr><th>SHORT (1 YEAR)</th><th>MEDIUM (2-4YEAR)</th><th>LONG (5+ YEARS)</th></tr>
<tr><td>Teacher capacity – both curriculum content, pedagogy and attitudinal (e.g. high expectations)</td><td>Further increases in teacher capacity
Schools presenting well evidenced examples of student success at annual forum
Schools demonstrating stronger relationships with community
Parental engagement increased
Community engagement increased
Schools committed to Prime Futures actively supporting students applying to awards program and entering the teacher and school categories
Significant numbers of PRIME Futures students applying for ASSETS
Schools committed to PRIME Futures becoming more involved in other CSIRO programs (CREST, SMiS)</td><td>Increased enrolments in university STEM degrees
Alternative STEM career options
PRIME Futures schools showing evidence of improved numeracy in NAPLAN</td></tr>
</table>

B.6 Indigenous STEM Awards Logic Model

INPUTS	OUTPUTS	
	ACTIVITIES	PARTICIPATION
Staff Program elements participants (students, teachers and schools) CSIRO Network	Develop award categories (student, teacher, school, community) Develop application process Identify experiential awards	Indigenous STEM Education Project team No. of applications No of schools represented (characteristics of schools – geography, %indigenous, SES) Number of CSIRO (and partner) STEM Professionals and sites identifying awards

ASSUMPTIONS

Providing recognition to students, teachers and schools for excellence is central to the strength based philosophy underpinning the Indigenous STEM Education Project.

EXTERNAL FACTORS

Discussions with BHPBF have suggested an openness to explore creative models for this awards program – i.e. not to just replicate the BHPB Science and Engineering Awards model.

OUTCOMES/IMPACT		
SHORT (1 YEAR)	MEDIUM (2-4YEAR)	LONG (5+ YEARS)
Strong engagement in Awards program by all program elements	Increasing levels of Engagement in Awards program by all program elements Increasing participation of students and schools in other CSIRO programs – e.g. CREST, BHPB Science Awards, SMiS Applicants and award winners showing: • High aspiration for STEM career maintained (over time) • Success in STEM subjects in Years 11-12 • high enrolments in university STEM degrees	Awards seen a significant motivator and affirmation for choices made to pursue upper secondary and university STEM courses and STEM careers

Appendix C – Monitoring and Evaluation Data

Monitoring and evaluation data by program element and additional research processes

		I2S2	SCIENCE PATHWAYS
Program Element Monitoring - used for regular (mostly annual) CQI processes and Program reporting to BHPB Foundation Program reports used for evaluation and individual records further analysed where given individual consent	Student	Engagement	Engagement: Jointly assess with teacher engagement on camp and contrast with teacher assessment of engagement in the classroom
		Attendance	Attendance: when doing activities (2 or 3 times a term) Contrast with 'usual' attendance (teacher or assistant teacher)
		Results	Note: Language and culture component often not assessed (NT) SP WA to develop assessment rubric (e.g. adapt I2S2) and seek agreement from schools to implement
		Subject selection (upper years non-compulsory)	
	Teacher (and assistant teacher)	Pre/post PD including attendance and engagement	On the job PD (no. of staff trained and SP staff assessment of teacher engagement) Did teacher do lessons when SP staff not there (Yes/No and if yes how many?)
		Classroom observation (e.g. by I2S2 staff) and feedback (reflective reports) including teacher assistant engagement	
	School/University	School plans/ strategies (document analysis)	Program becomes integrated into school plans, strategies and/or curriculum documents.
		I2S2/science pathways staff, Principal and teacher reflections on Parent and community engagement	
Additional Research processes – this will allow a deeper understanding of success factors or obstacles to the aims of the program elements as well as how the elements inter-relate and contribute to the project as a whole.	Student	Survey (aspirations, experience of school and support factors including culture)	Interviews with students (with teacher assistant present)

	PRIME FUTURES	ASSETS , EXCELLENCE AWARDS	BSC EXTENDED
	Nil	Application	Application numbers from potentially qualified applicants
		Pre/post survey - summer camp	Enrolments
		Subject selection 11 and 12	Progression in degree and retention in STEM pathways
		Results 11 and 12	Engagement in cultural support
		Course selection university/post school directions	Aspirations and employment
	Pre/post PD including attendance and engagement		
	Reflective journals (annual)		
	Post PD report by cluster coordinator		
	Post-school visit by cluster coordinator		
	Analysis of the use of Blackboard		
	School plans/strategies (document analysis		
	Annual forum showcasing success		
	Principal questionnaire – community and caregiver involvement; use of YDM methods; school planning; challenges (6 monthly)		
		Survey (aspirations, experience of school and support factors including culture) • Include questions about student involvement in Prime Futures and I2S2 where relevant	Survey (aspirations, experience of university and support factors including culture)

		I2S2	SCIENCE PATHWAYS
Results will also be fed back to program elements on an annual basis as well as data sets are analysed		Focus group/individual interview (as above)	
		Classroom discussion (as above)	Classroom observation
	Teacher	Survey (assess growth in ability and confidence, attitudes)	
		Interview/focus group (as above)	Individual interviews with teachers and/or teacher assistants (with SP staff member if necessary)
	School/ university	Parent and community engagement (possible focus groups or interviews)	
		School plans/structural changes	School plans/strategies (Document analysis if applicable)
		Principal survey/interview (uptake by teachers, community/care-giver engagement and perceptions of impact)	Interview
			Selected case studies (twice during program)

	PRIME FUTURES	ASSETS , EXCELLENCE AWARDS	BSC EXTENDED
		Focus group/ individual interview (as above)	Focus group/individual interview (as above)
		Case studies of award winners	
	Group discussions in PD		Interview/focus group (as above)
	Group interviews of community members (during school visits)	Interviews with schools (principal or science head) that nominate significant numbers of students - Include questions about Prime Futures and I2S2 where relevant	Sustainability and ongoing commitment in the university's Indigenous Student Plan (recruitment, high-quality student experience, culturally safe environment, realising Indigenous student capabilities)
	School plans/strategies (document analysis) - As a result of PRIME Futures	Include questions about student involvement in Prime Futures and I2S2 where relevant	
		Case studies of award winners	

Appendix D — Interview Questions

Interview Questions – Evaluation Report 2016

1. What has your previous work roles and other experience taught you about working in Indigenous education in general and this role in particular?

2. Reflecting on both the program element program logic and your experience of implementing the program:

   a. How would you describe the element?
   b. What have been:
      xi. the key highlights
      xii. challenges
   a. What are some of emerging trends re participation and take up?
   b. What makes this unique and important?
   c. How important are partnerships with other organisations in the delivery of your program element?” Please describe the key features of these partnerships.
   d. In your view is the program logic achievable?

1. Attached is Table 1 [refer Appendix A] from the Project monitoring and evaluation plan which you had input into previously. In it we have identified 10 research questions relating to:

   a. Increasing Aboriginal and Torres Strait Islander students participation and achievement in STEM subjects
   b. Supporting Aboriginal and Torres Strait Islander student cultural identity and the link between that identity and science knowledge
   c. Improving the capacity of teachers to effectively teach Aboriginal and Torres Strait Islander students
   d. The creation of supportive environments for Aboriginal and Torres Strait Islander students’ science interest at home, school and within peer groups.
   e. Do you see any flaws or have suggestions to improve the current program logic?
   f. Have there been any unintended outcomes?

2. What do you see as the potential for success of the program?

3. What do you see as the potential barriers to the success of the program?

4. What program monitoring processes have you established? How effective have they been to supporting the goals of the program?

5. Do you have any thoughts on how this program could be sustainable beyond the current funding?

6. Is there anything else you’d like to say about the program?

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We innovate for tomorrow and help improve today – for our customers, all Australians and the world.

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