Strengthening Indigenous Participation and Practice in STEM: University Initiatives for Equity and Excellence

Kathryn Paige, Robert Hattam, Lester-Irabinna Rigney, Sam Osborne & Anne Morrison
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- Aboriginal Summer School for Excellence in Technology and Science (ASSETS)
- Charles Darwin University
- Curtin University: Indigenous Australian Engineering Summer School
- UniSA College
- University of Newcastle
- Western Sydney University

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## Contents

**Executive Summary** vi

**Introduction** 1

**Literature Review** 6

**Case studies**

- Aboriginal Summer School for Excellence in Technology and Science 27
- Charles Darwin University 44
- Curtin University: Indigenous Australian Engineering Summer School 54
- UniSA College 69
- University of Newcastle 80
- Western Sydney University 90

**Conclusion and future directions** 97

**References** 108

**Appendix** 120
Authors

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Robert Hattam is an Associate Professor in the School of Education, University of South Australia. His research focuses on teachers’ work, educational leadership, critical and reconciliation pedagogies, refugees, and school reform. His research program includes: (i) school based studies that engage with teachers as they attempt to redesign pedagogical practices in response to their own existential classroom challenges and provocations for more justice; (ii) cultural studies in hopeful sites of public pedagogy of new social movements and especially socially-engaged Buddhism and ‘reconciliation’ broadly defined; and (iii) philosophical investigations into friendship, forgiveness, hospitality and conviviality. He has published in a range of international journals including Sociology, Pedagogy, Culture and Society, British Journal of Sociology of Education, British Educational Research Journal, Social Identities, Critical Studies in Education, and Discourse: Studies in the Cultural Politics of Education. He has been involved in book projects with others that include: Schooling for a Fair Go, Teachers’ Work in a Globalising Economy, Dropping Out, Drifting Off, Being Excluded: Becoming Somebody Without School, Connecting Lives and Learning, and Pedagogies for Reconciliation. He also has published a book entitled Awakening-Struggle: Towards a Buddhist Critical Theory.

Professor Lester-Irabinna Rigney is Professor of Aboriginal Education in the Centre for Research in Education at University of South Australia. He is a registered teacher and has worked in Aboriginal schooling and Education for over 20 years. Professor Rigney is the former Dean and Director of Wirltu Yarlu Aboriginal Education at the University of Adelaide and the Director of the Yunggorendi First Nations Centre at Flinders University. Professor Rigney has been a research member of several high
profile expert committees including the Longitudinal Study of Indigenous Children, the Australian Institute of Health and Welfare Scientific Experts Reference Group; the Australian Curriculum and Assessment Reporting Authority; the National Languages Curriculum Reference Group; the Ethics Council for the National Congress of Australia’s First Peoples; the First Peoples Education Advisory Group; the Australian Institute for Aboriginal and Torres Strait Islander Studies Research Advisory Committee; and an Australian Ambassador for Aboriginal Education. Professor Rigney is recognised as a national and international authority in the area of Indigenist Research Methodologies. Interest in his work has resulted in several visiting scholar positions including at Cambridge University, UK; Fort Hare University, South Africa; and University of British Columbia, Canada. He has been chief/co-investigator and led research teams for key benchmarking research/government agencies including: United Nations; DEEWR; NCVER; AIATSIS; the Office of the South Australia Premier and Cabinet; and the South Australia Department of Education and Children’s Services. Professor Rigney holds several prestigious awards including membership of the Australian College of Educators (1998); a United Nations award for his work on Indigenous Education (2009); and the National Aboriginal Scholar of the Year, NAIDOC (2011). Professor Rigney is in constant demand as a commentator on national and international Indigenous matters and has published widely on education, languages and knowledge transmission and is an active editorial board member on several national and international Indigenous Studies journals.

**Sam Osborne** has worked in Aboriginal Education and Aboriginal languages since 1995, including Deputy and Principal at Ernabella Anangu School in the remote north-west of South Australia. Since that time he has worked as the Central Australian consultant for the Principal Australia Institute program *Dare to Lead* and has taken on a number of consulting, research and corporation interpreting roles across Central Australia. Since 2011, he worked as a Senior Research Fellow at UniSA within the Cooperative Research Centre for Remote Economic Participation (CRC-REP) and has submitted his PhD Thesis for examination focussing on remote education in the remote tri-state area. He is currently working as a lecturer in HaSS (Humanities and Social Science) and is involved in Indigenous Education Research.

**Dr Anne Morrison** is a research assistant at the University of South Australia, working primarily in the School of Education. Since completing her doctoral degree in Linguistics and Professional Writing and Communication in 2008, she has provided research and editorial support to diverse projects. More recently, she has worked with Kaurna Elder Uncle Lewis O’Brien on an ARC Discovery Project entitled *Indigenous Knowledges: Water Sustainability and Wild Fire Mitigation.*
**Terminology**
Throughout this report, the term Indigenous is used to refer to Aboriginal and Torres Strait Islander peoples.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AAMT</td>
<td>Australian Association for Mathematics Teachers</td>
</tr>
<tr>
<td>ACIKE</td>
<td>Australian Centre for Indigenous Knowledges and Education</td>
</tr>
<tr>
<td>AIME</td>
<td>Australian Indigenous Mentoring Experience</td>
</tr>
<tr>
<td>ALEC</td>
<td>Arid Lands Environment Centre</td>
</tr>
<tr>
<td>ASSETS</td>
<td>Aboriginal Summer School for Excellence in Technology and Science</td>
</tr>
<tr>
<td>ATAR</td>
<td>Australian Tertiary Admissions Rank</td>
</tr>
<tr>
<td>BIITE</td>
<td>Batchelor Institute of Indigenous Tertiary Education</td>
</tr>
<tr>
<td>CDU</td>
<td>Charles Darwin University</td>
</tr>
<tr>
<td>CRP</td>
<td>Culturally responsive pedagogy</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>DEMO</td>
<td>Design and Evaluation Matrix for Outreach</td>
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<tr>
<td>DEMUE</td>
<td>Design and Research Matrix for University Equity</td>
</tr>
<tr>
<td>EAA</td>
<td>Engineering Aid Australia</td>
</tr>
<tr>
<td>HEPPP</td>
<td>Higher Education Participation and Partnerships Programme</td>
</tr>
<tr>
<td>IAEPP</td>
<td>Indigenous Australian Engineering Pathway Program</td>
</tr>
<tr>
<td>IAESS</td>
<td>Indigenous Australian Engineering Summer School</td>
</tr>
<tr>
<td>NAILSMA</td>
<td>North Australian Indigenous Land and Sea Management Alliance Ltd.</td>
</tr>
<tr>
<td>NAPLAN</td>
<td>National Assessment Program: Literacy and Numeracy</td>
</tr>
<tr>
<td>PBL</td>
<td>Problem-based learning</td>
</tr>
<tr>
<td>PISA</td>
<td>Programme for International Student Assessment</td>
</tr>
<tr>
<td>SES</td>
<td>Socioeconomic status</td>
</tr>
<tr>
<td>SiMERR</td>
<td>The National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
</tr>
<tr>
<td>UniSA</td>
<td>University of South Australia</td>
</tr>
<tr>
<td>VET</td>
<td>Vocational education and training</td>
</tr>
<tr>
<td>WINHEC</td>
<td>World Indigenous Nations Higher Education Consortium</td>
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<tr>
<td>WCE</td>
<td>Whole of Community Engagement initiative</td>
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</tbody>
</table>
Executive summary

*Excellence and Equity in Mathematics* [xe] aims to understand how Australian universities are currently developing initiatives to improve successful Higher Education study pathways for Indigenous students in the disciplines underpinned by science and mathematics. This project arises in response to the substantial under-representation of Indigenous students studying science, technology, engineering and mathematics (STEM) subjects in Australian universities.

For Indigenous students, school completion rates and transition-to-university statistics, particularly in STEM-related programs, remain significantly lower than for their non-Indigenous peers. Indigenous student enrolments in fields requiring strong mathematics and scientific literacy are low in relation to other disciplines, whereas more visible and longer-established disciplines within Indigenous communities such as Arts, Education and Society and Culture enjoy much higher rates of student participation. Recently, there has been some progress in raising awareness and encouraging collaborative pro-action in relation to Indigenous participation in STEM-related disciplines, evidenced in conferences and summits bringing together Indigenous Community leaders, educators and other stakeholders in order to develop co-ordinated strategies to improve opportunities and outcomes for Indigenous peoples in STEM-related disciplines and careers.

In the education sector, key issues relating to Indigenous participation and achievement in formal STEM include:

- Indigenous participation and achievement in literacy and numeracy programs that underpin Western scientific and mathematics conceptual development and understanding
- potential mismatches between the epistemological, ontological and cosmological contexts of Indigenous Knowledges and institutionally located Western STEM ‘cultures’ and worldviews, including the philosophical foundations of notions of aspiration and success
- unfamiliar, unsupportive and challenging university cultures, particularly in STEM disciplines

This report details six cases studies that demonstrate hopeful initiatives by the Higher Education sector that support the [xe] project’s aims. Potential sites and programs of interest were determined using a desktop scan of all Australian university websites for evidence of STEM initiatives for Indigenous students. In considering potential case study sites, several factors were taken into consideration, including national distribution, geolocation, diversity of programmes, and availability to take part in the research. The six case study sites and initiatives are summarised in Table 1:
Table 1: Overview of the six case study sites and their characteristics

<table>
<thead>
<tr>
<th>Aboriginal Summer School for Excellence in Technology and Science (ASSETS)</th>
<th>Core features</th>
<th>Engagement strategy:</th>
<th>Annual residential summer school (10 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student catchment:</td>
<td>Australia-wide with merit-based student selection process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age-group:</td>
<td>Years 10-11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funding source:</td>
<td>Philanthropic (including BHP Billiton Foundation)</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>Of the 20 participants in the 2008 summer school, 14 were contacted in 2010: 7 studying at university; 1 working full-time and studying part-time; 3 in full-time careers; 2 trade apprenticeships; 1 traineeship with TAFE study.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenges</td>
<td>Ongoing support for ASSETS participants during their final years of schooling through transition to university. Competition with other science summer schools. Requires ongoing financial investment to ensure continuity and sustainability.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Charles Darwin University</th>
<th>Core features</th>
<th>Engagement strategy:</th>
<th>Various programs, including Whole of Community Engagement (WCE) initiative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student catchment:</td>
<td>Within a national and international student body, WCE is specifically focused on remote Indigenous communities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age group:</td>
<td>Senior schooling to post-school</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funding source:</td>
<td>WCE funded via HEPPP</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>WCE aims to increase remote Indigenous student access to CDU’s VET and Higher Education courses. Community-based forums, staff and community relationships are well-established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths</td>
<td>Partnerships with a diverse range of institutions. Programs engage dual epistemological scientific approaches within a ‘both ways’ philosophy. Local communities, knowledges and potential students are engaging with the university.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenges</td>
<td>Strategic marketing attracts high-achieving Indigenous students to interstate universities. Lack of appropriate subsidies to mitigate the high cost of living in Darwin for students attending university, among other concerns. The WCE program sits within a long-term plan that is unlikely to remain viable without HEPPP funding.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Curtin University: Indigenous Australian Engineering Summer School (IAESS)</th>
<th>Core features</th>
<th>Engagement strategy:</th>
<th>Annual residential summer school</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student catchment:</td>
<td>Mainly Western Australia (targeting remote areas)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age-group:</td>
<td>Years 9-12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Funding source:</td>
<td>Philanthropic (Engineering Aid Australia) and HEPPP</td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>2014 survey data found: 95% of the students said they felt IAESS was valuable; 90% said their perception of engineering had improved; 75% said it increased their interest in studying engineering at university. Started in 2010; now in 6th year. 20-25 students each year. Academically supported exciting and educational activities. First student from program now enrolled in engineering.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenges</td>
<td>Long term financial sustainability. Availability of participants. Co-operating, rather than competing with other similar programs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Executive summary

**Table 1:** Overview of the six case study sites and their characteristics (continued …)

<table>
<thead>
<tr>
<th>UniSA College</th>
<th>Engagement strategy:</th>
<th>Multiple strategies. Alternative pathway to University. Collaboration with schools to co-design targeted STEM programs; workshops on specific STEM themes; STEM tutorial program.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student catchment:</td>
<td>Primarily northern and western suburbs of Adelaide</td>
<td></td>
</tr>
<tr>
<td>Age-group:</td>
<td>STEM engagement strategies target Years 10, 11, 12</td>
<td></td>
</tr>
<tr>
<td>Funding source:</td>
<td>HEPPP funding</td>
<td></td>
</tr>
</tbody>
</table>

**Outcomes**

UniSA College is establishing an *Indigenous Participation Pathways Program* in Mt Gambier, Ceduna, Port Lincoln, Whyalla, and for the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands students as a new way of delivering Foundation Studies. Introduced the AIME (Australian Indigenous Mentoring Experience) program, and in 2015 there were 350 student mentors.

**Strengths**

Underpinned by a University-wide equity strategy. Focus on engaging with groups who are under-represented at university. Enrichment program for secondary Mathematics/Science teachers to build capacity. *Year 12 STEM Tutorial Program*: free revision programs in Physics, Chemistry, Mathematics Studies, and Biology offered to students from low SES schools. Links developed with the South Australian Aboriginal Sports Training Academy, using sport to engage Indigenous youth with mathematics and science.

**Challenges**

Sustainability post-HEPPP funding.

<table>
<thead>
<tr>
<th>University of Newcastle</th>
<th>Engagement strategy:</th>
<th>School engagement programs and pre-entry to medicine program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student catchment:</td>
<td>Regional NSW</td>
<td></td>
</tr>
<tr>
<td>Age-group:</td>
<td>Year 4-12 and transition to university.</td>
<td></td>
</tr>
<tr>
<td>Funding source:</td>
<td>HEPPP funding</td>
<td></td>
</tr>
</tbody>
</table>

**Outcomes**

High levels of retention of medical students through training to completion and employment.

**Strengths**

Underpinned by a University-wide equity strategy. School engagement programs free to students with cohesive sequential activities starting early. Wollotuka Institute provides a rich and culturally appropriate supportive environment for students transitioning to university. Pre-entry to medicine: off-campus events to strengthen connections between students and staff. Strong focus on engaging with and giving back to community.

**Challenges**

Sustainability post-HEPPP funding.

<table>
<thead>
<tr>
<th>Western Sydney University</th>
<th>Engagement strategy:</th>
<th>School engagement programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student catchment:</td>
<td>Outer Sydney and regional NSW</td>
<td></td>
</tr>
<tr>
<td>Age-group:</td>
<td>Starting Year 3-4, currently through to Year 10 (Year 11-12 program under development)</td>
<td></td>
</tr>
<tr>
<td>Funding source:</td>
<td>Primarily HEPPP funding and philanthropic</td>
<td></td>
</tr>
</tbody>
</table>

**Outcomes**

Engagement program has not been running long enough to have students complete to university entry age. In 2015, 452 students from 22 schools participated in *the Pathways To Dreaming* program. A website was launched in 2015 featuring an interactive educational game called *Lightning Runners* which draws on traditional Indigenous knowledge and sustainability, linked to Heartbeat’s themes. Since 2010, over 1,300 students have taken part in Heartbeat.

**Strengths**

Range of inter-connected programs that build capacity for university study and familiarity with the university environment. Extensive consultation with communities, Aboriginal Elders and educators through an Engagement Plan which responds to community needs.

**Challenges**

Sustainability post-HEPPP funding.
Together, these case studies support the need for a number of policy and practice reforms.

Reform strategies for Indigenous STEM programs

- **Stabilising strategies**
  Stabilise all existing university Indigenous STEM outreach/engagement programs and personnel via new and existing funding sources. Human resources and financial support is required for the continuation of all existing programs.

- **Growth strategies**
  Expand university Indigenous STEM outreach/engagement programs via financial investment. Develop multi-site programs across schools, universities, and Indigenous communities in every state and territory that cater for urban, rural and remote jurisdictions. Currently the total number of university Indigenous STEM engagement programs is limited. There are no STEM programs run by Indigenous Communities.

High-impact priorities for Australian policy makers

Policy priorities of strategic importance in strengthening success of Indigenous STEM participation include:

- Develop a National policy and strategy on Indigenous STEM.
- Embed Indigenous STEM workforce targets in the Federal Government’s *National Innovation and Science Agenda*.
- Improve Indigenous school completion, numeracy and literacy rates (as advocated in *Closing the Gap* policy).
- Fund the continuation of Indigenous STEM outreach/engagement programs in universities via the Higher Education Participation and Partnerships Programme.
- Foster research to address the under-representation of Indigenous peoples within the STEM workforce.
- Support STEM Programs within Indigenous communities.
- Establish partnerships with Indigenous communities to address STEM learning.

A blueprint for research

At present, Australia lacks a coherent and coordinated policy-focused research agenda to inform the delivery of Indigenous STEM education and ultimately, jobs. The following research priorities are proposed:
Executive summary

- Improve measures and data collection for multiple sector purposes (school, university, adult education).
- Collect baseline data and monitor for changes over time.
- Fund high quality international comparative studies of Indigenous STEM research.
- Establish a website and data-base encapsulating existing Australian Indigenous STEM programs.
- Pilot Indigenous STEM collaborations between schools and universities programs of sufficient breadth to inform decisions about scaling up.
- Develop new culturally relevant STEM curricula, pedagogy, assessment, and teacher preparation programs.
- Research Indigenous parent and community involvement in STEM.
- Resource STEM research that works across dual-epistemological spaces and methodologically privileges Indigenous Knowledge, peoples and priorities.
Introduction

Aims

*Excellence and Equity in Mathematics* [xe] is a national initiative that aims to foster mathematics excellence and equity in schooling outcomes and Higher Education participation for Indigenous students, specifically to:

- improve Indigenous school student participation and achievement in mathematics and numeracy education; and

- increase the number of Indigenous young people with the aspirations and capability to undertake university study in Science, Technology, Engineering and Mathematics (STEM) disciplines.

The [xe] project aims to understand how Australian universities are currently developing initiatives to improve successful Higher Education study pathways for Indigenous students in the disciplines underpinned by science and mathematics.

The Indigenous school-to-university STEM trajectory

Across the world, STEM is of significant importance in education and the economy in ways that few other disciplines are. Being capable in STEM is now seen as key to productivity, technological adaptation and research-based innovation (see, for example, Pyne 2007; Office of the Chief Scientist 2014; Australian Industry Group 2015) Indeed, no other area of education has significant attention as the STEM disciplines in recent times, but there is a dearth of research about STEM policy, participation, programs and practice. Significantly for this research, there is also little known about the engagement of Indigenous peoples in STEM disciplines.

There is serious concern globally and in Australia regarding the apparent decline in both achievement and in participation in STEM learning in the later years of high school and in universities (Kennedy, Lyons & Quinn 2014; Wilson, Dalton & Baumann 2015). This research and the *Excellence and Equity in Mathematics* project arises in response to the substantial under-representation of Indigenous students studying STEM subjects in universities in Australia.

For Indigenous students, school completion rates and transition-to-university statistics, particularly in STEM-related programs, remain significantly lower than for their non-Indigenous peers (Dreise & Thomson 2014, p. 3). Improving literacy and numeracy is considered to be one fundamental element to increasing Indigenous participation in STEM at university, while other initiatives work from the belief that programs traditionally not prioritised by Indigenous students need to become more visible and orientation to these relatively unfamiliar programs made available (University of Notre Dame 2016). According to National Assessment Program: Literacy and Numeracy (NAPLAN) data, at Year 3 the mean scores for literacy and numeracy are already
measurably lower for Indigenous students when compared to non-Indigenous students (ACARA 2015, p. 63). At Year 7, ‘In all achievement domains and for all jurisdictions, the mean scale score for Indigenous students is substantially below the mean scale score for non-Indigenous students. (ACARA 2015, p. 191).

The disparity persists into secondary schooling. At age 15, the mean score for Indigenous students is significantly lower than the OECD average as determined by the Programme for International Student Assessment (PISA) (Thomson, De Bortoli & Buckley 2013, pp. 35-36). On average, Indigenous 15-year-olds are approximately two-and-a-half years behind their non-Indigenous peers in regard to scientific, reading and mathematical literacy (Dreise & Thomson 2014, p. 1). Nevertheless, in relation to STEM subjects, PISA data indicates that Indigenous students value mathematics (Thomson, De Bortoli & Buckley 2013, p. 248), and are more interested in contextualised science content (Woods-McConney et al. 2013, pp. 244-245) than their non-Indigenous peers.

In terms of university participation, recent data confirms that Indigenous student enrolments in fields requiring strong mathematics and science literacy (such as Natural and Physical Sciences, Engineering, Architecture and Agriculture) are low in relation to other disciplines, with the exception of Health (see Figure 1), whereas more visible and longer-established disciplines within Indigenous communities such as Arts, Education and Society and Culture enjoy much higher rates of student participation.

![Figure 1: Commencing and all Indigenous students in Higher Education courses by broad field of education, 2014. Source: The Department of Education and Training, Australian Government Statistics Collection](image-url)
In recent years, there has been some progress in raising awareness and encouraging collaborative pro-action in relation to Indigenous participation in STEM-related disciplines. For example, in November 2014, the recently formed Australian and Torres Strait Islander Mathematics Alliance held its inaugural conference, bringing together Community leaders, educators and the business sector ‘to consider ways forward to improving the mathematics outcomes of Aboriginal and Torres Strait Islander students, and hence life opportunities’ (ATSIMA n.d., p. 1). The first National Indigenous Engineering Summit was held at the University of Melbourne in June 2015 as part of the Federally-funded Indigenous Engineers: Partners for Pathways program. This summit brought together a range of stakeholders ‘to exchange ideas and develop strategies for creating and supporting pathways that will assist Indigenous Australians into the engineering profession’ (Prpic 2015, p. 2).

Initiatives such as these ultimately aim to improve opportunities and outcomes for Indigenous peoples in STEM-related disciplines and careers. In the education sector, key issues relating to Indigenous participation and achievement in formal STEM include:

- Indigenous participation and achievement in literacy and numeracy programs that underpin Western scientific and mathematics conceptual development and understanding (De Bortoli & Thomson 2010)
- potential mismatches between the epistemological, ontological and cosmological contexts of Indigenous Knowledges and institutionally located Western STEM ‘cultures’ and worldviews (Minutjukur & Osborne 2014; Nakata 2007a; Rigney & Hemming 2014; Verran 2005; Yunupingu 1999), including the philosophical foundations of notions of aspiration and success (Appadurai 2004; Burton & Osborne 2014; Osborne & Guenther 2013).
- unfamiliar, unsupportive and challenging university cultures, particularly in STEM disciplines (Bunda, Zipin & Brennan 2012; Hall & Wilkes 2015; Nakata 2007b).

**Methodology**

This research adopted a case study approach (Stake 1994) to examine university exemplars. Case study is understood as a reputable qualitative methodology and, borrowing from Stake (1994), has the following characteristics:

- bounding the case, conceptualising the object of study
- selecting phenomena, themes, or issues, that is, the research questions to emphasise
- seeking patterns of data to develop the issues
- triangulating key observations
- selecting alternative interpretations
Introduction

- developing assertions or generalisations

Potential sites and programs of interest were determined by a desktop scan of all Australian university websites for evidence of STEM initiatives for Indigenous students. In considering potential case study sites, several factors were taken into consideration:

- National distribution (case study sites distributed across the nation, rather than clustered in particular states or territories)
- Geolocation (for example, case study sites are not all inner metropolitan)
- Diversity (case study sites have differing strategies in terms of the programs offered)
- Availability (case study site is willing to participate in the research and has relevant staff available for interview)

Based on these criteria, the following sites/initiatives participated in the case studies:

- Aboriginal Summer School for Excellence in Technology and Science (ASSETS)
- Charles Darwin University
- Curtin University, Indigenous Australian Engineering Summer School
- UniSA College, Indigenous STEM
- University of Newcastle
- Western Sydney University

Prior to conducting the case study site research, an ethics proposal was submitted to the University of South Australia Human Research Ethics Committee and approval was granted.

The researchers interviewed key staff at each of six selected sites (either face-to-face or by telephone), including program providers and program leaders. The semi-structured interviews were informed by Burgess’s (1998) notion of the ‘purposeful conversation’ with the ‘interview’ proceeding through dialogue with the participants, and especially taking up opportunities for ongoing clarification and elaboration. With the permission of the participants, interviews were audio-recorded and later transcribed. In addition, any relevant documents (brochures, schedules, evaluations) were collected. Drafts of the case studies were sent to participants for feedback and to check for accuracy.

In conducting the case studies, consideration was given to Australian research by Gale and colleagues (2010) who proposed a Design and Evaluation Matrix for Outreach (DEMO). This matrix identifies ten characteristics grouped into four strategies that underpin successful university outreach/engagement programs for improving participation at university for low SES communities. The DEMO matrix is shown in Figure 2.
Introduction

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td><strong>Assembling Resources:</strong></td>
<td>People rich</td>
</tr>
<tr>
<td></td>
<td>Financial support and/or incentives</td>
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<tr>
<td></td>
<td>Early, long-term, sustained</td>
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<tr>
<td><strong>Engaging learners:</strong></td>
<td>Recognition of difference</td>
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<tr>
<td></td>
<td>Enhanced academic curriculum</td>
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<td></td>
<td>Research driven</td>
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<tr>
<td><strong>Working together:</strong></td>
<td>Collaboration</td>
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<td></td>
<td>Cohort-based</td>
</tr>
<tr>
<td><strong>Building confidence:</strong></td>
<td>Communication and information</td>
</tr>
<tr>
<td></td>
<td>Familiarisation/site experiences</td>
</tr>
</tbody>
</table>

*Figure 2: Design and Evaluation Matrix for Outreach (DEMO) (after Gale et al. 2010, p. 8)*

Gale et al. (2010) also identified a further three themes that underpin equity perspectives of successful university initiatives with schools:

*Unsettling deficit views*: Working with, rather than on, others based on positive understanding of historically disadvantaged schools, students and their communities.

*Researching ‘local knowledge’ and negotiating local interventions*: Research about ‘local knowledge’ is a key feature of interventions and university equity policy. This necessarily involves building viable relationships with specific schools and their communities and learning about their understanding of the ‘problem’ as a preliminary step to designing interventions.

*Building capacity in communities, schools and universities*: Achieving improved outcomes for disadvantaged students requires building increased capacity in communities, schools and universities, including increased funding for programs from sources such as state and federal governments and further supplementary funding from individual universities. Capacity building programs that aim to familiarise students and their parents with university are about developing cultures of possibility.

The DEMO matrix and these three further themes have provided a framework against which to consider each of the case study sites.
Literature review

Introduction

This literature review has been developed as part of the Excellence and Equity in Mathematics [xe] project, a national initiative that aims to foster mathematics excellence and equity in both schooling outcomes and Higher Education participation for Indigenous students. In particular the project aims to improve student participation and achievement in mathematics and numeracy education; and increase the number of Indigenous young people who have the aspirations and capability to undertake Higher Education study in science, technology, engineering and mathematics (STEM). The project is led by Professor Peter Buckskin (University of South Australia) and Mr Will Morony (Australian Association of Mathematics Teachers), and funded through the Australian Maths and Science Partnerships Program Competitive Grants Scheme.

This review begins with a brief overview of key Indigenous education and STEM policy documents. The [xe] project builds on the insights learned from Make it Count, a project implemented by AAMT from 2009-2012 which was designed to develop tools to improve mathematics and numeracy outcomes for primary-age Indigenous students. The [xe] project has experimented with translating the insights from Make it Count in primary schools to secondary schools. The literature review then describes the case of New Zealand, which has a similar colonial history and contemporary concerns about the under-participation of Indigenous students studying STEM in university. The review concludes by considering ‘culturally responsive pedagogy’ as a means for advancing theory and practice/pedagogy for improving Indigenous students’ learning outcomes generally. This section concludes with a discussion on culturally responsive mathematics pedagogy.

Policy background

To provide context and advocate for the policy significance for improving Indigenous students representation in STEM, key Australian policy and strategic benchmarking

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1 This literature review was compiled by Robert Hattam, Lester-Irabinna Rigney, Mel Baak and Joh Wurst
2 In constructing this review, an audit was conducted of literature written by authoritative and well-known authors published in Australia and internationally, and especially, but not entirely, between the years 2010 and 2015. The [xe] Project Reference Group member Dr Kaye Price provided advice and feedback on early drafts.
3 The [xe] Project carries some fuzziness around the exact nature of the focus for the intervention and research. On the one hand the project foregrounds the teaching and learning of mathematics in schools but then when considering the Higher Education sector, the project frames the issues around under-participation of STEM subjects. Simply put, the project logic assumes that success in high school mathematics is a reasonable pre-requisite for participation in STEM subjects in Higher Education. This dissonance probably requires some future work in the review of literature.
reports are reviewed. These policies have national frameworks that drive initiatives through central policy and funding, including curriculum reform and teaching standards in Indigenous education. Although State and Territory governments have responsibility for school education which is central to the STEM agenda, the Federal government has initiated numerous Indigenous education reforms. Together, these governments have produced a number of policies, reports and documents related directly and indirectly to STEM, which are examined briefly below.

The *National Aboriginal and Torres Strait Islander Education Policy* (Department of Education and Training 1989), the first of its kind, outlined the gaps between Indigenous and non-Indigenous literacy and numeracy and claimed the gaps were increasing at an alarming rate. The policy recommended objectives, and strategies for schooling and for university education to achieve equity of access to and participation in education, and equitable and appropriate educational outcomes for Indigenous people.

The *National Indigenous Reform Agreement (Closing the Gap)* (COAG 2008) was negotiated between the Commonwealth and the State and Territory governments. The agreement established the following targets to address Indigenous disadvantage in Indigenous health, education and employment outcomes:

- closing the life expectancy gap within a generation
- halving the gap in mortality rates for Indigenous children under five within a decade
- ensuring all Indigenous four years olds in remote communities have access to early childhood education within five years
- halving the gap for Indigenous students in reading, writing and numeracy within a decade
- halving the gap for Indigenous people aged 20-24 in Year 12 attainment or equivalent attainment rates by 2020
- halving the gap in employment outcomes between Indigenous and non-Indigenous Australians within a decade

Over time, state, territory and federal Education Ministers have developed a number of strategies for implementing the *National Aboriginal and Torres Strait Islander Education Policy* that emphasised numeracy, literacy, mathematics and science including the *National Strategy for the Education of Aboriginal and Torres Strait Islander Peoples 1996–2002*, *Australian Directions in Indigenous Education 2005–2008*, and most recently, the *Aboriginal and Torres Strait Islander Education Action Plan 2010–2014*. The *Aboriginal and Torres Strait Islander Education Action Plan 2010–2014* (Standing Council of School Education and Early Childhood 2014) emphasised the need for basic literacy and numeracy standards to be achieved and to ensure the use of interactive technologies.
Literature review

_Closing the Gap - The Prime Minister’s Report_ (Commonwealth of Australia 2015) was the seventh _Closing the Gap_ report produced since targets were set by COAG in 2008. Its findings revealed some improvement in education and health outcomes for Indigenous Australians. However most _Closing the Gap_ targets are not on track to be met. Key points in _Closing the Gap 2015_ include:

- No progress in halving the gap in Indigenous employment outcomes
- Small gains in Indigenous life expectancy
- Early childhood enrolment target not met
- No overall progress on halving reading and numeracy gap
- Slower progress on infant mortality gap
- On track to halve gap in Year 12 attainment

Within the education sector, the _Australian Curriculum_ has been developed by the Australian Curriculum, Assessment and Reporting Authority (ACARA). The national curriculum is designed to cater for students from kindergarten to Year 12 in learning areas that include: Mathematics; Science; general capabilities in Numeracy, Information and Communication Technology; and cross-curriculum priorities in Indigenous histories and cultures. The _National Curriculum Indigenous Cross-Curriculum Priority_ requires all students to gain an understanding of Indigenous culture and knowledge, including mathematics and science.

For example, in the Foundation to Year 10 Australian Curriculum: Mathematics (ACARA 2012a):

Students will explore connections between representations of number and pattern and how they relate to aspects of Aboriginal and Torres Strait Islander cultures. They will investigate time, place, relationships and measurement concepts in Aboriginal and Torres Strait Islander contexts. Students will deepen their understanding of the lives of Aboriginal and Torres Strait Islander Peoples through the application and evaluation of statistical data.

Through the Foundation to Year 10 Australian Curriculum: Science (ACARA 2012b):

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 practiced 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.
The Review of Higher Education access and outcomes for Aboriginal and Torres Strait Islander People

Aboriginal and Torres Strait Islander people are significantly underrepresented in the higher education system, contributing to the higher levels of social and economic disadvantage they often experience. Producing graduates qualified to take up professional, academic and leadership positions across the community, government and corporate sectors will help to address this disadvantage. (Behrendt et al. 2012, p. 9)

In the Review of Higher Education access and outcomes for Aboriginal and Torres Strait Islander People, Behrendt and colleagues provide a contemporary diagnosis of an intractable policy problem for Australian education systems, including both schooling and Higher Education, which reproduce educational disadvantage for Indigenous communities. The above quote not only identifies the issue of Indigenous under-representation, but asserts hope that schooling and Higher Education could be reformed in ways that would produce a critical mass of Indigenous graduates and hence contribute to a significant interruption to the logic of colonisation that works on and through education systems.

There are a number of themes from Behrendt et al. (2012) that provide a framework for the work of the [xe] project and confirm the two strands of the design.

- Schools are the primary avenue through which most people enter higher education, and the sector must work more closely with schools to make this true for Aboriginal and Torres Strait Islander people. (p. 11)

- [U]niversities can play a greater role in supporting Aboriginal and Torres Strait Islander school students, starting in primary school, through outreach programs that support aspiration building and provide mentoring and academic support in key areas like mathematics and science. (p. 12)

The Behrendt review argues for reforms in both the schooling and Higher Education sectors. Key sites for driving these reforms include university faculties, professional bodies, the National Indigenous Higher Education Workforce Strategy, vice-chancellors ‘leading from the top’ (p. 15), and the development of a national ‘comprehensive framework’ (p. 15) for responding to this issue. Importantly, the review argues that:

Indigenous perspectives and knowledge, translated into curriculum, teaching practices and graduate attributes, can make important contributions to helping professionals meet the needs of Aboriginal and Torres Strait Islander communities. Where professionals are being trained to work in fields with Aboriginal and Torres Strait Islander clients, business partners and/or communities, they should learn relevant knowledge and gain an understanding of contemporary Indigenous issues to help them in their professional work. The Panel proposes that universities develop Aboriginal and Torres Strait Islander
Teaching and Learning Frameworks that reflect the inclusion of Indigenous knowledge within curriculums, graduate attributes and teaching practices. (p. 15)

These proposals inform the [xe] project logic and require ongoing development, both theoretically and empirically, through the case studies in both the university sector and through work with mathematics teachers in secondary schools sponsored by the Australian Association of Mathematics Teachers. While the Behrendt review provides a contemporary account of the general issue of Indigenous peoples’ under-representation in the Higher Education system; this current project and literature review has specific focus on the under-participation of Indigenous students in STEM subjects in Higher Education.

Global STEM performance and participation

Around the world, STEM disciplines are of significant and specific importance in terms of education and the economy. Being capable in STEM is now seen as key to productivity, technological adaptation and research-based innovation. No other area of education has greater contemporary importance than the STEM disciplines and there is a plethora of research about STEM policy, participation, programs and practice (Roberts 2002; van Langen & Dekkers 2005; Osborne & Dillon 2008; Nelson & Romer 1996; Marginson et al. 2013).

As well, there are serious concerns globally and in Australia regarding the decline in both achievement and participation in STEM in the later years of high school and in universities. Referring to both Indigenous and non-Indigenous students, a recent study focusing on the situation in Western Australia (Hackling et al. 2014) reported:

- declining achievement and negative attitudes towards STEM subjects amongst primary and secondary school students; Year 4 TIMSS [Trends in International Mathematics and Science Study] achievement data for science and mathematics, and PISA data for 15 year old students in science and mathematics reveal declining performance relative to comparator countries; and, there is significant concern about the very low proportion of Australian and WA students reaching advanced benchmarks of achievement;

- declining participation in academically demanding STEM subjects at the senior secondary level; the average number of science subjects taken by WA Year 12 students declined from 1.42 to 0.66 between 1986 and 2012; the average number of mathematics subjects, that contribute to an ATAR, taken by WA Year 12 students declined from 0.92 to 0.69 between 1992 and 2012;

- strong negative impacts of social disadvantage on achievement, attitudes and participation in STEM subjects. (p. 2)

Marginson et al. (2013) explored Australia’s current profile and future trajectory in relation to STEM engagement and compared this with a number of other countries. They argue that:
Most nations are closely focused on advancing STEM and some have evolved
dynamic, potent and productive strategies. In world terms Australia is positioned
not far below the top group but lacks the national urgency found in the United
States, East Asia and much of Western Europe, and runs the risk of being left
behind. (p.12)

**Indigenous students’ under-participation in STEM**

The *Review of Higher Education access and outcomes for Aboriginal and Torres Strait Islander People* builds on the *Bradley Review* (Bradley, Noonan, Nugent & Scales 2008), which specifically considered STEM under-participation:

… in 2009, only around one third of Aboriginal and Torres Strait Islander students achieved the minimum proficiency level in international tests for science, mathematics and reading literacy, compared to around two thirds of non-Indigenous students ... Across all levels of education Indigenous participation in STEM [science, technology, engineering and mathematics] is well below that of non-Indigenous students, which is especially significant given the very young demographic profile of the Indigenous population (ABS 2006) ... without an appropriate level of STEM skills, Indigenous peoples’ share in the opportunities of Australia’s economy will be limited. (Behrendt et al. 2012, p. 19)

Recent research has identified continued and significant gaps between the performance of Indigenous and non-Indigenous students in standardised assessments of mathematical, scientific and reading literacy (Dreise & Thomson 2014). The results of the 2012 Programme for International Student Assessment (PISA), in which 14,500 Australian 15 year olds (including 1,991 Indigenous students) participated, indicate that, on average, Indigenous students are more than two and a half years behind their non-Indigenous peers in mathematical literacy, and approximately the same in scientific literacy (Dreise & Thomson 2014).

Indigenous students’ participation in STEM education has for many years been below that of the general Australian population. As Behrendt et al. (2012) have argued:

Across all levels of education Indigenous participation in STEM [science, technology, engineering and mathematics] is well below that of non-Indigenous students, which is especially significant given the very young demographic profile of the Indigenous population (ABS 2006) ... without an appropriate level of STEM skills, Indigenous peoples’ share in the opportunities of Australia’s economy will be limited … (p. 20)

Central to Behrendt’s report is developing an understanding of the reasons for these low levels of Indigenous engagement in STEM subjects, and in particular mathematics. It is acknowledged that there are multiple reasons for these low levels of engagement, many of which have been identified by Indigenous mathematician Chris Matthews in his research in this field (Matthews 2012; Matthews, Cooper & Baturo 2007; Matthews et
al. 2005; Sarra et al. 2011). Firstly, Matthews argues that it is essential to recognise the colonial history of Australia and the historical positioning of Indigenous people. As Bang et al. (2012) have also argued:

settled expectations are implicit and associated with blindness to institutionalized privilege and associated ontological and epistemological constructs. When applied to schooling, the construct of settled expectations can usefully articulate and problematize entrenched, usually hidden, boundaries that tend to control the borders of acceptable meanings and meaning-making practices. These have also shaped deficit-oriented discourses concerning students from nondominant communities. (p. 303)

Matthews (2012) suggests that the history of social Darwinism in positioning Indigenous people meant that prevailing conceptions of Indigenous people, their knowledge and their culture positioned them as having ‘no relevance in a modern, technological, advanced, industrial society’ (p. 103). He suggests that this has resulted in a Eurocentric mathematics curriculum and pedagogy in Australia (Matthews 2012; Matthews, Cooper & Baturo 2007; Matthews et al. 2005). As such, many Indigenous students have viewed mathematics as a subject that challenges their Indigenous identity, or in which they ‘must become “white” to succeed’ (Matthews, Cooper & Baturo 2007, p. 1). This, argues Matthews et al. (2007, p. 1), is one of the reasons that ‘Indigenous students continue to be the most mathematically disadvantaged group in Australia.’ Howlett et al. (2008) quote an Indigenous university student interviewed during their research into the retention of Indigenous students in Higher Education STEM studies:

A lot of us ended up wagging school because we couldn’t handle the maths. When I think about it now, it’s probably the way it’s delivered. (p. 22)

Not only did Eurocentric attitudes dismiss Indigenous knowledges and cultures, they also resulted in deficit views of Indigenous students (Matthews et al. 2005; Matthews, Cooper & Baturo 2007; Sarra et al. 2011; Matthews 2012; Morris et al. 2014). Deficit views include blaming parents and students for poor school attendance (Matthews et al. 2005) and underestimating the capabilities of Indigenous students (Kerwin & Issum 2013). Matthews et al. (2005) argue that deficit views of Indigenous students’ mathematics ability can ‘lead to a chauvinistic, almost missionary, zeal to bring mathematics (the “glory of Western culture”) to Indigenous people (so they can “experience its wonder”); or to a “dumbing down” of the mathematics curriculum (through repetitious rote teaching of rules)’ (p. 514). Kerwin and Issum (2013) suggest that it is essential to challenge these conceptions of deficit blame. They argue instead that:

poor resourcing, low expectations of students, no sense of the worth of gaining a dominant education, and no acknowledgement by the state apparatus of what Aboriginal people value for education are the real reasons for Aboriginal and
Torres Strait Islander children in these communities not attending school. A key facet of this dominant education is the “true” Australian history. (p.13)

Deficit views of Indigenous knowledges and students are still prevalent and demonstrated on many levels, from the classroom to university and government. For example, then Professor of Mathematics at Monash University, Michael Deakin (2010) wrote a published academic article on the Indigenous mathematics strand in the Australian National Curriculum. Reflecting on this he states:

However, I will argue here that these passages envisage the introduction into the National Mathematics Curriculum of a topic (Indigenous Mathematics) which, strictly speaking, does not exist. It is no derogation of Aboriginal or Islander culture to recognise this fact. Indigenous Australians did not build Gothic cathedrals either. We all know this and no-one thinks any the worse of them on this account. Attempts to discover an Indigenous Mathematics are undoubtedly well-intentioned, but ultimately ill directed. It is neither useful nor beneficent to bestow on aspects of Aboriginal and Islander cultures a significance that they do not, in fact, possess. (p. 233)

These deficit views have also been internalised by Indigenous people, who identify both an apparent lack of relevance of STEM subjects to Indigenous Australians (Howlett et al. 2008; Ball 2015) as well as deficit understandings of their own abilities in STEM subjects. Another participant in the study conducted by Howlett et al. (2008) reflected:

Yeah, I think science is a very scary word. And that most of us haven’t got enough brains to actually do science or law or anything like that. (p. 22)

In addition, Indigenous peoples have historically been situated as objects of scientific inquiry; therefore there is still a tendency to view science with suspicion (Howlett et al. 2008; Hauser, Howlett & Matthews 2009).

Overcoming Eurocentric and deficit views of Indigenous students requires particular approaches including a ‘decolonising of the curriculum, teachers’ thinking and approaches, and even that of the community’ (Owens 2015, p. 58).

In addition, it has been noted that the language of instruction presents a barrier to the engagement of Indigenous students with mathematics in schools. Matthews et al. (2007) argue that using Standard English to teach Indigenous students for whom it is not their first language may mean that they don’t have the words to describe mathematical ideas. A number of other authors have also noted the need to begin with the home language of children to enable a better foundation for the development of mathematical understanding (Graham 1982).

As a result of the above issues, Indigenous students begin to disengage from mathematics in primary school, a trajectory which results in lack of engagement which STEM subjects at university level and a consequent low participation of Indigenous people within the STEM workforce. Data from Australian universities shows that
enrolments in STEM disciplines are less than 1 per cent, but higher in areas such as teacher education, law and health (Figure 3).

**Figure 3**: Average total enrolment of Indigenous Higher Education students by field of study compared to total enrolments (2011-2013). Source: Excellence and Equity in Mathematics (2015, p. 7).

By interrogating the issued fundamental to the low numbers of Indigenous people entering and succeeding in STEM study, education systems can begin to change or grow programs and models that are culturally responsive. Existing evidence demonstrates that initial school experience contributes to an avoidance of involvement in STEM subjects. In addition, there is evidence that Indigenous students experience obstacles to future involvement with the result that they follow other pathways. The significant gap in educational outcomes and achievement limits career opportunities for Indigenous Australians, including in Indigenous communities where STEM-related professions are essential for development.

**Engagement of Māori in Higher Education**

As Matthews et al. (2005) have argued ‘the international situation also provides evidence that Indigenous disadvantage is not the particular problem of the Australian Indigenous people, but a problem of the globalised structures and systems under which
most countries operate’ (p. 515). Indigenous students in other settler-societies such as New Zealand, North America and Canada also face barriers to engagement in STEM subjects at both a school and university level. While there are continued barriers, New Zealand in particular provides an interesting case study on practices to improve the outcomes of Indigenous students. Although this exemplar does not focus specifically on STEM, it provides insight into the broad strategies employed by Māori educators/activists to increase Māori students’ participation and success in schooling and Higher Education (Smith 2003; Bishop et al. 2007; Ministry of Education 2009a).

New Zealand has adopted a national approach to the global problem of improving Indigenous peoples’ and First Nations’ educational outcomes. In 2008, the New Zealand government implemented a national strategy for improving Māori students’ educational outcomes and launched Ka Hikitia—Managing for Success: The Draft Māori Education Strategy 2008–2012 (Ministry of Education 2009b). This strategy has four main focus areas: foundation years; young people engaged in learning; Māori language education; and organisational success. The overall aims of the strategy are to have:

- a high quality education system that is accessible, equitable and responsive to different learning aspirations, ensuring every education option is a quality choice.
- Its purpose is to transform the education system to ensure Māori are enjoying educational success as Māori. (Ministry of Education 2009b, p. 11)

There are specific strategic outcomes including:

- Māori learners working with others to determine successful learning and education pathways
- Māori learners excel and successfully realise their cultural distinctiveness and potential
- Māori learners successfully participating in and contributing to te Ao Māori
- Māori learners gaining the universal skills and knowledge needed to successfully participate in and contribute to Aotearoa New Zealand and the world. (Ministry of Education 2009b, p. 18)

Historically this initiative began in the 1970s with a Māori social movement Kura Kaupapa Māori, as a reaction to poor educational outcomes for Māori and the near demise of Māori language. Māori communities established their own schools, funded by the government – Kura Kaupapa Māori – that aimed to meet the aspirations of Māori communities. The Kura Kaupapa Māori education movement took up the struggle to support the maintenance of Māori language, epistemology, cosmology and culture as a central tenet of education policy. This initiative led to the development of Kura Kaupapa Māori theory and pedagogy (Smith 1999). In terms of schooling, this model foregrounds ‘pedagogical decolonization’ (Kepa & Manu’atu 2008). Out of this movement Kura Kaupapa Māori Elementary Schools (Māori immersion philosophy and practice), Kura Tuarua (Māori Immersion Secondary school options) and Whare
**Literature review**

**Wānanga** (Māori tertiary options) were established (Smith 2003, p. 7).

Some of the indicators of success for the New Zealand approach include the following (Bishop et al. 2007; Ministry of Education 2009a).

- Attendance of children in Māori immersion schools has increased.
- Students attending Māori language schools are achieving higher scores in the National Certificate of Educational Achievement (at Year 11) than their peers attending English language schools.
- Māori enrolments in formal tertiary education courses have nearly doubled since 2001 and there has been a dramatic increase in the proportion of registered Māori early childhood teachers since 2004 (23 per cent to 45 per cent).
- There have been significant and gradual increases in the number of Māori students who are successful in the National Certificate of Educational Achievement at Year 12 level and gradual increases in numbers with university entrance qualifications.
- Participation of Māori in formal tertiary education has remained higher than that of other populations, despite a 5.4 per cent decline in 2006.
- Completion rates in tertiary programs for all Māori was 47 per cent compared to 44 per cent for all other students (Ministry of Education 2007a).

This approach to improving educational outcomes for Māori has also been taken up in the Higher Education sector, in the form of the Whare Wānanga (House of Higher Learning) which was established under the Education Act 1989. As an example, the Te Whare Wānanga o Awanuiārangi is a Mataatua-based tribal university, was established in 1992 and received Wānanga status until 1997.

In summary, the case of Māori provides a few lessons for Australia about improving Higher Education outcomes. The highly successful national strategy brings together the following features: (i) a national strategy for all levels of schooling with policy coherence about core ideas; (ii) national education policy that works to advance the nation’s aspirations for decolonisation through recognition of difference that is not another version of assimilation; (iii) national policy that collaborates with Māori advocates; and (iv) development of a university model that provides a process for credentiallling Māori knowledge, epistemology and economic interests.

**University engagement with schools to improve participation of under-represented groups**

Higher Education institutions do contribute initiatives to improve Indigenous students’ participation and success in STEM. However, Wilks and Wilson (2014, p. 1) argue that a lack of ongoing funding to support successful transitions has resulted in the current disparity in the completion rates between Indigenous and non-Indigenous students (22 per cent less). In addition, Aseron et al. (2013) suggest that many Indigenous people do
not see Higher Education institutions as accessible. Concerns relating to equity in Higher Education are often framed by conception of the four conditions that must be met for a student to enter Higher Education (Anderson et al. 1980; Anderson & Verboorn 1983):

- an adequate number of places must be available
- the institution must be accessible to the student, both geographically and financially
- the student must have the necessary scholastic attainment (or academic achievement) to qualify for entry
- the student must want to enter [aspiration] (Anderson & Verboorn 1983, p. 3)

Of note is the critique of overly simplistic notions of raising aspirations for Higher Education. Recent research casts doubts on the notion that students and their families from low SES and/or Indigenous communities do not have high aspirations for education (Prosser et al. 2008). The assumption that it is possible to generalise understandings of aspiration and hence ‘failing to appreciate the aspirations of different groups, understood as a collective cultural capacity, casts doubt over the ability of institutions to deliver increased numbers of knowledge workers’ (Sellar, Gale & Parker 2011, p. 37). Thus, the notion of aspirations needs to be understood as connected to achievement. Put simply, young people from all backgrounds have aspirations for their futures but they might not be able to further these aspirations if they cannot achieve success at high school and this is especially apparent in the STEM subjects.

In *Can’t Be What You Can’t See: The Transitions of Aboriginal and Torres Strait Islander Students into higher education Report*, Henderson-Yates, Dodson and Maher (2014) outline a leading practice framework that is pertinent for the [xe] project. This framework has the following key aspects:

- Early Indigenous student engagement
- Outreach and aspirational programs
- Targeted student and community outreach programs
- Preparedness pathways and enabling programs
- Targeted student case management and skills development
- Mentors and tutorial assistance
- Blended delivery for remote student access
- Finances and employment pathways
- Life cycle approach
- Policy contexts and strategies
- Governance-Whole of university approach
Literature review

- Indigenous Education Unit foundations
- The value and role of Indigenous knowledge Centres
- Cross cultural competency (pp. 13-14)

In summary, all young people have aspirations for their futures, but they need to be able to achieve academic success at high school to realise them. Successful interventions by Higher Education institutions to attract students from communities that have historically been absent often have these four features: assemble resources; engage learners; work together; and build confidence. Successful interventions also have a strong equity orientation that is characterised by: unsettling deficit views; researching ‘local knowledge’ and negotiating local interventions; and building capacity in communities, schools and universities (Gale et al. 2010).

Culturally responsive pedagogy

Given the arguments in the previous sections the question is, how might mathematics education be delivered in a way that enables and encourages the engagement of Indigenous students? As Matthews (2012, p. 102) suggests, given that most Indigenous students are taught by non-Indigenous teachers, most schools are run by non-Indigenous principals and most school curriculum content is developed by non-Indigenous curriculum developers, it is essential to interrogate the relationship between Indigenous and non-Indigenous people and how this informs teaching and learning.

The most hopeful space for improving Indigenous learning outcomes, and specifically in Mathematics, is what teachers do in classrooms. In the end, it comes down to pedagogy. Ultimately, all of the policy interventions either do or do not enable teachers to do innovative things with their students. Improving learning is a problem for pedagogy. In the words of Garth Boomer (1999): ‘Unless we solve the pedagogy problem, all other efforts at reconstruction … will be in vain. The curriculum is, in the final analysis, what teachers enact in classrooms’ (p. 136). In Indigenous education studies, the term ‘culturally responsive pedagogy’ provides the focus for that work, theoretically, practically and empirically. In reviewing the literature, there are many possible terms: culturally relevant, appropriate, sensitive, centred, congruent, compatible, reflective, responsible, mediated, contextualised, and responsive (Ladson-Billings 1995). Despite this diversity, the extensive body of international literature provides many recurring elements of culturally responsive pedagogy that have the potential to inform educators committed to improving learning for Indigenous students.

Culturally responsive pedagogy (CRP) is one way to encourage the interrogation of cultural differences and understandings that exist between teachers, school curriculum and students (Gay 2002), utilising the ‘cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively’ (Gay 2002, p.106). As Martinez (2005) has argued, CRP ‘brings students’ culture into the center of education, and recognizes that culture is a key element
through which people develop their worldviews, and also the way they understand life, and relationships’ (p. 10). CRP provides an essential tool to overcoming deficit views of Indigenous students and their knowledges, as it was developed specifically ‘as a critique of the cultural deficit paradigm’ (Taylor & Sobel 2011, p. 22). In addition, CRP ‘concentrates on recognizing the knowledge, skills, and rich cultural experiences that students from diverse backgrounds bring to school. It is a philosophical view of teaching grounded in nurturing students’ welfare, including their academic, psychological, social, emotional, and cultural wellbeing’ (Taylor & Sobel 2011, p. 22).

Taylor and Sobel (2011) characterise CRP as:

situated in a framework that recognizes the rich and varied cultural wealth, knowledge, and skills that students from diverse groups bring to schools, and seeks to develop dynamic teaching practices, multicultural content, multiple means of assessment, and a philosophical view of teaching that is dedicated to nurturing student academic, social, emotional, cultural psychological, and physiological well being. (p. ix)

Recognising and building on students’ home languages and cultures is foundational to CRP, particularly for students who speak English as an Additional Language. To develop CRP, teachers need to ‘understand the value of all languages and realize that a student’s native language provides a useful base and tool for accessing the new language being added to the learner’s linguistic repertoire. (Taylor & Sobel 2011, p. 6)

Gloria Ladson-Billings (1995a, 1995b, 2009) was one of the first academics to define CRP. She has worked primarily for improving learning outcomes for African American children and her version is developed in that context. In some of her early articulations of the approach she describes the ‘problem’ in terms of ‘discontinuity between what students experience at home and what they experience at school in the speech and language interactions of teachers and students’ (1995a, p. 160). In her attempt to disrupt this discontinuity, she suggests:

Culturally responsive pedagogy rests on three criteria or propositions: (a) Students must experience academic success; (b) students must develop and/or maintain cultural competence; and (c) students must develop a critical consciousness through which they challenge the status quo of the current social order. (p. 160)

Teachers need to move beyond deficit views of their students and demand high expectations for academic achievement. CRP, Ladson-Billings (2009) suggests:

uses student culture in order to maintain it and to transcend the negative effects of the dominant culture brought about, for example, by not seeing one’s history, culture, or background represented in the textbook or curriculum or by seeing that history, culture, or background distorted. (p. 17)
On the second of her themes, Ladson-Billings, argues that students need to ‘maintain some cultural integrity as well as academic excellence’ (p. 160), in which case ‘teachers utilize students’ culture as a vehicle for learning’ (p.161). In the context of Australia, this theme resonates strongly with Sarra’s (2012, 2014) *Stronger Smarter* philosophy, particularly the demand to ensure that students maintain a strong and positive sense of their own cultural identity, and their own Indigenous identity.

On the third of her key themes, Ladson-Billings, argues that:

students must develop a broader socio-political consciousness that allows them to critique the cultural norms, values, mores, and institutions that produce and maintain social inequities. If the school is about preparing students for active citizenship, what better citizenship tool than the ability to critically analysis the society? (p. 162).

Building on Ladson-Billings’ approach, Villegas and Lucas (2002a, 2002b, 2007) develop a notion of the culturally responsive teacher to address the complexities of the increasing cultural and linguistic diversity of classrooms. They advocate for a theory that has six characteristics:

1. is socioculturally conscious, that is, recognizes that there are multiple ways of perceiving reality and that these ways are influenced by one’s location in the social order;
2. has affirming views of students from diverse backgrounds, seeing resources for learning in all students rather than viewing differences as problems to be overcome;
3. sees himself or herself as both responsible for and capable of bringing about educational change that will make schools more responsive to all students;
4. understands how learners construct knowledge and is capable of promoting learners’ knowledge construction;
5. knows about the lives of his or her students; and
6. uses his or her knowledge about students’ lives to design instruction that builds on what they already know while stretching them beyond the familiar. (Villegas & Lucas 2002b, p. 21)

Gay (2002) also emphasises the role of the teacher in CRP, suggesting that culturally responsive teaching requires:

developing a knowledge base about cultural diversity, including ethnic and cultural diversity content in the curriculum, demonstrating caring and building learning communities, communicating with ethnically diverse students, and responding to ethnic diversity in the delivery of instruction. (Gay 2002, p. 106)

Similar to Villegas and Lucas’ emphasis on the role of the teacher, Indigenous American scientist Gregory Cajete (1999) proposes that changes must be made at the school level. He argues that the teacher is the one who should make curriculum
modifications and developments through the support of parents and principals. Cajete’s approach to curriculum development is guided through his First Nation world-view and a belief that it can dialogue with Western approaches (Martinez 2005). Cajete’s (1999) proposed framework suggests that students should develop ways to link and understand Western and Indigenous science, through restructuring and integrating the two systems and acknowledging and identifying the differences. Cajete’s identification of the importance of community members/parents builds on the seminal work of Paulo Freire (1998), who argues that community members are essential to curriculum development as they have the knowledge to make the curriculum relevant and significant for the community.

Bishop et al. (2007) have developed what they term a ‘culturally responsive pedagogy of relations’ to improve the educational achievement of Māori students in mainstream secondary school classrooms in New Zealand. A culturally responsive pedagogy of relations, they suggest, will be accomplished when:

- educators create learning contexts within their classroom; where power is shared between self-determining individuals within non-dominating relations of interdependence; where culture counts; where learning is interactive, dialogic and spirals; where participants are connected to one another through the establishment of a common vision for what constitutes excellence in educational outcomes (p. 1)

There is much research in the broad space of CRP, and many general approaches to CRP can be adapted for use in the mathematics classroom. The following section, however, turns to consider current research which specifically explores the utilisation of CRP in relation to mathematics.

**Culturally responsive pedagogy for teaching mathematics**

The lack of culturally responsive content in mathematics curricula is acknowledged as one reason for Indigenous student underachievement in mathematics across Canada, the US, Australia and NZ (Aguirre & del Rosario Zaval 2013; Gavarrete 2015; Gilsdorf 2012; Martinez 2005; Matthews, Cooper & Baturo 2007; Miller et al. 2012; Morris & Matthews 2011; Morris et al. 2014; Mukhopadhyay & Roth 2012; Owens 2015; Perso 2013). Miller et al (2012, p. 67) consider ‘how holistic Indigenous knowledge and an integrated STEM education approach can be mediated in part through an online environment to promote transformational learning experiences for American Indian youth.’ Drawing on the work of Cajete (1999), they argue that addressing the high dropout rates of First Nations students from secondary school requires an Indigenisation of the K-12 curriculum.

Greer et al. (2012) have argued that there is a dire need to valorise ‘the diversity of mathematical practices that are intimately bound up with forms of life’ (p. 5) which would, in turn, improve engagement with and outcomes in mathematics for Indigenous students.
Literature review

There has been limited research conducted into the use of CRP with mathematics teaching, in part because of the misconception of the neutrality of mathematics (Aslan Tutak, Bondy & Adams 2011). It has been argued that mathematics, and other STEM subjects, must be acknowledged as cultural subjects; they are not acultural (Averill et al. 2009; Matthews 2012; Miller et al. 2012). Aslan Tutak et al. (2011) use two examples to demonstrate that mathematics is not free of interpretation, value-neutral or apolitical. By looking at differing definitions of a trapezoid, and asking the mathematical question used in Nazi-era Germany ‘How much poison gas is needed to kill …?’, they demonstrate the need for a critical pedagogy of mathematics teaching (p. 66), arguing for the need in mathematics literacy to critically reflect on the ways in which numbers are used to ‘dominate and liberate’ (p. 67).

Several authors have now begun to write and research in the emerging field of Culturally Responsive Mathematics (CRM) (Nielsen, Nicol & Owuor 2008; Peterek 2009; Greer et al. 2009; Ukpokodu 2011). Martinez (2005), who explored the development of culturally-based mathematics lessons in a collaborative group using case study and action research methodologies with Indigenous people in Canada, argues that CRM makes it possible to bring together mathematical and cultural knowledges. Aguirre and del Rosario Zavala (2013) define Culturally Responsive Mathematics Teaching (CRMT) as:

a set of specific pedagogical knowledge, dispositions, and practices that privilege mathematical thinking, cultural and linguistic funds of knowledge, and issues of power and social justice in mathematics education. (p. 163)

They further suggest that:

culturally responsive mathematics teachers must develop a socio-cultural–political consciousness. This means teachers must understand teaching and learning as part of a broader socio-political context and see their job as preparing students to engage in these contexts. Teachers must see mathematics teaching as a political activity rather than neutral activity, develop an awareness of the role power plays in school policies and curriculum practices, and actively seek to dismantle structures and practices that perpetuate inequities in mathematics education. (p. 167)

The [xe] project builds on Make It Count, a project conducted by the AAMT. The Make It Count initiative developed evidence-based, responsive mathematics pedagogies and resources to improve the learning outcomes of Indigenous learners across Australia. Eight clusters of primary schools across regional and urban Australia participated in the project. Make It Count used a common language and understanding that enabled whole school communities to work together to improve mathematics pedagogies. Make It Count focused on building the capacity of school communities to maximise Indigenous students’ learning in mathematics and development of numeracy through:

Developing in primary school teachers high expectations of themselves and of Indigenous students.
Taking specific actions to find out the mathematics Indigenous students know, and using this to inform teaching and learning.

Knowing students’ cultural and home backgrounds and associated mathematical and numeracy practices and building on these to engage students in learning mathematics at school.

Giving students opportunities to make decisions about learning of mathematics.

Actively fostering positive attitudes towards mathematics, and building Indigenous students’ confidence in themselves as mathematicians.

Make it Count drew on the insights of Perso (2003b, 2003a) to advocate for culturally responsive pedagogies, and engagement with the local Indigenous community to increase Indigenous students’ achievements in mathematics in primary school. The Make it Count project provided a case study into the ways that Indigenous students’ apparent under-achievements in mathematics can be effectively addressed in primary school classrooms. Indigenous students are ‘alienated from mathematics’ because it is ‘not [explicitly] related to their world and their everyday experiences’. Drawing on the work of Morris and Matthews (2011), Make it Count advocated for a ‘responsive mathematics pedagogy’ which is characterised by:

valuing what Aboriginal learners bring to the classroom and responding to it in ways that develop deep mathematical knowledge’ and which demonstrates the three dimensions of inclusion—social, academic, cultural—interacting in a dynamic and generative way to achieve responsive maths pedagogy. (Morris & Matthews 2011, p. 8).

According to Perso (2003a, 2003b), effective teachers of Indigenous students in primary schools respond to each individual student and their local community cultural context; they demonstrate a capacity to be relevant and responsive to their students’ social, cultural, and academic identities. As well as advocating the use of culturally appropriate/responsive pedagogies, and demonstrating the implications of different learning styles and ways of seeing the world and the role of human beings, Perso (2003a, 2003b) argues that teachers need to engage in two-way/both-way teaching and learning, that is, teachers learning from students and students learning from teachers, and that the core focus of education should be to facilitate each individual student’s learning. As Perso (2012) has further argued:

… there seems little doubt that in order to provide successful schooling experiences for Indigenous students educators must become more bi-cultural, that is we must better understand the belief systems and values of the primary culture of each of our students. This does not mean that non-Indigenous teachers will be given a ‘skin-name’ or gain membership to Indigenous cultures. Rather it implies that teachers are willing to learn to understand their students and to meet their needs. (p. 83)

The notion of two-way/both-way teaching has been built on by Hatcher (2012), who described the process of ‘equal representation of knowledge from two cultural contexts’
Literature review

referred to by Mi’kmaw Elder Albert Marshall as ‘Two-Eyed Seeing’ (p. 346). Using the guiding principle of Two-Eyed Seeing, Hatcher argues that it is possible for Indigenous cultures to take a place ‘beside Western, not as an add-on to be brought out for multicultural “festivals”’ (p. 346).

There are a number of different approaches that have been developed to facilitate the implementation of CRP in mathematics teaching. Averill et al. (2009) have identified several conditions they believe are necessary for effective culturally responsive teaching in mathematics in light of their projects in New Zealand. They suggest CRP in mathematics requires:

- deep mathematical understanding;
- effective and open relationships;
- cultural knowledge;
- opportunities for flexibility of approach and for implementing change;
- many accessible and nonthreatening mathematics learning contexts;
- involvement of a responsive learning community;
- and, most important, working within a cross-cultural teaching partnership (p. 180).

In line with this approach, Matthews et al. (2007) developed a program which utilised CRP approaches. The program moves from the story-telling world of Indigenous students into the formal world of algebra through encouraging students to create symbols that have personal meaning. Matthews (2012) argues that there is a:

need to create a new pedagogical paradigm where mathematics is seen first and foremost as a creative act and students have the opportunity to reflect on their reality, create mathematical relationships and use mathematics to convey these understandings. In essence, students need an opportunity to express themselves through mathematics in a similar fashion to music or visual arts. (p. 100)

Utilising processes of story-telling and dance, Matthews suggests that teaching mathematics as an ‘artistic pursuit’ enables students to use their own (oral) language to explore and enable the development of student’s own mathematical reality. In addition, using these tools enables to acknowledgement of mathematics as a social construct which is ‘inherently culturally biased’ (Matthews 2012, p. 101).

Utilising CRP, it is possible to change the way that Indigenous students learn mathematics. If school mathematics programs reinforce pride in culture and identity, highlight the capacity to succeed in mathematics, challenge students and expect them to perform, and provide relevant educational contexts, Matthews et al. (2007) argue that there is large scope for improving Indigenous learning outcomes in mathematics.
CRP in teacher training

Averill et al. (2009) suggest that to encourage CRP in mathematics teaching, it is important that pre-service teachers arrive in mathematics education courses already knowledgeable and able to utilise CRP strategies. They would then be able to apply this knowledge within mathematics course work, enabling a stronger utilisation of CRP once they embark on teaching careers. Averill et al. (2009) further argue that:

mathematics teachers and teacher educators need to do the following: explore cross-program strategies for developing culturally responsive teaching in order that mathematics teaching time can be maximized; incorporate in every classroom contexts and pedagogies drawn from the communities in which their students will teach (including indigenous cultures); and adopt holistic and integrated culturally responsive strategies that can be justified with integrity. (p. 181)

Ethnomathematics

In developing a culturally responsive approach to teaching mathematics, is it vital to consider the important work on ethnomathematics and various names through which it is known (i.e. cultural mathematics, multicultural mathematics, traditional mathematics, indigenous mathematics, oral and written mathematics) (Gilsdorf 2012). While Aslan Tutak et al. (2011) consider ethnomathematics as distinct to culturally relevant or responsive teaching, they suggest that both provide for equity in mathematics education.

Ethnomathematics was first described by d’Ambrosio (1985) who considered the interaction between mathematics and culture. Rosa and Orey (2011) have described ethnomathematics as a way to present:

mathematical concepts of the school curriculum in a way in which these concepts are related to the students’ cultural and daily experiences, thereby enhancing their abilities to elaborate meaningful connections and deepening their understanding of mathematics. Ethnomathematical approaches to mathematics curriculum are intended to make school mathematics more relevant and meaningful for students and to promote the overall quality of their education. (p.32)

Dickenson-Jones (2008) identifies five types of ethnomathematical curriculum:

1. seeks to make mathematics meaningful by presenting the mathematics as a response to the needs of students’ inclusive of ideas of students’ culture
2. focus on the concept of mathematics as a human and socio-cultural construction’ students examine history of mathematical development in different cultures
3. mathematical ideas from the students’ own cultures would be incorporated so that learning experiences would begin with concepts that are familiar to the child in order to connect existing knowledge with their own cultural mathematics
4. Acknowledgement that ‘practices of the mathematics classroom constitute a distinct culture … the way mathematics is taught may be adjusted to make the classroom context more suited to the cultural backgrounds of the students

5. seeks to validate the mathematical ideas that form a part of the students’ culture by integrating them with classroom mathematics (pp. 33-34)

Several authors have identified possible issues with ethnomathematical approaches, primarily the possibilities for ethnomathematics leading to increased identification of cultural minorities—whom ethnomathematics is supposed to support—as the Other (Pais 2011; d’Ambrosio 1997). Pais (2011), for example, has suggested that:

Whether we choose to use this different knowledge as a curiosity, an illustration or a “starter” to the formal mathematics of the curriculum, or to develop a curriculum where one of the topics is local knowledge per se, the result may not be students' emancipation or the valorization of different cultures. On the contrary, the process of bringing diversity and ethnomathematical ideas into the classroom may end up conveying practices opposed to the benevolent multicultural ideas these researchers want to enforce, by promoting a desubstantialized view of Other’s culture.’ (p. 227)

Indigenous cultural contexts in mathematics pedagogy

A number of authors have looked at specific examples of engaging with Indigenous knowledges and cultural contexts in the teaching and learning of mathematics. One of the most cited examples is the Garma mathematics which is used at the Yolngu people’s Community School in Yirrkala (Matthews et al. 2005; Dickenson-Jones 2008; Jones, Kershaw & Sparrow 1995). Through Garma mathematics, both Western and Yolngu mathematics are presented alongside each other. For example, Yolngu children develop understandings of complex kinship systems at a young age. The kinship systems rely on ‘cyclical, recursive patterns’ which are also found within number patterns and other areas of mathematics (Matthews et al. 2005, p. 5). Knowledge about kinship systems is therefore used as a way to introduce and develop ideas and understandings about pattern in mathematics.

As Matthews et al. (2005) have argued:

consideration of Indigenous cultural contexts for mathematics (e.g., kinship relationships) requires a rethink of mathematics and what is important in it. It may be that their culture will enable mathematical understanding to be a strength of Indigenous students if the mathematics is taught holistically through pattern and structure (rather than through sequential teaching of number and algorithm. (p. 516)
Aboriginal Summer School for Excellence in Technology and Science (ASSETS)

Introduction and context

The Aboriginal Summer School for Excellence in Technology and Science (ASSETS) is a residential program for Indigenous students in Years 10 and 11. The program, held annually, recruits students from across the country and includes academic, cultural and leadership aspects. ASSETS is a long-running program, with summer schools held in Adelaide from 1992–2014. During this time the program was managed by the University of South Australia and the Australian Science and Mathematics School at Flinders University.

This case study is centered on the legacy of the Adelaide ASSETS program to examine STEM (Science, Technology, Engineering, and Mathematics) education for young Indigenous Australians. It specifically focuses on the ASSETS program from 1992-2014. Data for this case study was derived from relevant internal and external reports, student access and success documents, media releases, journal articles and relevant websites. Semi-structured focus group interviews were conducted with previous and current ASSETS Project Directors.

The ASSETS program has now become part of a broader five-year project partnership between CSIRO and the BHP Billiton Foundation. In 2014, CSIRO staff worked with existing ASSETS staff to jointly run the summer school and learn about the ASSETS model. From 2015, CSIRO took on management of the ASSETS program, continuing to have a summer school in Adelaide as well as expanding the program to also include summer schools in Newcastle and Townsville. The ASSETS program, now managed by CSIRO as part of their broader Indigenous STEM Education project, engages 100 students each year across the three summer schools.

The ASSETS program

Aldous, Barnes and Clark (2008) highlight that ASSETS began as an initiative of the Faculty of Aboriginal and Islander Studies at the University of South Australia and operated for almost 10 years up until 2000. The core program aims were to increase participation and achievement of Indigenous students in science, technology, engineering and mathematics (STEM). In 2007 the program was revived in South Australia by Science ICT, Mathematics Education for Rural and Regional Australia (SiMERR-SA).

Participants

ASSETS is designed for Year 10 and 11 Indigenous students. All student cost are covered to maximise access and opportunity. A merit-based student selection process is used, taking into account student competency against selection criteria and their fit with
ASSETS program

ASSETS’ goals and values and their potential for further development. Merit based selection criteria include:

- Mathematical abilities assessed from testing
- Recommendations from Mathematics and Science teachers and or School Principal
- Interview
- Parents’ approval

Figure 4 indicates a trend snap shot over a 24 year period of student participation, being overwhelmingly from Queensland. Over this duration there was a paucity of students from the Northern Territory and Australian Capital Territory. Since 1993 low student volume is evident from South Australia, Northern Territory and Victoria. Despite New South Wales having the largest Indigenous population of all states and territories, ASSETS student uptake there is relatively low. Western Australia and Queensland are well serviced by the ASSETS program.

Figure 4: ASSETS participations by State 1993-2013

Over the history of ASSETS, data gaps in student participation by regional postcode makes it difficult to conduct trend analysis of student participation by location including: urban, rural and remote.

Table 4 shows that each of the programs run since 2008 has achieved very close to gender balance excluding 2013. In 2013 there was a 4:1 female to male distribution. Over the ASSETS’ 24 year history, over one hundred expressions of interest have been received annually. A possible cause of this demand is the lack of Mathematics and Science summer school programs. When ASSETS began in 1992 it was the only national STEM program targeting Year 10-11 students, and that has fuelled demand.
Table 4: ASSETS Adelaide participation by gender and expression of interest

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
<th>Expressions of interest</th>
</tr>
</thead>
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<td>19</td>
<td>11</td>
<td>30</td>
<td>120</td>
</tr>
<tr>
<td>1995</td>
<td>18</td>
<td>12</td>
<td>30</td>
<td>n/d</td>
</tr>
<tr>
<td>2010</td>
<td>13</td>
<td>14</td>
<td>27</td>
<td>125</td>
</tr>
<tr>
<td>2013*</td>
<td>16</td>
<td>4</td>
<td>20</td>
<td>150</td>
</tr>
</tbody>
</table>

*Funding constraints in 2013 saw a reduction of the usual 30 placements to a limit of 20 available places.

**Location**

The ASSETS program has been held in Adelaide each year with various contributors and venues over the years. The 2014 summer school was hosted at the Australian Science and Mathematics School, based on the campus of Flinders University, in conjunction with Wiltja, a residential accommodation facility for young Indigenous students in South Australia. Seminars and research projects were conducted on local lands of the traditional landowners, the Kaurna peoples. The project was also supported by the Living Kaurna Centre at Marion.

**Program description**

The 2008 ASSETS Adelaide program involved: an academic component; cultural program; and a residential, social component.

Academic component: There is a consistency of over the history of the ASSETS Summer School in the formal curriculum offered that can be divided into four strands:

1. Science
2. Mathematics and engineering
3. Information Technology
4. Aboriginal Studies, Identity affirmation, Leadership

The 2008 ASSETS Adelaide academic curriculum provided students with authentic and engaging scientific experiences.

Key pedagogies used include:

- Inquiry based learning
- Problem solving approaches
- Culturally responsive pedagogies

Teaching staff were supported by Indigenous educators with a background in the sciences. Aldous, Barnes and Clark (2008) outline the program in a three part analysis:
Part 1: Initial Exposure

Refresh student skills and knowledge in STEM while introducing students to different areas of science, disciplinary research techniques, methods, key concepts and processes of scientific inquiry. Personalised assistance in science standards and core curriculum areas is provided to ensure student competency and confidence in scientific measurement, testing and reporting skills. Students are introduced to the pillars of science through the following questions: What is a hypothesis; what does it mean to think scientifically? What is the most important part of the scientific method? What is the study of environmental science? How is science different from other forms of human endeavours? What are the career possibilities in science? During this phase students are ‘exposed to a range of teacher-directed activities, guest speakers and workshop sessions in three areas: Environmental Science, Electronics/Robotics and Health Science’ (Aldous, Barnes & Clark 2008, p. 37).

Part 2: Expert projects

‘Students elected to work in one of the three ‘Expert Project Areas’: Environmental Science (wetlands), Electronics/Robotics or Health Science. Students negotiated workshop sessions to further develop content knowledge and skills in specific areas of inquiry’ (Aldous, Barnes & Clark 2008, p. 37). Mentored by scientists and an Indigenous educator, research ‘Expert Inquiry Groups’ comprising of three students were arranged to cater to various student interests, aspirations and talents. In groups, research investigation, data gathering and analysis engaged students as they developed and answered an inquiry question (Aldous, Barnes & Clark 2008, p. 37).

Part 3: Scientific presentation

The ten day program culminates in final presentations by the student Expert Inquiry Groups where students share the findings from their investigations. The audience consists of Indigenous Elders, ASSETS alumni, peers, stake-holders, philanthropic fund raisers and ASSETS staff.

Residential component: Wiltja

The residential component complemented the intense academic activities of the day with a rich offering of social activities (Aldous, Barnes & Clark 2008, p. 37). Steen (1993, 1995) and Ball (2011, 2013) describe the residential program that included such things as: ‘basketball, 36ers, Indigenous games on the beach, Indigenous speakers and role models, swimming, snooker, TV, visits to the Tandanya Cultural Centre, local sports, and … good food’ (Aldous, Barnes & Clark 2008, p. 37). Accommodation was separated along gender lines ‘and staff members were present at all times. Of critical importance Wiltja staff were trained in youth work and had considerable experience with Indigenous teenagers. Central to the evening program ‘was the presence of Aboriginal role models and informal workshops focusing on identity, leadership and positive attitudes’ (Aldous, Barnes & Clark 2008, p. 37).
Partnerships, partners and supporters

Funding or ‘in kind’ support to meet the operational costs of the program was provided by a range of sponsors and partners over the ASSETS program’s history. These include: Wiltja Residential Program; RiAus; Flinders University; UniSA; the Australian Science and Mathematics School; CSIRO, IBM Australia; SA Department of Education (Now DECD); Prince Alfred College; South Australian Aboriginal Education and Training Advisory Committee; Independent and Catholic School Associations; Senior Officers National Network Indigenous Education; Australian Secondary Principals Association; Dare to Lead coalition.

Corporate Sponsorships: Santos; BHP Billiton; QANTAS; Normandy Poseidon; Beach; South Corp Holdings; South Australian Aboriginal and Islander Careers Aspirations Program; State Government Insurance Company; South Australian Department of State Aboriginal Affairs; South Australian Department of Education and Children Services; Thyne Reid Foundation; Tim Fairfax Family Foundation; St George Foundation; CSIRO; University of Tasmania; University of NSW (EAA); Graham (Polly) Farmer Foundation; IBM Australia; Education Departments nationally; Catholic Education Commission; Resources and Engineering Skills Alliance.

Risk, child protection and legal frameworks

The educational, institutional and Indigenous context has changed considerably since 2008. Risk mitigation, child protection and legal frameworks present challenges for the program. Any program that involves minors under the age of 18 needs to ensure high standards of security and safety for students and staff. As the program involves multiple institutional partners at several sites and locations in three different states, risk mitigation is paramount.

Cultural engagement and leadership based instruction

1993 ASSETS Coordinator Tangi Steen (1993, 1995) highlights that a Cultural Engagement and Leadership module was embedded and ran parallel in the ASSETS STEM Summer School curriculum. Steen (1993, 1995) suggests that from its beginning ASSETS linked Indigenous culture to science culture. Indigenous mentors and leaders conduct sessions to assist students to cross these boundaries of cultural and scientific borders for connection. From 2008 the program used culturally appropriate residential accommodation to house the students at the Wiltja facility for young Indigenous youth in South Australia. Wet-land projects were conducted at the Warriparinga wet lands and workshops held in the Living Kaurna Centre that made connections between science and the Kaurna (traditional landowners of the country). This approach is well supported by Indigenous researchers who have examined schooling success when coupled with Indigenous content and engagement. These include: support programs created in collaboration with Indigenous stakeholders (Rigney, Rigney & Hughes 1998); education providers revising curricula and embedding Indigenous perspectives with Indigenous stakeholders (Rigney 2011a, 2011b); partnerships established that are
ASSETS program

responsive to Indigenous needs and interests between education stakeholders (students, educators, Elders, family, community, industry, government) (Worby & Rigney 2006). Aldous, Barnes and Clark’s (2008) analysis of ASSETS outcomes concluded that this module has proven successful over the life of the program and has consistently achieved outcomes in the development of student self-confidence, personal growth and self-actualisation. The module is designed to strengthen students’ cultural identity and gain confidence through enhancement in the following skills:

- Academic competencies
- Personal and social skills
- Personal, cultural awareness and identity
- Self-management

The Cultural Engagement and Leadership module is a collaboration with the Wiltja Aboriginal Centre. ASSETS also appointed a Cultural Ambassador Professor Peter Buckskin (UniSA) to oversee the program. Students engage with the Ambassador and Wiltja staff for cultural and pastoral care throughout the summer school program. Important to the module’s success is involvement of recognised Indigenous scholarly and cultural leaders with a reputation for excellence and cultural integrity, This has included Professor Peter Buckskin (UniSA), Professor Lester-Irabinna Rigney (UniSA), Frank Lampard OA, (Aboriginal Legal Rights Movement), and Steve Goldsmith from the Living Kaurna Cultural Centre at Marion. Students reported they gained new insights and appreciations of their own heritage while engaging in STEM. This cultural awareness is essential to help build confidence, and to help create educational success for Indigenous students.

Students believed the cultural program was central to the program’s success. They also considered it an important obligation to become role models for others.

From the Wiltja program I gained greater respect and knowledge about my culture where I wanted to learn more about my family and where we originated from. After listening to the guest speakers I felt that it was important to do well in my studies, so I could eventually become a role model to others just as the Wiltja staff, were role models for me. (Ball 2008, p. 1)

It has showed me to ALWAYS stand up for my culture and wear my black skin proudly ... after all we are black, strong and deadly” “I am now prouder of my Indigenous culture, I know that we are a strong people and together we can change how we are seen ... My mind connected to my heart and helped reinforce my beliefs. (Ball 2010, p. 2)

Students stated they were part of a limited STEM national group and that bringing like-minded STEM students together as one collective cohort was important to their success.

To put it simply, ASSETS was an all-round fantastic experience that I will never forget. I think it is a great idea, getting indigenous students from all around the
country and bringing them together to acknowledge their skills and achievements. Unfortunately, not many indigenous students are attempting university education, let alone completing a secondary education. This is why a program like ASSETS is so important, as it recognises students’ abilities, gives them great techniques, advice and support for furthering their learning and provides encouragement towards completing an education and doing your best. (Ball 2008, p. 2).

Local Kaurna Elders Dr Lewis O’Brien, Dr Alitja Rigney and Aunty Josie Agius are engaged throughout the program. These Elders are academically qualified and/or have worked in the field of education. Elders participate in teaching that is active, experiential, and relational.

Elders are the symbolic connection to the past, present and future and bring excellence to academic, scientific and traditional teachings, stories and ceremonies. The ASSET program cultural educators connect cultural contexts of student lived experiences to the scientific curriculum using culturally responsive pedagogies that places scientific reason into practice as everyday living.

Engaging Elders and local community this way builds a partnership of trust and understanding. The added value is that these respected leaders have become STEM and ASSETS advocates within the local Indigenous community.

The Cultural Engagement and Leadership module is informed by high standards coupled with strong and effective Indigenous leadership. Indigenous students find this engagement empowering and inclusive while reinforcing success within ASSETS and beyond. It delivers STEM programs that are culturally grounded and provides a strong foundation for Indigenous students accessing STEM content and career advice.

The module is designed as a critical point of engagement with ASSETS external communities and other stakeholders including: fundraising; philanthropy; governments; and schools. The Cultural Engagement module has an environment that is ‘Culturally Affirming’ and ‘Intellectually Engaging’ for students. The academic and cultural engagement programs delivered by ASSETS represent the most current knowledges, skills and practices in Indigenous STEM through five key areas.

1. Respect and understanding
2. Community responsiveness, indigenous involvement, places and spaces
3. Cultural celebration
4. Scientific research
5. Inter-institutional relationships and philanthropic engagement.

Model of Innovation Facilitating Border Crossing

Aldous, Barnes and Clark (2008) evaluated ASSETS 2008 and concluded that a critical element to the program’s success was facilitating student’s ability at ‘border-crossing’ cultures smoothly. For example Science is a culture and every culture is comprised of individual groups and defined by a set of beliefs, norm, behaviours and expectations.
Drawing on the works of Aikenhead (1996), Aldous and her colleagues (Aldous 2006; Aldous, Barnes & Clark 2008) suggests that such groups of individuals form a series of sub-cultures within an overarching larger culture. Science is a sub culture of larger social structure. Sub cultures influencing students understanding of science include: family; peers; classroom; school; and physical, social and economic environment. The authors concluded that the ease at which the culture of science is acquired is related to how well students can cross cultural borders between the sub-culture of science and the student’s cultural view of the world. Students whose world view harmonises with the culture of science will experience less difficulty than those for whom the culture of science is foreign.

The findings of Aldous, Barnes and Clark (2008) highlighted the pedagogical innovation of ASSETS 2008 that facilitated the learner to successfully move in and out of Science and Indigenous subcultures. This included high student capacity and fluency found in: transiting subcultures; switching language conventions; enabling students to cross into science and back again at a number of places including peers, family, school, culture, classroom and environment.

Figure 5 shows Aldous, Barnes and Clark’s (2008) Model of Innovation Facilitating Border Crossings in ASSETS 2008. They explain that each factor identified in the diagram facilitates a ‘border crossing’ into the subculture of science at a number of points. These border crossings maintain student identity and self-esteem in a way that is culturally supportive (p. 39). The use of Indigenous mentors and teachers, for example, facilitated entry into the subculture of science (p. 39). The Indigenous landscape used in the classroom enables access into science from the subculture of family.

Figure 5: Model of innovation facilitating border crossings in ASSETS 2008 (from Aldous, Barnes & Clark 2008, p. 39). Reproduced with permission, Teaching Science journal.
Aldous, Barnes & Clark (2008) report:

The use of role models and the running of a leadership program facilitated entry into science from the peer subculture. The provision of culturally-appropriate accommodation enabled access from the subculture of the school. Further, the adoption of the Living Kaurna centre as a culturally significant environment facilitated movement into the subculture of science from an environmental subculture. (p. 39).

It seems the success of teaching students to border cross into science evidenced in ASSETS 2008 should be continued. The fluency with which students border cross into science and the factors that increase the speed of crossing is to be enhanced in future. It is clear a number of such border crossings can be used to dramatically expand the scientific career horizons of Indigenous students. Other border crossings that seem worthy of further research and investigation include: Sport; popular culture; arts; and music.

**Student support and mentorship**

Participants are supported by tutors (in 2009 and 2010, these were three post-graduate students from Flinders University School of Education) and receive cultural support from Indigenous mentors. Skills development workshops build on participants’ capabilities in web page evaluation, using internet search engines and effective use of PowerPoint presentations.

**Site visits**

In 2010, ASSETS participants visited the CSIRO Food and Nutrition laboratories, observing scientists at work in laboratories and participating in hands-on activities. Students also spent a day at Panorama TAFE campus where they experimented with computer-aided design and manufacture.

**2008 ASSETS student outcomes**

The aim of ASSETS is to raise the number of Indigenous graduates in the sciences and mathematics by building connections between universities and participants. ASSETS reported that, of the 14 (out of 20) 2008 participants contacted by the program in 2010:

- 7 progressed to university (Archaeology & Forensic Science, IT, Medical Science, Nuclear Medicine, Paramedics, Justice Studies and Corporate Systems Management, Teaching)
- 3 working full-time (Department of Aboriginal Affairs, Royal Australian Air Force, Indigenous Field Officer with National Parks & Wildlife Services)
- 2 accepted to sheet metal work and painting apprenticeships
- 1 traineeship with Rio Tinto involving Occupational Health, Safety and Welfare studies at TAFE
I completed Certificate III in Aged Care, and was working full-time and studying part-time towards a Nursing degree

**2008-2010 ASSETS student and parent experiences**

Student P.10

I was also selected to attend Newcastle University for a 2 week medical course amongst students from all over NSW, and just in case you didn't know I am going to be a doctor when I am older. I have had many admirable achievements, and I am coming in the top 5 of all of my subjects that I am studying. I guess what I am trying to say is if it wasn't for ASSETS I would not be where I am. I honestly believe that it gave me the extra push to pursue a high career for my education and to actually make a difference for young Indigenous Australians. Also I would like to thank you for such a great opportunity for it has really helped me in every area of my life and for the fact that if I wasn't selected I would never have met the wonderful people who were all a part of it and formed such strong life long friendships.

Student J.9

I thought the Assets program was a great experience, not only the education side of it, but meeting new people and learning more about Aboriginal culture and heritage. I learnt a lot of new things from the lessons we took, including programing a robot, building a circuit, forensic science and lots of other science activities. After leaving assets I carried on with my science and took biology and chemistry as subjects in yr 11 as well as literature, hospitality, maths methods and legal studies. I am now in year 12 and am still doing well in biology but I dropped chemistry as it wasn’t for me. I am also completing literature, hospitality, international studies and further maths. I initially wanted to be a marine biologist but being at Wiltja and also seeing first hand what chemistry was like I want to become a youth worker. Assets has taught me many education skills as well as life skills, I would highly recommend it to future students interested in science or maths. It’s a great experience and am so glad and grateful I was able to take part.

Student JST.8

The teachers especially Steve Goldsmith from the Flinders Uni, inspired me to do well at school, and be proud of my work and especially my culture. From the Wiltja program I gained greater respect and knowledge about my culture where I wanted to learn more about my family and were we originated from. After listening to the guest speakers I felt that it was important to do well in my studies, so I could eventually become a role model to others just as the Wiltja staff, were role models for me. At the moment I’m in year 12 at Thomas More College and studying Physical Education, Biology, English, Outdoor Ed and Studies of Society. My grades are a mixture of As and Bs and after school I am planning to go to university and study outdoor and biology as one goal from me is to
eventually become a Marine Biologist. Before I went to Wiltja I didn’t really take my studies very seriously, but I do now because the program allowed me to see some of the many future opportunities available to me.

Student D.12

ASSETS program … really rewarding… it explained to me what the privilege of being Aboriginal or Torres Strait and the responsibility of keeping our culture intact.

Parent J.13

On my ….. return from the ASSETS program, she completed 25hrs volunteering (a school requirement) at Cairns Tropical Zoo, she enjoyed it so much decided that one day should would like to work there so she began volunteering every Saturday for about 9 months until they offered her a paid Saturday job … received an OP 10 which allowed to her get into her first preference at JCU to do a Bachelor of Science majoring in Zoology and Ecology and will continue to work part-time at Cairns Tropical Zoo … has achieved everything that she has set out to do and will now concentrate on the next 3 years at university.

Parent A.12

Attending the program has opened … eyes to the many possibilities of further education and actually having a career opposed to just working to pay bills. He was buzzing when he came home. As a parent it is lovely hear your child aspirations and goals for their future.

Increased student confidence

Participants reportedly experience a shift in their thinking about study, post-school options and themselves as individuals belonging to a strong, proud culture. Many participants were inspired to mentor other Indigenous students at their school and community, leaving Adelaide with strengthened cultural pride and belief in their ability.

Exposure to university

ASSETS’ setting at the Australian Science and Mathematics School exposed participants to the environment, encouraging them to aspire to university as an attainable post-school pathway to a career in the professions or research. CSIRO 2016 program will continue to engage Adelaide, James Cook and Newcastle Universities.

Post-program support

A finding of this case study was post-program support to improve student transition to STEM university pathways or careers were limited. This was largely due to limited financial and human resources, however future improvements could include ongoing student contact post the program through the Indigenous centres based inside partner universities. Post program contact with alumni is more accessible online through social media like Facebook, twitter, blogs, texts, phone calls and emails. Online now makes it
possible for parents spread across the country to view student presentations across the internet.

**ASSETS post 2014 and into the future**

In September 2014 the ASSETS program became part of the CSIRO Indigenous STEM Education Project. This $28.8 million, five-year project partnership between CSIRO and the BHP Billiton Foundation aims to deliver Indigenous STEM education programs, excellence awards, mentoring, summer schools and tailored university degrees across Australia (more information about the CSIRO Indigenous STEM Education Project is included in the Appendix).

An expanded iteration of the ASSETS program forms the senior school component of the broader CSIRO Indigenous STEM Education Project. The current ASSETS program is based heavily on the Adelaide ASSETS model discussed in this case study but has expanded to include multiple sites with approximately 100 students across the three sites. 2015/2016 summer school locations were:

- **Adelaide Summer School**: University of Adelaide; Investigate botanical survey and discover traditional uses of plants for food; medicine; fibres; food, nutrition; and health science with CSIRO researchers.

- **Newcastle Summer School**: CSIRO Energy Centre; solar energy challenge; investigate contaminants in local water sources; and compare purification techniques.

- **Townsville**: James Cook University researcher: investigate and model mini ecosystems using sensor arrays; animal ecology; and surveying with CSIRO scientists.

In response to concerns over the lack of ongoing support for ASSETS participants, an ongoing leadership and support program has also been implemented. ASSETS staff have ongoing contact with ASSETS participants and continue to engage with them as they complete their senior schooling. This aspect of the program includes access to an online community, networking events, work placements and access to information about pathways into STEM fields.

While only preliminary data on the 2015/2016 summer schools is available, 98 of the 105 students selected to attend participated across the three summer schools and the ASSETS model was successfully adapted to the new locations.

**Evaluation**

The majority of data collection for this case study was conducted in November and December 2015, just before the commencement of the first ASSETS Summer Schools managed solely by CSIRO.
The current ASSETS program is modelled on the previous Adelaide ASSETS program that operated from 1992-2014. The program works with Indigenous and non-Indigenous scholars skilled in evidence-based scientific analysis and Indigenous knowledges with the ability to translate practices into the learning and teaching of science.

What we try to do is, I guess two aspects to it. We’ve got to make the Science engaging in and of itself, and so there’s all the classic strategies for how do you make Science interesting and engaging, so looking at actually getting the students to do their hands-on inquiries, and see the significance and the relevance of what they’re doing to the world around them. I guess with ASSETS we’re really aware that there’s the view of the world around these students is through a filter of their culture and their heritage and that we can’t ignore that, so we basically try and embed the two, embed all the cultural significance and relevance, as well as just the Science engagement, significance and relevance ... we try to draw the links where we can. This is Western science, this is Indigenous knowledge. (Past ASSETS Director 2010-2015)

I think it’s all about the context and the relevance, but that’s true of STEM for any student, not just Indigenous students. You’ve got to make the science interesting, engaging and relevant, and point out how this is impacting on their lives. Then it’s important to apply that lens of cultural relevance, however we need to be very careful that we don’t impose Indigenous links that are tenuous or tokenistic. I think it’s important that we say, STEM is important to your life, and your life can have all sorts of different inputs and contexts. While different sorts of things that are relevant to each person STEM is an integral part of whatever your world is. (2015 CSIRO ASSETS Director)

A significant observation of the ASSETS program is its strong focus on scientific learning and research that is responsive to contemporary issues, and the continued outreach/engagement activities with local Indigenous communities. The integration of Indigenous knowledges and Western content through scientific investigations improves fluency and speed of border crossing cultures. The utilisation of Indigenous philosophies, ideas and imagery is fundamental to the new scientific Indigenism emerging in Australia according Rigney (1991, p. 11) as argued in his seminal paper, A First perspective of Indigenous Australian participation in science, Rigney (1991, p. 11) calls for this new form of science and the need to build Indigenous scientific capacity so Indigenous peoples themselves produce their own science and become the scientist rather than merely being consumers of science. Rigney (1991, p. 11) argues:

Contemporary Indigenous intellectual scholarship must go through a process of building an intellectual community … The return to traditional forms of Indigenous knowledge and cultural realisation can complement the research approaches that are being developed in the contemporary context. The birth of a new body of knowledge by Indigenous scholars is emerging in what I describe as
Contemporary Indigenous Australian Critical Studies. Whatever the future holds, it is an exciting time for our mob and other Australians.

A key ingredient to the program is an holistic framework that ‘engages students at every level, incorporating academic work, wellbeing, culture, sport and recreation, and identity’ (Aldous, Barnes & Clark 2008, p. 39). While the program is nested in a broad equity policy logic that informs its commitment to addressing the underrepresentation of Indigenous students in STEM, it engages strongly with strategies for academic excellence and merit.

A key ingredient to ASSETS’ success seems to be coupling self-esteem and identity to the validation and celebration of Indigenous cultures using science. Clark and Merrotsy (2008, p. 88), reporting on past ASSETS programs, identified successful student outcomes for self-esteem and scientific learning that are categorised as:

- An unforgettable enriching experience
- A positive life orientation
- An affirmation of skills and talents
- A building of confidence and academic self-efficacy
- An inspiration from the successes of others
- The development of new skills
- The acceptance by an Indigenous peer group of academic skills and abilities
- Impact on career choice.

Clark and Merrotsy’s (2008) findings of ASSETS’ success in improving student STEM achievement is confirmed by Aldous, Barnes and Clark’s (2008) research on ASSETS 2008 pedagogical innovation which showed successful student fluency in border crossing in and out of Science and Indigenous subcultures. This research also indicates improved self-confidence, self-belief and awareness of future STEM pathways to future careers. It is clear the program succeeds in increased student cultural pride, enjoyment, satisfaction and self-belief from feeling valued and understood as an Indigenous learner. For example ASSETS 2011 students’ responses (Ball 2011) claim:

- I enjoyed the hands on work and meeting new people
- ASSETS is absolutely AMAZING
- I want to keep the sense of community and belonging I had here and staying at Wiltja
- Thank you for this wonderful opportunity
- I learnt I can do anything I set my mind to
- Knowing where I come from has made me feel proud
- I really value the connections with like-minded peers
- It helped me express my pride for my Aboriginal culture
- It was really interesting to see all the science labs when there were actually people in there working
- Being involved in so many hands on, exciting activities made me feel really special

**Conclusion**

There is considerable evidence that a STEM summer school model works and that there is demand for such programs. The following features are worth noting.

Analysis of the 1992-2015 Adelaide ASSETS literature, interviews and data reveal a successful program that has a participation rate of 30 students annually over the past 24 years. Impressively, alumni numbers total 710 and ASSETS remains the only national summer school that supports cross-disciplinary learnings in science, mathematics, engineering, information technology, Indigenous studies and leadership. The program strengths of the ASSETS model are its three distinctive components: scientific academic modules, cultural program, and residential and social component. Despite its financial resiliency over the past 24 years, the continuation of the program was uncertain in 2014, with funding constraints reliant on annual government grants or irregular philanthropic investment challenging the sustainability of the program. The ASSETS program is fortunate to have secured funding through the CSIRO BHP Billiton Foundation partnership and this has allowed for an expanded version of the program to continue.

The ASSETS concept is potentially transferrable to other educational settings including schools and universities. However it would be problematic for ASSETS competing with other science summer schools. A possible solution is for other universities to run similar programs for high-potential Indigenous students in other disciplines. ASSETS has scalability potential, yet its sustainability depends on consistent funding from philanthropic trusts, and the private and public sectors. Additional long-term government investment would ensure stability, allowing staff resources and energy to focus on the program rather than on fund-raising distractions.

It appears a key ingredient to success is students working with researchers on cutting-edge science and technology projects, and also connecting with Indigenous mentors and community leaders. The summer schools seek Indigenous excellence and are designed to skill, challenge and inspire students in STEM. Mentorship and career guidance after the ASSETS summer school encourages participants to pursue Higher Education while building self-confidence and pride. The case study did not centre on ASSETS’ engagement with parents yet the research literature overwhelmingly indicates the importance of such engagement to facilitate student aspirations and careers.

The new CSIRO partnership with BHP Billiton Foundation will enhance and expand STEM education programs to reach Indigenous students across Australia. The
opportunity this affords Indigenous peoples is a dedicated Indigenous science program that not only aims to get more Indigenous scientists working in CSIRO, but also delivers science projects for Indigenous communities. Summer school STEM education is proven to be a powerful way to support the professional aspirations and career opportunities of a generation of young Indigenous Australians and the continuation of the ASSETS program will have a significant impact. Moreover, encouraging an increasing number of Indigenous students to consider a rewarding career in the STEM disciplines will go some way to further closing the gap and recognising the important contribution Indigenous Australians make to the economy.

**Summary: Case study characteristics**

- Cultural program both embed and run parallel throughout STEM learning program
- Pedagogies: Inquiry based learning, problem solving approaches, culturally responsive
- Delivery by scientists, Indigenous academics, professors, mentors and Elders
- Culturally-appropriate accommodation
- Program workshops run at or on Indigenous places, spaces and sites to make connections between science and the local traditional owners
- Scientific mentors throughout the academic program
- Relating a science unit to an environmental project at the Living Kaurna Centre.
- Philosophy that learning science is akin to learning a new culture. Scientific instruction must be aligned with the student’s cultural view of the world.
- Aim to teach students code-switching fluency to move back and forth between the sub cultures of the science-world and life worlds of the student
- Students whose cultural world view harmonises with the culture of science will experience less difficulty than those for whom the culture of science is foreign.
- Financial instability and reliance on philanthropy and one off grants not sustainable
- High cost in human and financial resources that impact sustainability and scalability
Links to the DEMO framework in this case study:

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembling resources</td>
<td><strong>People rich</strong></td>
</tr>
<tr>
<td></td>
<td>Evidenced through Indigenous Ambassadors, Indigenous</td>
</tr>
<tr>
<td></td>
<td>House Parent Witlja, Student mentors, staff student</td>
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<td>ratio, teachers of science and mathematics</td>
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<tr>
<td></td>
<td><strong>Financial support and/or incentives</strong></td>
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<tr>
<td></td>
<td>All student costs met by program</td>
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<td><strong>Early, long-term, sustained</strong></td>
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<td></td>
<td>Financial instability and reliance on philanthropy</td>
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<td></td>
<td>and one off grants: Program not sustainable</td>
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<tr>
<td>Engaging learners</td>
<td><strong>Recognition of difference</strong></td>
</tr>
<tr>
<td></td>
<td>Cultural integration into program via Indigenous</td>
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<tr>
<td></td>
<td>accommodation, house parents, Cultural program.</td>
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<tr>
<td></td>
<td><strong>Enhanced academic curriculum</strong></td>
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<td></td>
<td>Problem based learning with design tasks set to solve</td>
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<tr>
<td></td>
<td>real world Indigenous challenges for</td>
</tr>
<tr>
<td></td>
<td><strong>Research driven</strong></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
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<td>Working together</td>
<td><strong>Collaboration</strong></td>
</tr>
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<td></td>
<td>Evident from in kind support from Universities,</td>
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<tr>
<td></td>
<td>philanthropic sector and Mathematics and Science</td>
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<tr>
<td></td>
<td>benchmarking agencies</td>
</tr>
<tr>
<td></td>
<td><strong>Cohort-based</strong></td>
</tr>
<tr>
<td></td>
<td>Alumni and Year level cohort based with return</td>
</tr>
<tr>
<td></td>
<td>students developing close relationships through</td>
</tr>
<tr>
<td></td>
<td>residential program</td>
</tr>
<tr>
<td>Building confidence</td>
<td><strong>Communication and Information</strong></td>
</tr>
<tr>
<td></td>
<td>Online, Newsletter, website</td>
</tr>
<tr>
<td></td>
<td><strong>Familiarisation/site experiences</strong></td>
</tr>
<tr>
<td></td>
<td>Traditional Indigenous owners and local geographical</td>
</tr>
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<td>areas of cultural significance used as sites for</td>
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<td>scientific investigations.</td>
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Charles Darwin University

Background

Charles Darwin University (CDU) is an Australian public university with around 22,000 students enrolled. The main campus is located at Casuarina in Darwin, with campuses located in Palmerston, Alice Springs, Katherine and Nhulunbuy. Smaller training centres are located at Jabiru, Tennant Creek and Yulara, with a Waterfront Campus opening in the CBD of Darwin in 2015 where the Business School is located.

The university offers a wide range of degrees and certificate level training courses with flexible study options, including part-time, external and online. The university works in close collaboration with numerous organisations including Batchelor Institute of Indigenous Tertiary Education (BIITE), the Northern Territory Government, Flinders University and Menzies School of Health. There are numerous industry, Cooperative Research Centre and Australian and international university partnerships in place across the programs offered through CDU.

Australian Bureau of Statistics (ABS 2016) data shows that Indigenous peoples make up 26.8 per cent of the overall Northern Territory population, around 240,000 people. CDU currently works in partnership with (BIITE through the Australian Centre for Indigenous Knowledges and Education (ACIKE) and is founded on Batchelor’s ‘both ways’ philosophy (Huijser et al. 2015; Ober & Bat 2007; Yunupingu 1999) of working between and across Indigenous Knowledge and Western science spaces. Both institutions have a long history of engaging Indigenous students in Higher Education programs and their partnership enables a differentiated approach to engaging Indigenous students in university programs, including specific programs such as STEM. Strategies and programs range from community engagement and community-based programs and delivery through to enabling and support strategies for Indigenous participation in the university’s formal Darwin-based courses.

Context

The historical, cultural, linguistic and geographical uniqueness of the Northern Territory presents unique challenges and opportunities, often in stark contrast to the contexts of other Indigenous university programs across the nation. This case study presents an opportunity to outline remote community perspectives and describe CDU’s community engagement strategy but also highlights broader questions that shape Indigenous participation in formal Western scientific programs and institutions. The continuing presence of Indigenous lore and law, language, reciprocal cultural obligations, and the retelling of stories as the conduit for activating Indigenous knowledges and histories marks the terrain for scientific engagement at what Nakata (2007a) calls ‘the cultural interface’, a complex and contested space where knowledge is negotiated between and amongst significant points of epistemological, ontological
and cosmological difference (see also Foley 2003; Ford 2005; Rigney & Hemming 2014; Rigney 1999).

In terms of geographical definition, Darwin and Palmerston are considered to be a regional area, the townships of Katherine and Alice Springs sit within an area defined as remote, and the rest of the Northern Territory is classified as very remote (ABS 2011). According to staff interviewed for this case study, approximately ‘30% of our VET students … are Indigenous, which is on parity with the population … but it’s much, much lower [with] Indigenous students entering higher education’. This is consistent with national figures that indicate much lower Indigenous participation rates in Higher Education than the non-Indigenous population nationally, with Indigenous participation rates tracking lower across the geographical categories of regional, remote and very remote (Long & North 2009, p.10). It is estimated that around 4.9 per cent of Indigenous students transition from VET courses into Higher Education programs nationally (Wilks & Wilson 2015).

Additionally, an interviewee for this case study explained further challenges in attracting and retaining Indigenous enrolments where:

... what we see in the NT, particularly with our private schools and our higher-achieving Indigenous students, is that interstate universities have very strategic marketing approaches in the way that they offer incentives to attract those students to their universities.

CDU does take interstate enrolments but given the relatively small population of the Northern Territory, the attraction of high performing students to interstate universities through marketing and incentive strategies, and the significant cohort of remote and very remote communities where university participation is traditionally problematic for Indigenous students, a community engagement and enabling strategy is necessary to increase the opportunities for Indigenous Northern Territorians to participate in Higher Education.

This case study documents CDU’s enabling strategies, including the ‘Whole of Community Engagement Initiative’ which received around $7.5M of funding in 2013 through the Higher Education Participation and Partnerships Programme (HEPPP) over a three year period. The case study will also describe the partnerships and initiatives that feature ‘both ways’ partnerships and knowledge production projects. As part of the field work for this case study, an experienced mathematics educator and professional association member was interviewed to explore the geographical and cultural issues that face young Indigenous Northern Territorians living remotely who have interest and aspirations in pursuing STEM in Higher Education. In this sense, this case study focuses more closely on the remote Indigenous community context than the nature of Indigenous participation in the university’s more-mainstream courses. This focus also contrasts other case studies offered in this collection.
Overview of CDU programs aimed at increasing Indigenous participation in Higher Education and STEM

CDU has a range of programs that encourage participation in Higher Education. Many of these programs have a whole of community focus such as the Aspire program (see http://www.cdu.edu.au/aspire) where senior secondary students are provided with mentoring, workshops, student supports and orientation to CDU’s Darwin campus to encourage successful transition from senior schooling into Higher Education. Such programs include, but are not specifically targeted towards Indigenous students. CDU facilitates opportunities for on-site student visits to expose Indigenous students to programs, including within the field of STEM, such as Nursing, Midwifery, Aquaculture and a range of VET programs. CDU partners such as Menzies School of Health also offer orientation visits to the lab science program and these were the kind of opportunities described by a STEM educator in an interview for this case study as being highly valued in bringing together remote students from outside of Darwin to spark student interest in STEM and encouraging students to see themselves as being part of a larger group. A CDU manager described a successful ‘site orientation’ approach, but notes the resource-intensive nature of such initiatives:

A group of six students from [a local Indigenous private school participated in] a more tailored program with our Nursing and Midwifery area. That resulted in five or six students enrolling in Nursing at CDU, many of which got scholarships. Many of those students were high-achieving Indigenous students at [the school and] were rewarded as such, but it was through a simple tailored program for six students that we were able to get that result, and that can be quite highly intensive and resource intensive.

Both ways programs located on country are also strengthened through a partnership approach, such as with the North Australian Indigenous Land and Sea Management Alliance (NAILSMA), piloting an Indigenous Land and Conservation Management program tailored to a Northern Australian context as well as a partnership with the Research Institute for Environment and Livelihood developing an Indigenous fire curriculum. These programs feature scientific both ways knowledge engagement on country, create local Indigenous employment opportunities and underpin certificate-level courses that provide pathways into various environment and land management programs at university.

In 2011, CDU commenced a partnership with Flinders University to offer medical studies to 14 Indigenous students within a combined intake of 24 students. These students represented communities across Australia but included enrolments from within the Northern Territory. Four years on, retention of Indigenous students in this program has proved to be difficult. Likewise, within university STEM programs, Indigenous enrolments are well below wider population rates and retention of Indigenous students faces numerous challenges, including the high cost of living in Darwin and scholarship programs and other subsidies often being limited to part-time visitors to the campus, or to a specific cost such as accommodation but excluding costs such as tuition or other
ongoing expenses. For some students, this situation forces them to live with relations where conditions are not always conducive to ongoing study. CDU staff interviewed described current efforts at providing more appropriate supports for full-time students who are not eligible to receive supports in relation to accommodation, tuition fees and other ongoing costs.

These concerns have prompted the university to address some of these issues through a ten-year plan to build on existing relationships and strengthen the university’s current work in Indigenous engagement strategies. A specific focus on Indigenous leadership programs and an NT Centre for STEM engagement has already been identified.

According to ‘fast facts’ on the CDU website homepage (http://www.cdu.edu.au/), ‘each year CDU teaches over 4,000 Indigenous students in over 150 locations across the NT’. In partnership with Batchelor, programs include Literacy and numeracy foundations programs, studies in health, education and community-based studies. A feature of CDU’s approach to providing access to quality programs in remote areas is their commitment to partnerships.

A partnership approach strengthens the university’s ability to gathering expertise and a critical mass of students which in turn strengthens the economic sustainability of programs.

CDU works in close partnership with the Northern Territory Government (currently within a formal 2014-2021 partnership agreement), Flinders University, Menzies School of Health Research, Batchelor Institute (through ACIKE), NAILSMA and CSIRO, although disinvestment in CSIRO as an organisation has more recently presented challenges in the provision of STEM programs.

A senior school mathematics educator interviewed for this case study described some of the challenges for Indigenous students living in remote locations such as Alice Springs and beyond. The absence of large-scale programs and, often, university-bound peer groups, make it very difficult for students to pursue STEM through the senior years and into Higher Education. Currently, student interest in STEM is encouraged through a series of partnership-based short term programs. These include visits to CSIRO in locations such as Alice Springs, field trips to Menzies School of Health and CDU in Darwin with small groups of interested students, engagement activities with the Arid Lands Environment Centre (ALEC) (see http://alec.org.au/) and an annual STEM ‘open day’ in Alice Springs, held in partnership with the University of Newcastle. These types of programs rely heavily on the energy, interest and goodwill of teachers.

The mathematics educator expressed frustration at the level of support for high profile programs that provide active supports, mentoring and role models for Indigenous students focussed largely on participation in sport, school attendance and wellbeing. Such initiatives often take students away from regular lessons in STEM and limit student interest and availability to participate in STEM initiatives to explore opportunities offered through CDU and their Darwin-based partners, for example. A similar frustration was shared by a CDU based interviewee who estimated that up to 12 Indigenous student programs had approached one community partner school, largely
targeting the Indigenous leadership program space, a dynamic that can distract potentially high-end achievers in STEM.

CDU recognises the importance of a flexible community engagement approach within the cultural and geographic context of the Northern Territory, but also the need to step outside of the limitations of traditional, institutionally based Western scientific programs in engaging Indigenous communities, their knowledges and values in Higher Education programs (see, for example Smith et al., in press). HEPPP funding received in 2013 has provided an opportunity for CDU to undertake a broad-based approach to community engagement with selected remote Indigenous communities. This program is described below.

**Whole of Community Engagement initiative**

**Program description**

The Whole of Community Engagement initiative (WCE) is funded under the three year HEPPP program, with funding due to finish in 2016. The WCE initiative works across six very remote community sites to explore alternatives for increasing the potential for university participation in these communities. The communities include: Yirrkala, Galiwin’ku, Maningrida and Gunbalanya in the Arnhem Land region, Tennant Creek in the Central Desert region and Yuendumu in the Tanami, some 300km north-west of Alice Springs. Each of these communities and regions has unique linguistic and historical contexts, including diverse interactions with colonialism that shape the nature of engagement with education and the potential for participation in Higher Education.

For example, Yirrkala has a long history of championing a bilingual approach to education and was the site where the late Dr M Yunupingu (1999) worked as principal and developed the ‘both ways’ vision and model, a tradition continued through the work of his wife, Yalmay (Yalmay is also employed casually through the WCE initiative) along with a host of other Yolngu and Balanda (non-Indigenous) educators (see CDU 2007; Dhimurru Aboriginal Corporation 2013; Matthews et al. 2005).

Tennant Creek is situated around the Stuart Highway between Alice Springs and Katherine, some 900kms south of Darwin. The Warumungu people were buffeted between the expanding pastoral industry and gold mining activities in the region, placing Warumungu and their language under severe challenge. Now a town of some 3000 people, local Indigenous people live dispersed throughout the town, in fringe camps and in small communities and pastoral stations in the area.

Yuendumu is one of four major Warlpiri communities (including Lajamanu, Willowra and Nyirripi) in the Tanami region. The community also has a long history of engagement with bilingual education (Nicholls 2005) with qualified Yapa (Warlpiri) educators still actively involved (a number of whom are also employed through WCE). Yapa invest heavily in education initiatives through gold mining royalties which are administered through the Warlpiri Education and Training Trust (Minutjukur et al. 2014).
The Arnhem Land communities of Gunbalanya, Maningrida and Galiwin’ku represent dozens of languages and dialects and incorporate a large network of homelands. Some of these homelands have small education centres known as Homeland Learning Centres where limited schooling is provided as available resources and seasonal conditions allow. Gunbalanya School is the first remote school in the Northern Territory to achieve Independent Government School status (January 2016) and has achieved a steady increase in year 12 graduates over the past few years. Other independent schools are also surfacing in the region, such as the Narwaddeken Academy (http://www.nawarddekenacademy.com).

Aims and Objectives

CDU has taken an action research approach to informing the next phase of community engagement across these six sites with the view to increasing university participation, including STEM programs. In the remote context, this approach includes the employment of local people with tertiary experience or community level leadership to lead the process of investigating the aspirations of local community members and proposing models for how possibilities for tertiary participation might be strengthened. An informant for this case study described the process as trying to identify and better understand the broader issues, including:

...the system blocks, so it’s not merely about what do we do when the students get there, it’s about understanding these various system barriers for them to be able to enter higher education, full stop. So it’s addressing issues around accommodation, addressing issues around travel and family support; it’s addressing those issues around academic literacy and [numeracy].

CDU has taken a ‘bottom-up’ approach in pursuit of these questions.

Capacity building and intergenerational approaches

A senior manager of the WCE initiative interviewed for this study identified two key issues arising from this work in relation to participation in STEM:

...looking across the six sites ... it’s been very much bottom-up in the approach, and to be honest STEM hasn’t emerged as [an immediately obvious]priority, and I would probably say that’s because the issue of LLN [language, literacy and numeracy] has been identified as a priority in ... all of the six communities that we’re working in

The manager outlined that students in the partner communities (and by implication, the broader remote community context) are not completing school and VET courses with the mathematics and literacy skills required to gain direct entry into Higher Education. This restricts opportunities for remote Indigenous learners to participate and succeed in tertiary STEM programs:
...there’s a need to systemically invest in that space, and ... there’s been a failure both of the school system and of VET and the Higher Education system in supporting Indigenous students to excel in that regard.

Traditional pathways into STEM such as completing high school with an ATAR score and a strong grounding in mathematics and science leading to enrolment in STEM courses based at the university are not visible for remote students, but STEM engagement is not invisible by any means:

There has been a great deal of work in the STEM space happening through a partnership with NAILSMA and the Research Institute for the Environment and Livelihoods (RIEL) – these activities have primarily centred around land and sea management. This has included the development of Indigenous land management curriculum resources. Ultimately this work will create pathways into higher education in the environmental sciences space.

I think a problem... is that the term STEM does not mean anything to the communities in which we are working. If it is broken down, and examples provided, then it may emerge as a higher priority.

CDU’s WCE approach has involved employing a local Community Engagement Leader and mentor, a Mentor and an Engagement Officer working alongside each of the six partner communities. Additionally, between two and four local people who have an interest in education have been employed to support the work. Many of these local employees are senior community members who have degrees and double degrees through institutions such as Batchelor Institute, CDU, Deakin University and Curtin University. A manager describes the process this way:

We’re having conversations with communities to say, ‘What are the issues? What are the problems?’ We’re documenting those, and then we’re starting to have conversations at more of a systems level around how can they be changed or how can they be improved. So part of it is taking... some of the community perspectives back to institutions like Batchelor, CDU, and the Department of Education who are... partners in this project, and saying, ‘Hey guys, what’s happening is not working. Schools aren’t fulfilling their obligation in terms of language and literacy for these remote students, and we’ve all got improvements to make.

To put some perspective around this concern, according to one interviewee, there was only one very remote Indigenous student in the NT who attained an ATAR score that could enable direct entry into university in 2015. This issue is not a recent phenomenon, however, and CDU and Batchelor have long-standing ‘Indigenous specific’ enabling programs in place to support students, including adult entry students who haven’t achieved an ATAR that allows entry into a university course, but have the capacity and desire to enrol with support. These include bridging courses, (such as Preparation for Tertiary Success, and the Tertiary Enabling Program, see Hall & Wilkes 2015), academic literacy programs, language supports and scholarship programs
to assist with accommodation and other ongoing costs. One interviewee felt that the strength of these initiatives places the university well to be able to cater for the needs of international students. Beyond questions of how the university might break down barriers to bring people in to the university, there are important questions in terms of engaging the existing languages, knowledges, strengths and values in the myriad of remote communities situated throughout the Northern territory.

**Working both ways**

Building on Batchelor’s ‘both ways’ approach, Indigenous ways of knowing are central to a range of CDU partnerships and programs where scientific engagement works between and across the spaces of Indigenous Knowledge and Western science. This knowledge negotiation process takes place across all courses in the context of the NT, including education and health, and also across VET courses, but is particularly important in programs such as ‘Learning on Country’ and environmental sciences. The dual-sector structure enables CDU to offer a wide range of structured and formalised learning which can be constructed and delivered within a both ways pedagogical frame, including research methodologies, but these units can also be recognised for credit towards university degrees. This opportunity is firmly in the minds of CDU management but has not fully become embedded in what the university offers. A manager explains:

*We’ve got that opportunity to get those pathways and transitions between VET and higher education mapped out. We can look at articulating pathways between Cert IV and diploma-level courses, so we’ve started that certainly in the Education space, and in the Nursing space.*

*There are opportunities there but we’ve still got a long way to go. It needs to be systematised and coordinated much better than what we do at the moment, but certainly we’re starting to do research in that space as well, which will be really important to inform the way that the university moves forward.*

Partnerships offer potential for both ways engagement through bringing expertise and resources to the region that are otherwise limited if working in isolation.

**Working within partnerships**

Formal partnerships are in place to bring expertise to the wider student cohort, including Indigenous students, such as the medical research and studies partnership with Flinders University and Menzies School of Health, as well as partnerships with ALEC and CSIRO, among others. Partnerships specifically aimed at Indigenous students on-site within the current university structure have tended to focus on the area of Indigenous leadership and aspirations through work with the Foundation for Young Australians and the Michael Long learning and Leadership Centre. As mentioned
above, there are also discussions underway to establish the NT Centre for STEM Education, which CDU expects to take the lead on.

Both ways programs located on country are also strengthened through a partnership approach, such as with the Northern Australian Indigenous Land and Sea Management Alliance, piloting an Indigenous Land and Conservation Management program tailored to a Northern Australian context as well as a partnership with the Research Institute for Environment and Livelihood developing an Indigenous fire curriculum. These programs feature scientific both ways knowledge engagement on country, create local Indigenous employment opportunities and underpin certificate-level courses that provide pathways into various environmental science and land management Higher Education programs.

From data collected in the process of developing this case study, it is clear that the CDU/Batchelor partnership has many strengths across areas outlined in the rubric. CDU has invested in people in a proactive manner to build a long term, research informed approach to increasing Indigenous participation in Higher Education, including STEM. CDU prioritises methodologies that are both culturally and contextually responsive (Guenther 2015; Perso 2012) which engages learners and the wider community in a differentiated approach to curriculum development, teaching and research. The CDU model prioritises collaboration and the notion of working together. There were a number of initiatives described that are aimed at offering familiarisation/site experiences, although some comments suggested the university is aware of the need to be more systematic and better coordinated in how this occurs across the partnerships and disciplines.

One of the concerns for CDU is the sustainability of programs through securing long term funding. The Northern Territory, particularly in the Indigenous policy space is sensitised to boom and bust cycles of policy and industry fortunes (Stafford-Smith & Huigen 2009). Recent examples include the Northern Territory Emergency Response (NTER – commonly referred to as ‘the intervention’), the rise and subsequent downturn of mining activity in the region, and the newly emerging policy and funding focus centred on ‘Developing Northern Australia’. Each of these cycles potentially present opportunities for partnerships, funding and research engagement, but none of these are a given in the medium to long term. The fickle nature of securing resources in the NT is well understood by the university and the long term planning process is an approach being utilised to allow the various cycles to enhance, rather than determine the university’s priorities.

Gale et al.’ (2010) DEMO model also suggested what evaluations might look for through the following equity perspectives:

* Unsettling deficit views, researching ‘local knowledge’ and negotiating local interventions, and building capacity in communities, schools and universities.

The ‘both ways’ philosophy and pedagogy described in this case study along with the partnership approach to strengthening local community capacities, including aspirations
Charles Darwin University

(Appadurai 2004) places the Batchelor/CDU model in good stead, preferring a logic of building local community capacity over a logic of externally imagined and derived intervention.

Summary and issues for reflection

The CDU/Batchelor approach is to work closely with Indigenous students and communities and build capacity for tertiary engagement. This is undertaken through a range of enabling strategies and programs. The university is building on Batchelor’s long-established ‘both ways’ philosophy and pedagogical approach to support joint teaching and research programs in a dual-epistemological context. The Whole of Community Engagement initiative is a research informed process aimed at increasing remote Indigenous student access to CDU’s VET and Higher Education courses. The university recognises that more Indigenous students enrolled in VET could be encouraged and supported to transition into Higher Education courses and HEPPP funding provided over a four-year period has enabled a comprehensive program to investigate options of how this might be achieved.

CDU is in negotiations to establish a Centre for STEM education and this will generate resources to encourage engagement with STEM, although the tendency has been for Indigenous students, particularly in remote communities, to be attracted towards courses and disciplines outside of STEM. The Whole of Community Engagement initiative is only funded until 2016 and is a program that can only continue if additional funds are received. The university is considering how they might bridge the divide between remote students and the university’s programs that will be resourced in the longer term, such as Indigenous leadership programs, continuing courses and the newly emerging focus on STEM. There is national attention being focused around STEM, but the importance placed on Indigenous Knowledges and their attributed scientific and economic value in a national policy context such as the Commonwealth Government’s ‘Developing Northern Australia’ policy (see http://www.liberal.org.au/2030-vision-developing-northern-australia) remains to be seen. These political decisions will strongly influence the amount of resources a ‘working both ways’ methodology could potentially attract into the future.

The Whole of Community Engagement initiative has prioritised the engagement (and employment) of senior community members to guide questions regarding the possibility for increasing tertiary engagement, to inform and shape research methodological practices, and to encourage young people in the communities to get involved. The CDU/Batchelor model stands as a unique approach to Indigenous engagement in Higher Education through resisting language and impulses towards notions of deficit and disadvantage and instead, adopts an approach that builds on the strength of Indigenous communities, languages and knowledges in their approach to teaching and research in a dual epistemological context.
Curtin University: Indigenous Australian Engineering Summer School (IAESS)

Background

Engineering Aid Australia (EAA) is a philanthropic organisation run entirely by volunteers and dedicated to encouraging young Indigenous high school students to complete Years 11 and 12, to consider engineering as a profession, and ultimately to go on to university. The organisation’s first Indigenous Australian Engineering Summer School (IAESS) was held at Sydney University in 1998. Since then, summer schools have been held every year in January, either at the University of Sydney, the University of New South Wales or the University of Newcastle. Since January 2010, summer schools have also been held at Curtin University in Western Australia. In total, 24 summer schools have now been conducted across these institutions, 18 in New South Wales and 6 in Western Australia. At the schools, students take part in engineering activities, tutorials and site visits. This case study focuses on the summer schools held at Curtin University.

Funding for the summer schools is raised by EAA from engineering organisations, philanthropic foundations and individual donors. EAA reimburses the universities for their costs after their substantial in-kind contributions. All student expenses are paid by EAA including air fares, accommodation and meals. Students also receive a $300 to $400 Continuing School Scholarship to help with education expenses during their final school years. For those students who progress to university, a $3000 Undergraduate Scholarship is awarded. In 2015 EAA awarded three Undergraduate Scholarships and 24 Continuing School Scholarships. Currently EAA has 33 undergraduates at universities around Australia, and a number of graduates are now employed as engineers in sponsoring companies.

Through EAA sponsorship and the scholarship program students are linked with industry sponsors with the view to students gaining work experience and possible future employment. This is important to companies striving to improve Indigenous participation in their workforce and to fulfil their Reconciliation Action Plan obligations.

Each year, all money raised is pooled and used to pay for the summer schools in WA and NSW, the Continuing School Scholarships, the University Undergraduate Scholarships, EAA administration costs such as insurances, auditing and ASIC compliance costs, printing and stationary etc. The annual budget is approximately $250,000.

In the 2015 calendar year EAA funded two summer schools (Sydney University and Curtin University), provided 31 Continuing School Scholarships for Year 11 and 12 students, awarded four Undergraduate University Scholarships (Sydney University, University Technology Sydney, Queensland University and Flinders University),
awarded two Bob Hawke Leadership Awards, and eight Scholarships for the girls who attended summer schools. There has been a definite increase in girls attending the IAESS.

This background information was generously provided by executive officer of EAA and the IAESS.

**Context**

Having provided an overview of the IAESS program, this case study focuses on the Western Australian component. Since 2010 seven summer schools have been conducted. Initial phone calls with the Engineering Outreach Coordinator at Curtin University, showed a commitment to a project that made a difference. This was followed with an interview with the Student Equity Advisor, Faculty of Science and Engineering, Curtin University, in Fremantle in December 2015 and responses to questions and documentation in March 2016.

Advertising material indicates that students enrolling in a summer school must be currently in Years 9, 10 and 11 and have demonstrated both interest and academic potential to pursue a career in engineering; that is, have an interest and aptitude in mathematics and science, like to be hands-on with machinery or practical tools and enjoy solving challenges.

With the support and recommendation of their teachers, chosen students are fully financially supported to participate in the IAESS in Perth. They participate in classes, laboratory activities and field trips to give them a hands-on engineering experience. They meet engineers, participate in design work activities, visit engineering projects and gain an understanding of the career options that are available within the profession. In addition, the summer schools provide an opportunity for students form social networks to encourage each other, and others, to follow a career in engineering (https://engineering.curtin.edu.au/outreach/indigsummerschool.cfm).

**Curtin University Outreach program**

The IAES summer school sits within the Faculty of Science, Engineering and Mining at Curtin University, which coordinates science and engineering school outreach/engagement activities. There are three arms of Outreach and Engagement: (1) Science Outreach (a team of about 10-12 staff members); (2) an Engineering Outreach team (3 or 4 staff members), and (3) Equity Outreach Division, which is non-specific to either Science or Engineering. The IAESS fits with this third arm. Whilst content area is focused on science, engineering and mining, the mandate is to work with the low SES identified student cohort. This cohort includes metropolitan, regional, and remote students, Indigenous students, as well as students that might fall into diversity categories of gender and sexuality.

As part of their Indigenous Engagement Strategy, Curtin University is involved with
the *Follow the Dream: Partnerships for Success* program, which is funded via the Graham (Polly) Farmer Foundation and the state Department of Education and Training. This program is run in metropolitan and semi-regional sites and the very regional areas, where high-achieving Indigenous students are identified and supported through their high school education. Each site has 15 to 30 students depending on the size of the town and make up of population (per cent of Indigenous). This is a key practice to Curtin’s engagement stream. Outreach staff engage with students at their schools, during class time, as well as after school. Class activities are undertaken after school hours from about 3pm to 5.45pm with 14 metropolitan schools, and six to seven regional schools. The program involves students actively involved in hands-on science and mathematics.

*Science aspiration-raising activities, fun, pop and whiz bang type activities, to kind of reinvigorate or re-energise students around their Science or STEM (Science, Technology, Engineering and Maths). We then invite those students onto campus to dispel those myths about coming to university.*

In Year 10 or 11, the students are encouraged to take part in the IAESS, which is a week-long program aimed at showcasing Engineering, in order to increase participation numbers of Indigenous students in Engineering. While there are a number of Indigenous students enrolled in the science and resource-based courses and Occupational Health and Safety, only a very low number of students are enrolled in Engineering at Curtin University.

The students who did come through to university needed to complete bridging programs, and this developed a supportive environment, provided an opportunity to profile students’ needs, connect them with university career guidance specialists to construct a career map, (or a pathway map) for them to come to Engineering or Science. In this context, the IAESS has been a further strategy to support the transition to university-level Engineering.

**Aims and objectives**

Broad aims include:

- to increase numbers of young Indigenous high school students to stay on at high school in Years 11 and 12
- to increase achievement in science and mathematics particularly between Year 11 & 12
- to encourage more Indigenous students to consider engineering as a profession
- to increase numbers of indigenous students attending university and undertaking STEM based courses.

The IAESS has two key aims, the first being to showcase Engineering in the metropolitan area; students visit Engineering sites and are shown what Engineering is and what it involves. While most students gain a concept of Science through their schooling, Engineering is taught only in very specialised schools and programs.
Consequently, the school redresses this by showing students what Engineering is, and demonstrating that it’s attainable across gender and that it’s not reserved for males. A larger female participation in the IAESS program is encouraged where possible. The IAESS aims to support Indigenous student retention in high school mathematics and science so that increased numbers transition into Higher Education.

The second aim of the IAESS is to formalise relationships with students, to assist them regardless of which area they are interested in or which institution they are planning to enrol in. Some students choose to go to the University of Western Australia, Edith Cowan University or Murdoch University, because family members (siblings and cousins) are there, and it is more logical that students go there. So the aim is to support students to select their pathway. Although Curtin University hosts the summer school, it is deemed a success if a student transitions to any university in a Science-based course.

The objectives of IAESS are to provide a challenging environment for Indigenous students:

- to discover the benefits of the engineering profession
- to provide a forum for students to meet engineering role models
- to gain insights into the excitement and opportunities engineering can provide to indigenous communities.


**Characteristics of the IAESS program**

Characteristics underpinning the IAESS program at Curtin University include:

- a week residential program on campus- Sunday to Saturday
- live-in: accommodation provided, travel to/from Perth
- catered: all meals, drinks and snacks included
- supervised: Indigenous university students as house parents
- industry supported: site visits and industry representatives
- academically supported: exciting and educational activities
- free: spending money is all that the student might need, but even that isn’t necessary.

**Participants**

The Curtin outreach team works closely with Indigenous officers and the *Follow the Dream* staff and these liaise with staff and teachers in schools. Where there are no contact people, hard copies of the program are sent to designated science and mathematics coordinators gathered from the Education Department staff list. The students then apply to participate in a summer school. They need a reference from a staff member as well as the school Principal, citing behaviour and aptitude for science
and mathematics. The students go through a selection process and up to 20 to 25 students are chosen:

*Often we only get to the 20-22 mark because ... we don't know why schools don't recommend, we don't know if the information gets to the teachers that are concerned, we don't know if the information gets to the children that are concerned, but we've been satisfied with the level of participation in the past.*

Most students are from Western Australia:

... last year every student was from WA, which was the first time that everyone was from WA. We usually have 80% WA students, a few from South Australia, Northern Territory, the eastern states, perhaps students that have done IAESS in the east have come over and done it here as well. There’s a few students that kind of cross-migrate and do both.

**Getting there and costs**

Support and pastoral care is a central component, with each student being met at the airport by an Indigenous mentor and another staff member to welcome them and to give an initial orientation.

*Because of geography in WA, logistically it’s very, very difficult to coordinate because the distances in WA are quite large, and some students have to go from a community to a small town, from a small town to a larger centre, to Perth, and it can take the best part of half a day to get here. So we have airport runs happening from 6.00am to middle of the night, because we just can’t coordinate all the flights at the same time.*

They travel to the campus, are shown their accommodation and given a campus induction and immersion experience. When everyone has arrived there is an induction. The program is cost free for the students, with no parental, community or school contribution. Everything that’s needed is covered, including the Summer School t-shirts, food, transport, technology that they use.

**Program description**

Although it started off quite small, The IAESS has now been running for six years in Western Australia. It is funded through EAA who assist Curtin University to run it. The costs are very high because every student and mentor is flown in and kitted out with all the clothing and safety gear (boots, helmets, high-vis equipment) which they keep. Students and mentors are accommodated for the week in campus housing which also comes at a high cost. There are also costs in transporting participants to and from sites. There is a very high ratio of mentors and house parents to students, virtually 2:1, so that there’s large amount of care in place to minimise risk.

Many of the mentors and house parents are past participants, so they know and understand the demands the program. Students now studying at other universities are purposefully selected as mentors and house parents to give a broader perspective, because it is about retention and transition of students into Higher Education.
After four years of the program it was noted that it was largely superficial in that students would come, have fun, and learn about Engineering, but never really have the skills or the ability to transition to an Engineering pathway. Three years ago a secondary component was introduced, this involved a return to the IAESS. If a student had attended an IAESS in Year 10, they would be invited back to attend an academic camp in Year 11. This initiative is called the Indigenous Australian Engineering Pathway Program (IAEPP). So instead of just coming along, walking around sites and doing practical hands-on activities, they were given a more university-based experience. This included daily lectures focusing around specific subjects that they were doing at school (Mathematics, Physics, Chemistry or Human Biology). The lectures focused on content knowledge especially revising aspects students had battled with in previous years, as well as study skills. Another strength of the program was technology. iPads and computers have been allocated for student use during the summer school and to keep permanently, in order for them to stay in touch and connected with mentors (i.e. after they go back home). This allows for ongoing support for preparation on an academic pathway through the following year.

2016 is the first time that a third group of students has returned, so there would be some repeat students. Each year there are between 20 to 25 participants in the program. In the first year there were 6 return students, last year there were 9. In 2016 there were 6 return students, although not every student has an interest in STEM.

_We’ve also tried to create the safety, kind of culturally safe space where students can actually say, Look, I am more interested in Commerce or Medicine, or whatever the case is, and we try and assist them as best possible._

**IAESS and IAEPP activities**

A typical day for first years involves breakfast, then an activity and a site visit. The site visit changes each year, depending on developments in Perth. In 2015 the site visit included the Fiona Stanley Hospital and the new Elizabeth Quay. There is always a resource visit to a mine or processing site in Perth, or the surrounds. Links are also made to Electronic Computer Engineering. There are 11 different types of engineering at Curtin University, so visits are in line with those if possible and also, and in line with industry connections:

_We want them to meet any wacky professors from strange areas that they’ve never heard of, and take them into Medical Imaging, or take them up to a Physics lab or a Chem lab to meet a lab technician, but it’s highly dependent on who’s available._

The program includes hands-on activity building, so if there are circuits in play at an electronics company, or they’ve done some work in Chemistry, they will do a similar activity in the afternoon. This hands-on dimension helps to show them that they have the capacity to do engineering. There are also opportunities for engagement and networking with industry.

On day three EAA and Curtin University, as part of the IASESS, host an evening
Networking function where students dress more formally and engage with people from the engineering profession. There are always lots of past students and industry members, so the students are encouraged to engage with everyone. These evenings are important as traineeships can eventuate and relationships are initiated with HR staff from companies that have scope to employ Indigenous students in work programs and graduate programs. There is also a reasonable amount of scheduled leisure time.

The second year return students have a much more rigid, almost university-style timetable, including a Mathematics lecture, a Physics lecture but, where possible, tailored to suit each student:

Sometimes it's one-to-one, there might only be one student doing Human Biology, so they would have a Human Biology tutor. When we do common subjects like Mathematics or Physics or Chemistry, those subjects for that day are actually taught in corporate Boardrooms. So we take the students to a financial house, for instance, and they are taught their Mathematics for that day, if they're doing Interest and Depreciation, or they're doing Calculus that's related to whatever. Industry people would come in and actually talk about the relevance ... it allows them to see how industry operates, to see what it’s like to report in at Reception and to meet the HR person, go into boardroom, and then they have their lecture in the boardroom, and then there’s some engagement as well with industry. So we found that really successful.

For the second year program, a local Mathematics and Science teacher does lots of the teaching. He writes the curriculum and study guide material to ensure that it meets the needs of each student. Local study guides (Physics and Chemistry textbooks) are purchased so that students can learn how to use them effectively. This also ensures the students are learning the science and mathematics content required by the Australian Curriculum.

A focus on problem solving

The IAESS program includes problem-solving tasks set which students work in teams to solve. The DMAIC (Define, Measure, Analyse, Improve and Control) framework is modeled for solving engineering problems. Students work in collaborative teams to solve various tasks using lego.

... we don’t give recipes for success, so when we pose them with a problem or bridge-building activity, or ... they use a supply and demand type activity, we basically give them a very rough sketch of what’s required, and allow them to set the rules, allow them to set the framework, the times, and all the rest of it, and to achieve a result, and see whether they can actually achieve a result within that amount of time. So we keep it as structure-less as possible.

There are some very practical hands-on activities because some of the students are vocational. It has been noted that even though they are high achieving, they’re high achieving within their vocational pathway, or they do a lot of Vocational Certificates. The tasks involve hands-on and practical skills, such as soldering and setting up circuit
boards. It is about sequencing, setting those goals and working together:

*There’s a lot of group work which we have huge amounts of in our first year Engineering as well, our Foundation year, so it’s a mini replica of what would happen in Engineering Foundation Year at Curtin, group work and group tasks, and group responsibilities.*

*There’s one very, very strong problem-solving activity around removing oil from sand, drilling wells and all the rest of it, and it’s really just basically thrown at them and saying, You need to get the oil out, do it, kind of thing, so not much guidance is given.*

**Residential component**

Residential arrangements during the IAESS provide a high level of student support:

*So every three students – we have single rooms in our dorms and every three, perhaps four – has a house parent as well, and then the other house parents have a collective house that they live in.*

*Generally speaking there are female house parents for the girls’ houses and male house parents for the boys’ houses, and they tend to be on duty breakfast, lunch and dinner, and evening.*

The mentors are from an Engineering and Science background. They set up and assist with the activities, accompany the students to industry and facilitate Science. The house parents have more logistic roles, such as ordering t-shirts, making sure the lunch has arrived. Some of them do both roles, depending on their past experience.

The program is led by the Indigenous house parents who elect a person to take the lead role. They ensure that the program runs to schedule.

**Cultural engagement and leadership based instruction**

Cultural engagement has been gradually increased over the years as Curtin IAESS responded to the comments by both participants and the Indigenous house parents (most of whom are currently studying at university). Besides the Welcome to Country (at both opening meeting and the Graduation Evening) and Smoking Ceremony, other activities have been introduced:

- An inspirational talk and workshop held on the Sunday before the camp starts, hosted by a local Indigenous woman who has worked at the executive level of the resources sector for more than a decade
- a Dreaming Stories activity based on the sky and the stars was integrated into the visit to the Bickley Observatory
- separate times allocated for the boys and girls to gather and spend some time reflecting on their goals and dreams, based on the traditional ‘yarning’ time.
- A visit to a local not-for-profit group Abmusic, where the local Nyoongar musicians and hip-hop artists assist them to write a song about themselves.
The returning group – the Indigenous Australian Engineering Pathway Program (IAEPP) – undertook an Engineers Without Borders day-long project where they analyse a remote Indigenous community’s needs and design an engineering solution for a problem they face, and then produce a PowerPoint presentation to deliver to a panel of engineering academics.

**Student feedback**

A survey in 2014 final report provided evaluation comments about the following key items:

- 95 per cent of the students said they felt IAESS was a valuable experience for them
- 90 per cent said their perception of engineering had improved
- 75 per cent said it increased their interest in studying engineering at university

Student comments from the report include:

*This experience means a lot to me, it has bought me out of my comfort zone, and opened my eyes up to the different types of engineering and the fun side of engineering. This trip has also allowed me to make new friends that I can keep forever, we have bonded so good, it’s kind of like our own little family. But this experience has showed me there is a lot more to engineering than I think and the mentors we have are amazing and I hope to keep in contact with everyone.*

(Student A)

*The IAESS camp was a great experience in terms of practical activities and learning further about my capabilities and future career options. IEASS is very informative and helped me to learn about engineering and job opportunities available for me if I were to study engineering at Curtin. Overall, I loved IAESS.*

(Student B)

*The IAESS experience has actually changed my mind about engineering, before i had no idea that there were so many various types of engineering until this week. Engineering is now in my mind for my future. I had so much fun and I’m now going to take away from this summer school a whole new perspective of engineering.*

(Student C)

The following testimonial comes from a student who completed IAESS 2013, IAEPP 2014 and IAEPP 2015:
I first started with the IAESS program back in 2013 as I was moving into year 10. It wasn’t the first science and engineering summer school I had been a part of, but it would soon prove to be the most memorable; a defining moment in my schooling choices and future endeavours.

During the 2013 summer school, I was exposed to a very unique program, one which left me wanting more. The week was filled with engaging and fun activities, such as building water powered rockets, scaled oil rig digs and so on. There was also site visits, and even a trip out to the Perth astronomy observatory.

The mentors were the best I’ve ever had for such a program, as they were all fun, engaging, and didn’t take on that authority figure all the time. People you could have a good conversation and a laugh with.

The living arrangements were great, getting a room to yourself with plenty of living space. Nights were taken up by rigorous rugby and football matches and chilling on the grass outside our houses.

The days blended into one, and soon came the defining moment in the camp, the IAESS ball at the Pan Pacific. The atmosphere for this was amazing, in particular the lead up where we were all getting dressed to the nines, ready for what proved to be a truly great night.

As I said previously, after this first encounter with IAESS, I was left wanting more, so I planned on applying for the camp a second time, until I received a call from Tim, explaining to me that the program was ready to take the next step and introduce a pathway program, for students whom had completed the IAESS program the year before. He asked if I would take part in the program, and of course the answer was yes.

This program was a bit different to the IAESS summer school, as we were now moving into more serious territory, getting to experience tutoring for our WACE subjects and have a deeper look at our subjects and how they are applied to engineering. Again this was a new and unique summer school program, and, unlike anything I had experienced before. I went on to partake in the pathway program for another year, meaning I had been involved with the IAESS program for 3 years at that point.

As I said, this program was a defining moment in my life, as it has lead me to do what I am doing now. I am currently studying a bachelor of engineering at Curtin university and am looking forward to my continued involvement with the program that has played a major role in getting me to where I am today.
Mentors and cultural responsiveness

Having mentors who have previously participated in the program in either Perth or Sydney is a real strength.

Sometimes the two programs run concurrently, so sometimes the Sydney and Perth run at the same time, so then the more experienced mentors get to choose which way they want to go. So one year they’re with us, one year they’re in Sydney, and they tend to oscillate between the two.

There’s a core group of Indigenous mentors Australia-wide, consisting of IAESS participants who have gone on to study engineering. There is also a core group of local Indigenous university students, not all studying engineering, who return year after year to be House Parents at the Perth IAESS. Of the ten staff involved in the Perth IAESS, more than half would be Indigenous. However, the Program Manager, and the two assistants are non-Indigenous, so the three staff who are the key Curtin University staff (and who really hold the Duty of Care) are non-Indigenous. To address this, staff is seconded from the Centre for Aboriginal Studies and has access to an Indigenous Equity Advisor, who is seconded for the duration of the camp.

We do consult with Indigenous leadership every month before the camp, so we have meetings with them. Sometimes it’s informal meetings about the ways of working and the things we need to do, the protocols that we need to have. If we’ve got people that are from off country, out of country, all these kinds of things, that we need to manage and maintain, so we have localised meetings with the Centre for Aboriginal Studies, or their designated staff that assist us in making sure that we’re as culturally appropriate and safe as we possibly can be.

The mentors are on duty day and night, and it is fairly demanding work to coordinate all the student groups, as well as industry players. So responsibilities are delegated, two or three mentors stay behind to set up the night’s activity while the other two or three are taking the students on excursion.

Issues and dilemmas raised

Sustainability and funding

It appears that sustaining this program on an ongoing basis is problematic. With budget cuts to the Higher Education sector there is less opportunity to survive on faculty funding. However there is a commitment and passion for it to continue.

We survive on faculty money and university money, as well as HEPPP money, so we use some of HEPPP money as well, but HEPPP, as you know is very soft, and we never know whether we’re going to qualify for anything. Faculty, you know, the four Schools, the Science School and the three Engineering Schools have really been through the mincer this year, so there’s no money left, but it’s an imperative and that’s why we’ve kept it.
Issues around needing hard outcomes for ongoing funding have been exacerbated in recent years. The time required to develop meaningful relationships and contribute to change regarding increased participation in science and mathematics at tertiary level of education and training is a complex issue.

I am concerned ... that if we don’t have enough students like this boy that’s coming through this year, if we don’t have success stories that are regular, we could, there’s enough cynics around who could actually say that the money, the $20,000, $140,000, $150,000 ...

The cost associated with the Indigenous Australian Engineering Pathway Program program with the students returning in subsequent years is causing concern in terms of ongoing costs for Engineering Aid Australia. But the business model suggests that the investment over time will have impact.

... and it saturates out because, you know, the earliest students coming in as Year 9s so, you know, they would come twice, perhaps three times, and then there’s a new crop of students, and the fact that not everyone returns.

Availability and sustainability of participants

There is an identified need to support the retention and achievement of Indigenous high school students in science and mathematics and subsequent pathways to university. When the IAESS program started in Western Australia there wasn’t much support available.

The National Youth Science Forum had a year or two where they had an Indigenous branch. We anticipated a bit of competition because we’ve always known that drumming up 20 to 25 participants is really difficult, so having other stakeholders in it at a similar time, you know, offset by a week or two, did create a few problems. For some reason the Indigenous part of the NYSF didn’t last very long, or it’s operating somewhere else and I’m not aware of it.

There have also been issues with programs competing with each other rather than complementing and building on each other:

In the Perth metro there are a few groups that oppose each other. Fortunately we work across all of those groups so we don’t favour any one particular group, but we have the Aspiration Initiative, which has been running here for four years now, because they were students in Year 9, and they’re now in Year 12, and we also have the Follow the Dream program. There’s also AIME, the Australian Indigenous Mentoring

Summary: Case study characteristics

Higher Education pathways

There is clear evidence that the IAESS program has opened up Higher Education pathways for some participants, and that students value this investment:
... one of the mentors did the IAESS in Sydney because it wasn’t offered in Perth then, but he’s a WA man, and he fell so in love with the university over that side, he went to university in the eastern states, but he’s repaid, he’s paid it forward by coming back to be a mentor here, three or four years he’s actually done the job.

There is also investment in Higher Education beyond engineering. Although some students have attended the summer school they have been accepted in to other programs such as psychology. Nevertheless, they return to mentor younger students in the following years:

The same with two past female participants. One has gone into Psychology, the other one into Media and Relations, but they’ve become lead house parents. So having the non-Engineers also benefited the program because it creates legitimacy for those that are maybe just there to see what university is about, not necessarily interested in Engineering. So we’ve had large-scale support from the university and the faculty that it’s not about Engineering, it’s not about Science and Engineering, it’s not about resources, it’s about the continued pathway for that student into their tertiary education. So luckily we have that support and we have very, very, low KPIs and low expectations. I know that sounds negative but there’s no pressure on the kids to actually, you know, to push them into Engineering, it’s more of a holistic approach to their education.

**Technology**

One year the students were given expensive $240 calculators, another group received iPads, others received laptops. It depends on funds that are available from Engineers Aid Australia. It is a good incentive for students to stay in touch, maintain a relationship with each other and to start building that network. These networks will help them survive in the university and in the corporate world as well.

**Relevance**

The focus on problem solving and site visits keeps the program relevant and hands on.

**Capacity building**

Students have the opportunity to return over several years, building capacity for university study. Return visits also build capacity for participants to become future mentors.

**Attracting STEM students**

What has IAESS learnt about making science, technology and mathematics more attractive for Indigenous students? The following factors are considered significant:

- provide role models for students who may not have Indigenous role models in STEM professions.
- provide a positive experience
- provide the opportunity to return over several years
• provide mentors who have been through similar life experiences
• recognise that a one size doesn’t fit all by developing a more individualised approach for each student

Links to the DEMO framework in this case study:

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembling resources</td>
<td>People rich</td>
</tr>
<tr>
<td></td>
<td>Evidence through house parent mentor, staff student ratio, engineers volunteering, guest lectures, teachers of science and mathematics</td>
</tr>
<tr>
<td></td>
<td>Financial support and/or incentives</td>
</tr>
<tr>
<td></td>
<td>Free, no student costs involved (flights, accommodation, food), also incentive with gifts of technology e.g. laptops or iPads</td>
</tr>
<tr>
<td></td>
<td>Early, long-term, sustained</td>
</tr>
<tr>
<td></td>
<td>Moved to encourage students to attend each year from Year 7</td>
</tr>
<tr>
<td>Engaging learners</td>
<td>Recognition of difference</td>
</tr>
<tr>
<td></td>
<td>One on one tutoring provided in second and third year matching subjects enrolled in. Indigenous house parents. Cultural program.</td>
</tr>
<tr>
<td></td>
<td>Enhanced academic curriculum</td>
</tr>
<tr>
<td></td>
<td>Problem based learning with design tasks set to solve within particular parameters modelling ‘real’ engineers work</td>
</tr>
<tr>
<td>Working together</td>
<td>Collaboration</td>
</tr>
<tr>
<td></td>
<td>Evident between AAES and Curtin University lots of in-kind support.</td>
</tr>
<tr>
<td></td>
<td>Cohort-based</td>
</tr>
<tr>
<td></td>
<td>Year level cohort-based with return students developing close relationships</td>
</tr>
<tr>
<td>Building confidence</td>
<td>Communication and information</td>
</tr>
<tr>
<td></td>
<td>Endeavour to keep in touch through free iPads and laptops</td>
</tr>
<tr>
<td></td>
<td>Familiarisation/site experiences</td>
</tr>
<tr>
<td></td>
<td>Students attend classes with lecturers available in summer break. Provide university experience. Stay on campus in student accommodation so become used to environment.</td>
</tr>
</tbody>
</table>

Using the DEMO framework, it is evident that the Curtin IAESS Summer School meets most of the criteria listed. It is strong in assembling resources that is being people rich and providing financial support. It is also strong in engaging learners with a balanced
academic curriculum using a problem based hands on approach that has been strengthened in recent years. Within the same section strong research base is less evident but issues around collecting better data was acknowledged. Working together through collaboration with engineers, teachers, university staff both academic and indigenous support units is another strength. Building confidence to dispel the myths of universities was also a strength with accommodation on campus and exposure to a range of academic staff.

The other three aspects addressed the DEMO framework, *Unsettling deficit views*, *Researching ‘local knowledge’ and negotiating local interventions* and *Building capacity in communities, schools and universities* were also evident. In terms of unsettling deficit views the focus was on working with, the students from wide rural and remote geographical locations. Though 1:2 ratio of support from both house parents and academic mentors students were supported to develop positive understanding of their cultural heritage.

Researching ‘local knowledge’ was evident as programs for return students were individually crafted to match science and mathematics subject enrolled in final year of school. Building capacity in communities, schools and universities was evident with the range of programs feeding in to support indigenous students take up STEM, e.g. Graham (Polly) Farmer Foundation, *Pathway to Dreaming* and *Follow the Dream*. 
UniSA College, Indigenous STEM

Introduction

To properly account for how the University of South Australia (UniSA) has been attempting to improve Indigenous students participation in STEM we need to map how a university drives its equity strategy through University-wide Strategic Plans, the development of UniSA College, specific School-based strategies and how UniSA organises its Indigenous support services.

Importantly UniSA asserts the following in its mission statements: ‘UniSA is a globally-focused, locally-engaged institution established on the dual principles of equity and excellence’. The commitment to is framed in various ways including:

- UniSA remains strongly committed to ensuring the opportunities offered by our programs are available to a diverse range of students …
- UniSA gives effect to reconciliation with Indigenous Australians and builds social cohesion by achieving equitable educational access and outcomes across our diverse student community, through research that aims to improve the quality of life and by acting responsibly as a corporate citizen.

(http://www.unisa.edu.au/About-UniSA/University-vision/)

Strategic planning

Historically, UniSA has strong remit for advancing a social justice agenda in Higher Education in South Australia. UniSA formed out of the amalgamation of an Institute for Technology and colleges of Advanced Education and has long-term connections to the Northern and Western suburbs of Adelaide. As such, it serves communities that are recognised as educationally disadvantaged regions by any measure, and including success in the SACE, and participation in Higher Education. One of the important strategies that UniSA has put in place in the past few years has been UniSA College. From the UniSA College Website:

- UniSA College provides education opportunities for people from all walks of life.
- Our Diplomas and Foundation Studies programs provide pathways to degree level study for people who may not have the required qualifications for direct entry into a bachelor degree. These programs are a supportive way for students to settle into the university environment and learn the skills they need to succeed at university.
- Our UniSA Connect team engages with secondary schools and the community to inspire further study and educational attainment, particular in the areas of science, technology, engineering, mathematics and career development. Practical
workshops which are linked to the SA school curriculum are available for booking through this website.

UniSA College also provides support for the Australian Indigenous Mentoring Experience (AIME) and the James Morrison Academy of Music @ UniSA. ([http://www.unisa.edu.au/Study-at-UniSA/UniSA-College/](http://www.unisa.edu.au/Study-at-UniSA/UniSA-College/))

UniSA College started in 2011 and, from the outset, was conceived of as a site for providing strategic focus and drawing together a range of disparate activities across the university. In the beginning UniSA College reported to the Deputy Vice Chancellor Academic (who at the time was Professor Joanne Wright). More recently, UniSA has appointed a Pro Vice Chancellor: Student Engagement and Equity (Dr Laura-Anne Bull). The college was established with a mandate to engage with groups within the community who are under-represented in the university, and to respond to the university’s founding legislation which outlines an obligation to provide additional opportunities and pathways for people who traditionally haven’t taken up Higher Education as a post-school option. Given the Universities early history, this commitment was focused focus around northern Adelaide in the first instance. Another important focus was and advancing the STEM disciplines and within UniSa College this work is part of UniSA Connect, which is the curriculum enhancement arm of the College.

UniSA Connect focuses on inspiring science, technology, engineering and mathematics (STEM) study and career awareness with secondary school students. The suite of UniSA Connect experiential programs aims to promote further student STEM study and educational attainment.

Professional development opportunities for teachers particularly focuses on new technologies and engaging pedagogies.

UniSA Connect utilises academic expertise to identify current STEM ideas to develop interactive programs for secondary school students. Scenario based problem solving is used as a key approach in the programs, with authentic learning links for secondary school students. Most STEM programs are delivered at our Mawson Lakes campus utilising specialised equipment and facilities.

The UniSA Connect secondary school programs also connect with careers. The Career Awareness Program is designed to give senior secondary students the opportunity to explore career options and pathways. ([from the UniSA Connect brochure](#))

This focus was developed in collaboration with the Chief Scientist, who at this time was arguing for the need to address national and international priorities about the STEM workforce. UniSA College took up this priority for STEM engagement for Year 10, 11, and 12 students, as the mandated focus, and also to offer career awareness workshops.

*There is still some really clear evidence in schools that STEM in primary [schools] is still a problem area, and then STEM in secondary schools,*
particularly in South Australia with the restrictive nature of the SACE where people only can do four subjects and a research project at Year 12, was having a decline in student engagement. So the real issue for us was to be able to provide enriching, engaging experiences that were interactive for students, and that enthused them about continuing to study STEM subjects in that environment. (UniSA College director)

This focus on advancing the STEM subjects for students who have historically under-participated in Higher Education has evolved from previous work by the Division of ITEE (IT, Engineering and the Environment) with secondary school in the Northern suburbs.

So there have been historical engagement through [ITEE] with Northern Region schools for about a decade, and it was really, I guess project based rather than curriculum based, so we’ve changed the focus of that. However in saying that, I mean one of the strong partners in our establishment place has been the division of ITEE, and the collaboration with them. (UniSA College director)

One of these strategies has been running senior secondary science classes for students from Northern public secondary schools, because these schools don’t have enough students selecting science subjects to make a viable class. ITEE also convened various projects based strategies such as a robotics project. But ‘it’s important to highlight how that model has changed, and the way that schools have seen the added value of the new model’ (UniSA College director).

What we did was we flipped the model and we, instead of going to schools saying, We’ve got this set of activities that we can deliver because we’re interested. We went and said, Tell us what your STEM priority is, tell us where it fits with your Site Improvement Plan, and then we’ll have a look at co-designing, co-delivering, and co-evaluating a range of activities ... The curriculum delivery belonged to the schools. The activity that we have developed over the last four years has a link to either the Australian Curriculum or SACE. It’s not a glossy one-off activity, it builds into the students’ curriculum experience and it enriches it ... So [now] the teachers from the schools actually deliver the subjects [Physics and Chemistry], we don’t, but what we’ve been able to do is value-add, so we get Maths academics to do spotlight lectures for Specialist Maths kids ... we get a researcher or an academic to come in and do a spotlight lecture, which provides the applications of the Specialist Maths curriculum ... we’ve actually been able to value-add because we’ve been able to provide better access to Physics labs, help with the actual practical component, application is part of the Physics curriculum, so that’s the enrichment bit of that. (UniSA College director).

This science class is convened at the Mawson Lakes Campus of UniSA, situated in the Northern suburbs of Adelaide and the site for the Division of ITEE.

This work with ITEE also has other elements:
...part of our commencement phase was to actually have a reference group with ITEE. So I worked closely with the [Head of ITEE] and asked him to recommend someone from the School of Engineering, Natural Build Environments, Computer Science, Mathematics, and actually talked to them about some ideas.

Staff at UniSA College work with an academic or a researcher to focus on a current concept around STEM, and to build an enrichment program for secondary Mathematics/Science teachers. It takes about six months to build a two-hour workshop, because of the consultative work.

The ‘flipped model’ has been informed by the work of Gale et al. (2010) on university interventions with the low SES students. This study argued against interventions as one-offs and instead found the most successful exemplars of university interventions into schools were connected into some bigger project.

You call it the sort of flipped sort of logic ... and so we are framing our intervention around: The schools have got the big project around the Australian Curriculum and SACE, how do we hook up to that?

As well, UniSA College offers a Year 12 Revision Program, or the Year 12 STEM Tutorial Program. Basically this strategy offers free revision programs in Physics, Chemistry, Mathematics Studies, and Biology to students from low SES schools in the north, and the schools select the students.

What we were trying to aim for was the students for whom an extra couple of points on their ATAR scale would actually get them across the line to undergraduate entry.

As well, the College is developing an interactive website for Year 11 and 12 curriculum for Physics, Chemistry, Mathematics, and Biology, with interactive animations that are demonstrating a whole range of things where people can witness how, for instance, a nuclear reactor works, how a photocopier works, how muscles work, and you have a lecture but it is accompanied by animations and examples. UniSA College has been working with an animator who works with other animators from England and America, and has a number of the clips up on Science Photo Lab, and Science Photo Lab has a clip of the week that often is dominated by either NASAR or National Geographic. The site also has a series of questions that relate to the Year 12 curriculum with a series of answers to those questions. Students can go to the lectures, lecturettes, which are about 20 minutes long, then go to the question sheet, test their own knowledge, then go to the answer sheet, check it, go back to the relevant lecture and so on. This website will be released at the end of this year.

UniSA College Connect Team

The UniSA Connect team has as its main focus the problem of STEM, and one of the key activities has been developing enrichment programs that consist of two-hour
workshops, or one-day or two-day programs for students. By way of examples are workshops on geospatial science, nuclear physics, and 3D printers.

The UniSA Connect team also runs a Career Awareness Program, which is a flagship program. Some schools have been using that program since 2011, and could talk quite clearly about the impact of that program on their school and community. The College runs an evaluation type of questions to examine how this program could be changed to accommodate what the students have experienced, or in our Teacher Professional Learning Programs, what the teachers have experienced.

The UniSA Connect team also has a strong working relationship with the School of Education, who work on teacher professional learning programs. The Teacher Professional Learning focuses on new technologies. New program take six months of development, which involves schools trialling, and feedback about appropriate levels.

The UniSA Connect activities have grown significantly from about 600 students in 2011 to 5,000 students in 2014, and at least 5,500 in 2015.

Whilst the College does not have exact numbers, these strategies have worked with a few Indigenous students but the College does have more specific and targeted programs for improving Indigenous participation in STEM.

But before we move onto describe those, it’s important to state that the UniSA commitment to the development of UniSA College as a site for ongoing development of the University’s equity strategy does provide a sustainable and institutionally stable site for the development of a range of activities that aim to attract low SES students to university to study STEM, and this includes Indigenous students.

**Working specifically to improve Indigenous student participation**

... we are now able to target more things, and in working with Aboriginal and Torres Strait Islander students, we chose to first of all start with the SAASTA group, South Australian Aboriginal Sports Training Academy, because we saw that there was a way to provide intervention through more engaging and challenging curriculum that would move beyond the Certificate III that is the fundamental underpinning of that, and so we’ve developed some curriculum ...

UniSA College has been able to establish a connection with the South Australian Aboriginal Sports Training Academy, which convenes the Aboriginal Power Cup, with the local Education Department. The university has been a partner since 2008, when the Aboriginal Power Cup started. The program grew out of the Attorney-General’s Department, and Breaking the Cycle Report developed by the Social Inclusion Unit around criminal justice system for young Indigenous people. This Unit engaged the Port Adelaide Football Club to be partners, because of a history of developing young Indigenous football players, and so it became the Power Cup.

*So in the early days it was about sport and engagement. Over time it’s become much more. So the Steering Committee has focused more on attendance of kids at*
school, so being at school, and then the engagement of kids in the curriculum at school, and so they’ve been measuring the SACE Completion. So the Aboriginal Power Cup is built into a curriculum unit at Year 11, and it talks about leadership, goal setting, and career exploration, and cultural identity. So it actually focuses on those things.

One thing we’ve talked to SAASTA about just recently is actually exposing what the curriculum is about, because people see the word Aboriginal Power Cup, but they don’t actually see the depth of the curriculum that goes with it, and so that has changed, like I can see how it’s changed since 2011 until now, and we’ve been able to assist in that curriculum development.

We’ve got 350 students across the state, and as part of the outcome there will be a process where they will be supported to either go through Foundation Studies, go into an undergraduate program, go into a diploma program, go into a traineeship with Maxima and partner groups, or into employment, and that’s one of the things that is a significant change from this thing that started as a sports program, because that’s the curriculum arm of it, and without the SAASTA Program there is no Power Cup, so the curriculum ...

Linking the program up to the SACE Curriculum is really important because this provides a quality assurance process, with a curriculum that focuses upon literacy, numeracy, analysing, synthesising, and writing, and articulating your point of view.

But it’s got to be meaningful, it’s got to be a genuine engagement with the credential. One of the things that we were saying initially was a number of kids would get the credential but they didn’t have any skills, you know, their reading skills, their writing, their literacy skills ... so you can get a credential by doing some things that will minimally satisfy a Standards, or you can set challenging goals and support people to engage with those and to achieve. That’s the journey we’ve been on, and we’re still trying to push around. Don’t be patronising, be supportive of engaging with complex concepts ...

So what we’ve done since we’ve been working with SAASTA is support them to develop and trial curriculum. So we’ve developed a numeracy unit which is a Smart Basketball/AFL Dream Team App, we have some GPS trackers, so we’re using the sport engagement to hook them into doing some Maths, and that’s, we trialled that in Semester 1 at Mawson Lakes Academy, and we trialled it at, or are currently trialling it with John Pirie Secondary School, who is a SAASTA as well, because we wanted to try it in two different locations, and the idea of that is that when it’s trialled and refined, then it would be available for all the other academies next year, and it would be supported with Teacher Professional Learning as well, and this semester we’re trialling Sports Science, and we’ve written it into Scientific Studies, SACE Framework, so we’re not doing PE, we’re doing some Science, and again we’re using the GPS trackers to look at the rich data around matrix.
We’ve got resources [from] Health Sciences has developed, and we’ve been utilising those resources, so he has books on biology of exercise, physiology, nutrition, game analysis, a whole rich suite of books that were a well-hidden resources, so we’ve exposed those as well, and teachers love them, like they’re such a good resource, and so we’ve used those in curriculum as well.

We’re talking to SAASTA as the moment about putting it into the Aboriginal Power Cup, because we had some stuff this year, and then it didn’t end up getting into their Aboriginal Power Cup book, but it’s deepening the understanding of the kid. So the GPS trackers, you know, then you can talk about Sport Science, What are the metrics that elite athletes have, and how do you compare yourself to that? So it’s actually using that data again. Yes, they’re doing an activity but it’s using the data to do some Maths and Science, and actually understand it, so it deepens the learning that they’re actually doing, and during the final of the Aboriginal Power Cup we actually had the GPS trackers on some of the kids who were playing in the final, and then we just able to show them the data, you know, of their game and stuff.

The AIME program

The UniSA College has introduced the Australian Indigenous Mentoring Experience Program (AIME program) into South Australia, and again started in the northern suburbs schools with submission through the Vice Chancellor’s Development Fund. The College has also used Higher Education Participation and Partnerships Programme funds to expand this strategy into the western suburbs, and specifically to build a mentoring strategy for Indigenous students in their school environment, from University of South Australia students. In 2015, there are 350 volunteer student mentors, the biggest number of volunteers in Australia for AIME. For UniSA College the AIME program is part of the answer to a question raised above, How do you cash in your aspiration? ‘You cash it in by having people support you’. The AIME program has also been strengthened with the development of The Deadly Alumni, an initiative led by Professor Peter Buckskin, and provides a supportive network for Indigenous graduates of UniSA to develop a strong, supportive professional network.

The Deadly Alumni will provide you with opportunities to:

- Network, reconnect and strengthen relationships with other Aboriginal and Torres Strait Islander graduates
- Attend events and meet well-known Aboriginal and Torres Strait Islander community leaders
- Enhance your career opportunities
- Apply for graduate intern positions
- Access existing UniSA Alumni benefits and services
• Mentor Aboriginal and Torres Strait Islander secondary students. ([Deadly alumni website](#))

This strategy is a response to historical critiques of social justice initiatives for Indigenous students in Higher Education that often assume deficit views and hence attempt to implement strategies with low expectations. Indigenous students don’t want a curriculum that doesn’t give them an entitlement or purchase to the next step.

UniSA College is also attempting to establish an [Indigenous Participation Pathways Program](#) in Mt Gambier, Ceduna, Port Lincoln, Whyalla, and for the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands students as a new way of delivering *Foundation Studies*. This initiative is part of two wider UniSA strategies: supporting UniSA outreach into rural campuses, as well as a [digital learning strategy](#). For the *Foundation Studies* program, the College is developing online study guides that aim to ensure that students are engaging with the curriculum. The online learning is supported by a local tutor, Indigenous Student Services, and also with appropriate lecturers as the course requires. Importantly for this case study, Foundation Studies provides pathways into every degree of the university, including STEM courses. As well, other way of supporting Indigenous students into the STEM area, is UniSA College offers a [Diploma in Science and Technology](#). Both the Foundation Studies program and the Diploma in Science and Technology aim to develop the generic skills for successful university study, including being introduced to the key concepts of your subject discipline, critical literacy, writing essays, researching effectively, and managing your time. There is a lot of anecdotal evidence that those students who do go on into UniSA degrees from the Foundation Studies program, report being well prepared and confidently engage with the rigors of undergraduate study. There is a pathway between the two programs:

> Now the reality is that if they are in Foundation Studies and they’re doing okay and they want to continue, we will offer them the diploma, and the diploma means they sit in the first-year undergraduate lectures, they go to the first-year undergraduate tutorials. They come back to us to study Tertiary Learning Strategies ...so they’re getting an extended support into the university. At the end of the second year they graduate with a diploma and they go into the second year of the degree.

**Working with school systems**

UniSA College is working with school systems including the Catholic Education Office SA, and the Northern Area State Secondary Schools Alliance ([NASSSA](#)). In collaboration with the Catholic Education Office SA, UniSA College has been supporting a leadership program, that in 2014 was focused on career awareness focus, and in 2015 focused on STEM. This type of initiative gets developed by UniSA College, using principles of project co-design, based on negotiating with partners around their needs, offering taster activities as opportunity to prove the concept can work in practice. One of UniSA staff is the University representative on the University
Working Group of NASSSA. NASSSA schools have the largest number of secondary school Indigenous students in the state in northern Adelaide and many students who are high achievers. NASSSA is presently looking for a high achievers’ program for these students.

Conclusion

The UniSA College provides an exemplar of an equity strategy that has these elements:

- A whole of university equity strategy that is elaborated in the UniSA’s Strategic Plan, supported by a PVC Equity, and long-term funding commitments, including continuing salaries for most key staff in the UniSA College.

- Provides a platform for seeking other forms of funding (e.g. HEPPP) to augment and develop various equity programs/initiatives including STEM-related initiatives.

- Offers one of the last truly open access Foundation Studies program in Australia which provides entry into pre-university preparation courses and then into a range of undergraduate degrees including STEM courses.

- Provides a platform for negotiations and co-development of a range of equity initiatives with a range of stakeholder groups, including the large school systems (DECD and Catholic Education South Australia), school-based groups such as NASSSA, and the South Australian Aboriginal Sports Training Academy.

- Provides a platform for offering professional development for teachers. UniSA College has prioritised STEM and hence has multiple projects with mathematics and science teachers.

- Provides introductory events for prospective students including career awareness, enrichment activities on specific-STEM themes, and provides support for UniSA’s version of the AIME Program with the extra support from the Deadly Alumni.

- Facilitates and supports the development of equity initiatives with schools and Divisions and especially with those responsible for STEM courses.

- Provides a platform for substantial strategic policy development for the University on equity that is informed by research and has resources for significant program evaluation. Specifically, UniSA College works with the DEMO framework and lessons learned from the University Aspirations Project (Paige et al. 2015).
Links to the DEMO framework in this case study:

<table>
<thead>
<tr>
<th>Strategies</th>
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</thead>
<tbody>
<tr>
<td>Assembling resources</td>
<td><strong>People rich</strong>&lt;br&gt;Substantial numbers of fulltime continuing staff and a strategy that is based on ongoing co-construction of initiatives with stakeholder groups. Positive working relationships with many of the key stakeholders both in and outside the university.</td>
</tr>
<tr>
<td></td>
<td><strong>Financial support and/or incentives</strong>&lt;br&gt;Substantial financial resources dedicated to sustaining and building UniSA College and also a productive site for applying for additional funding such as HEPPP.</td>
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<tr>
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<td><strong>Early, long-term, sustained</strong>&lt;br&gt;The UniSA College is a long-term strategy of the university and many of the initiatives of UniSA College target working with schools in some of these involve projects that work with teachers of the middle years of school.</td>
</tr>
<tr>
<td>Engaging learners</td>
<td><strong>Recognition of difference</strong>&lt;br&gt;UniSA College is founded on commitment to increase university participation of young people from low SES communities and also programs targeting Indigenous students.</td>
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<td></td>
<td><strong>Enhanced academic curriculum</strong>&lt;br&gt;Many initiatives of UniSA College, including the Foundation Studies program, curriculum and professional development with schools, and with South Australian Aboriginal Sports Training Academy take up the challenge of providing access to mainstream and high quality credentials and qualifications. As well, many initiatives provide support for teaching and learning in the academic curriculum in schools and universities.</td>
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<tr>
<td>Working together</td>
<td><strong>Collaboration</strong>&lt;br&gt;UniSA College has collaborations with substantial stakeholders inside and outside of the university.</td>
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<td><strong>Cohort-based</strong>&lt;br&gt;Some of the strategies involve working with cohorts of students.</td>
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<tr>
<td>Building confidence</td>
<td><strong>Communication and information</strong>&lt;br&gt;Provides multiple strategies for students to learn and to access university and go beyond the usual one-off events or tasters.</td>
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<td></td>
<td><strong>Familiarisation/site experiences</strong>&lt;br&gt;Students can access a whole range of strategies, from homework support, Year 12 science and mathematics classes and direct access into university under-graduate courses through open access foundation studies programs.</td>
</tr>
</tbody>
</table>
Researching ‘local knowledge’ and negotiating local interventions: UniSA College has many examples of how this theme is key to their modus operandi. In specific Indigenous examples, the Deadly Alumni and work with key systems stakeholders demonstrates how this strategy operates successfully.

Unsettling deficit views: The Foundations Studies program is fundamentally based on rejecting deficit views of young people who have traditionally been unsuccessful in schooling, and this group includes Indigenous students. This program is an open access equity strategy.

Building capacity in communities, schools and universities: UniSA College has developed initiatives that are substantially about building capacity in communities, schools and universities.
University of Newcastle

Context

According the University of Newcastle Indigenous Education Statement (2014), the institution serves approximately 800 Indigenous students. These students are drawn from the Awabakal, Darkinung, and Biripai Nations from the Newcastle, Central Coast and Port Macquarie regions respectively, as well as from other Aboriginal and Torres Strait Islander nations. The 2015 Indigenous Education Statement (2015a) states that the University of Newcastle ‘is the preferred study destination for Indigenous students in NSW and ACT’, and has a 2.8 per cent enrolment rate compared to the national average of 1.1 per cent.

The university’s NeW Futures Strategic Plan 2016-2025 (University of Newcastle 2015b) lists ‘an enduring commitment to equity and social justice’ as one of six priorities. At both a domestic and international level, the University has committed to ‘ensure students from under-represented backgrounds can enter university, graduate and succeed’, and identifies the following goals:

1. We will achieve parity between the proportion of UON students who enter and graduate from diverse socioeconomic, cultural, and disability backgrounds with the proportion of people who are from those backgrounds in our regions.

2. UON will be recognised by communities, governments and scholars worldwide for excellence and innovation in the field of equity in higher education and for the high success rates of all of our student cohort. (University of Newcastle 2015 p. 5)

These goals are underpinned by three primary strategies:

1. Develop a unique UON entry model that provides new ways for students from a range of backgrounds to access undergraduate and postgraduate studies.

2. Deliver tailored learning experiences that support successful outcomes for all of our students independent of background.

3. Work collaboratively with international partners to develop state of the art higher education equity frameworks in countries where access and participation rates are low and unequal.

Key measures of success will be to:

achieve parity of participation of students from low SES and Indigenous backgrounds or with a disability with the proportion of these populations in our regions.

achieve parity of retention and success across all of our student cohorts. (University of Newcastle (2015b, p. 5)
The university also explicitly commits to ‘excellence in Indigenous education and research and to the importance of Indigenous culture and knowledges’ (University of Newcastle 2015b, p. 10). This commitment is evidenced in the appointment of a Dean of Aboriginal and Torres Strait Islander Education and Research in 2014.

As part of their commitment to the recognition and engagement of Indigenous peoples, the University has an Elders in Residence program. These Elders, referred to by the Awabakal term Nguraki (elder, wise person, cultural mentor), ‘play a pivotal role in the governance structures and leadership within Indigenous education at the University’ (http://www.newcastle.edu.au/community-and-alumni/community-engagement/indigenous-community-engagement/cultural-competency-workshops/elders-in-residence-program).

As Behrendt (2012, p. 162) notes, the University of Newcastle employs a strategic ‘whole-of-university’ approach to Aboriginal and Torres Strait Islander education which is consolidated under the one body, the Wollotuka Institute. With an all-Indigenous staff and four Indigenous Directors, the Wollotuka Institute ‘consolidates all Indigenous activities of the University under one strategic and operational body’ (website). Its responsibilities and functions include:

- Teaching and learning
- Research and innovation (via the Umulliko Indigenous Higher Education Centre)
- Indigenous student engagement and experience
- Community engagement
- Indigenous staff employment and development

Wollotuka’s Board of Aboriginal and Torres Strait Islander Education and Training, comprised of Indigenous community members, Elders, student representatives, alumni and professional and academic staff, provides high level advice to university’s Vice-Chancellor. Wollotuka takes a holistic approach to engaging with Indigenous students, laying the groundwork during school years, and subsequently offering support and engagement through the Higher Education experience.

Wollotuka Institute is the first Australian institution to gain accreditation with the World Indigenous Nations Higher Education Consortium (WINHEC) and is the second to be accredited internationally as a provider of Indigenous Higher Education within a mainstream/western dominant university system. For accreditation, institutions are assessed against 21 criteria which are informed by local ‘cultural standards’. Wollotuka Institute’s Cultural Standards are grouped under the following five priorities:

- Respect and honouring
- Community responsiveness
- Cultural celebration
- Academic and research
School and community engagement activities

A range of school and community engagement activities has been developed to promote university study to Indigenous communities; some of these activities specifically target STEM. The AIM high program, within the university’s Centre of Excellence for Equity in Higher Education ‘is focused on supporting educational aspiration, attainment and access for students and families from low SES backgrounds.’ This initiative therefore does not specifically target Indigenous students. Wollotuka’s School to University (S2U) Program ‘is a strength based program that provides further understanding of opportunities and pathways available to Aboriginal and Torres Strait Islander students transitioning from secondary study to tertiary education. The program also contributes to the development of key attributes that are valuable at a tertiary level, including cultural, emotional, social and academic’ (University of Newcastle 2015a). Together, these initiatives start at Year 4 and engage students right through to Year 12:

Careers through Science (AIM High, Year 4)

Students work scientifically to conduct first hand investigations, developing skills such as observing, measuring, using scientific equipment, identifying patterns and predicting.

Careers through Reading (AIM High, Year 5)

University students read books about careers related to their degrees to school students.

Discover University Day (AIM High, Year 6)

Students participate in a ‘day-in-the-life’ of a university student, including a lecture, tutorial, and library session.

Hour of Code (AIM High, Year 7/8)

Aims to increase knowledge of career pathways in ICT, strengthen student engagement with computational thinking and challenge gender stereotypes in ICT.

iBelieve (S2U, Year 7/8)

Inspires Indigenous students to begin thinking of their future in a culturally safe space through talking circles, activities and traditional Indigenous games.

Girls Choices (for girls) LIVE IT! (for boys) (AIM High, Year 9)

Five-day residential university program encouraging students towards mathematics and science subjects in years 11 and 12 and exposing them to study and career options in these subjects. A Welcome to Wollotuka breakfast is held for Indigenous students participating in the programs.
My Big Tomorrow (AIM High, Year 9/10)

Encourages young people to think about their future careers through the My Big Tomorrow website, which features 93 careers with accompanying films, information and activities.

The Next Step (AIM High, Year 10)

Provides students with skills and information about their post-school educational options and pathways. The program is held on two campuses and gives students an opportunity to experience the facilities first-hand.

Insight Days (S2U, Year 10)

Familiarises students with the Aboriginal and Torres Strait Islander Entry Program. The program is delivered at Wollotuka Institute. Participants meet staff and students with the aim to consolidate their subject selections to support their university pathway.

Yapug Program, Entry Program and UAC talks (S2U, Year 11/12)

This program is delivered at school and informs students of their tertiary options. Students gain information on Yapug Aboriginal and Torres Strait Islander Enabling Program, the Aboriginal and Torres Strait Islander Entry Program and Universities Admissions Centre process.

Collated from the University of Newcastle website

Wollotuka Institute engagement programs and STEM

Wollotuka Institute’s School to University (S2U) engagement program begins in Years 7/8 with iBelieve, which focuses on

- cultural confidence, self-esteem, developing self-esteem, aspiration, resilience ...
- it concentrates on all of those sort of qualities, and gets students to understand connection to Country, connection to community, and connections to family. (Director, Wollotuka Institute)

By Years 11 and 12,

we’re trying to get them to identify more a discipline area of interest where we can then target, like be more targeted. So we do things like shadowing where the students can come and shadow a student in the Discipline that they’re interested in, and they go to lectures and tutorials, and to the cafeteria, into the library, whatever that student is doing on that day … that creates a mentoring relationship. (Director, Wollotuka Institute)

According to the University of Newcastle’s 2015 Indigenous Education Statement,

Since the programs beginnings in 2007 school engagement and participation with S2U has increased from 43 schools in 2008 to 89 schools in 2014 which is a 106.9% increase over 6 years. On average the S2U program has 600 student
participants throughout each calendar year and this number is expected to increase further through increased rural and remote engagement. (University of Newcastle 2015)

Opportunities to strengthen the STEM focus are currently being developed at Wollotuka:

*We're actually introducing a new program this year that will ... have a specific strand to STEM. It will start from a community engagement perspective.*  
(Director, Wollotuka Institute)

Once Indigenous students enter university in STEM subjects, there are improved opportunities to support them. In the past, the federal Indigenous Tutorial Assistance Scheme (ITAS) scheme funded two hours per week per subject of tutoring in discipline-specific content. Staff at Wollotuka noticed that students tended to rely on that tutoring without the opportunity for more broad-based capacity-building. With changes to ITAS funding criteria, Wollotuka has been able to appoint four FTE staff to form a Student Engagement Team in order to provide more tailored strategies to support Indigenous students. While the team is ‘very new’, it is envisaged that they will be able to work with students to develop individual learning plans, run workshops, provide feedback in essay drafts, etc.

One of the staff on the Student Engagement Team (an Engineering graduate) will focus on students in Mathematics, Science and Engineering:

*Maths is sort of common, not just in Engineering and Science but a lot of primary school teaching and high school teaching. They have to do some components of Maths, and a lot of people struggle with that, so I’m running workshops maybe two or three times a week, just drop in, come in, ask questions.*

One of the Wollotuka Directors commented on barriers to attracting Indigenous student to STEM:

*Students know that if they do Education or they do Health, they can go back into their communities and they can contribute back to those Disciplines, or those professions. It’s not as easy to see that in Science and Engineering. I think you need to visualise the contribution that those Disciplines make to communities, and they do, they make substantial differences to communities. They also can do substantial harm to communities, and I think sometimes that that’s what students see as well.*

*...*

*How does Engineering and Science and IT contribute back to Aboriginal communities, and to empowering Aboriginal communities, and building capacity in Aboriginal communities? I really believe that is a key to attracting Aboriginal students.*

This points to a broader philosophical issue in attracting Indigenous (STEM) students to universities:
I think the challenges are that ... a lot of the time ... universities, just try to duplicate whatever is happening in the mainstream and just, like you know the only difference to the program is it’s targeting Aboriginal students, there’s no other difference. But you’ve got to think about what the difference in the philosophy and the principles of the Aboriginal students are compared to the non-Aboriginal students or communities.

... if you ask the students why they’re here, you ask a non-Aboriginal student why they’re at university they all respond, I’m here to get a good job, to earn good money, to buy a house, to travel, to buy a nice car, and obviously Aboriginal students want that as well, but it’s not the first thing that comes to their mind, it’s not their first priority of why they’re here at university, and most of the students will say, We’re here to be able to build a qualification where I can go and give back to my community, and then it’s about getting a good job and having more money. So ... there’s got to be an understanding of the differences before programs can be developed that then respond. (Director, Wollotuka Institute)

The philosophy underpinning Wollotuka’s initiatives (in STEM and other disciplines) reflects a strong and ‘very deliberate’ focus on engagement and community:

I also changed the language. We used to be Support, Student Support, and now we don’t use ‘support’ at all, it’s about engaging because also, we had a lot of students that wouldn’t access Wollotuka because ... they didn’t feel they needed support.

So then we thought that what students actually do want is they want the engagement, so if you talk to students about how Wollotuka has contributed to their success, like graduates, they say, Wollotuka was a community for us, it was a family, it was a home away from home ... So we changed our focus to be more about providing an environment that was a community environment ... So they were the sort of philosophical changes that we made in the last four years or so. (Director, Wollotuka Institute)

An opportunity has also recently arisen to collaborate with international universities with significant Indigenous student populations in the online teaching of STEAM subjects:

We would all co-teach together online so that students sitting in Newcastle would be with students in the same class as Nebraska, Alaska, New Zealand. (Director, Wollotuka Institute)

Miroma Bunbilla Pre-entry to Medicine program

In collaboration with the University of New England, the University of Newcastle offers a five-year Bachelor of Medicine (called the Joint Medical Program). The University of Newcastle is highly successful in graduating Indigenous medical students,
with ‘almost half of the Indigenous doctors in Australia graduated from UoN’ (http://www.newcastle.edu.au/about-uon/our-university/equity-and-excellence). Nevertheless, at the University of Newcastle, the attrition of Indigenous medical students has historically been of concern, and in one cohort, ‘only 25% of students commencing first year continued on to second year, with the completion of the medical science and professional practice courses being identified as significant barriers to success’ (Holliday, O’Mara & Watts 2015, p. 25). This attrition has flow-on effects for Indigenous communities:

*What I’d seen in the past, we were setting people up for failure. And a lot of the universities, I think, have done this, particularly in Medicine. They sort of front-load the numbers, so they get lots of people to come in with the hope that by pure percentage X-amount will graduate at the end, and they’re not thinking about all those people who drop out on the way ... [When students enrol in Medicine] people come on board and they’re all excited, there’s excitement in the Community, and if they go back to the Community as what they perceive as a failure, the Community then go, Oh see, we can’t do that Western Medicine stuff anyway. So now in a sense you’ve set a whole Community up for failure, not just one person.* (Director, Wollotuka Institute)

Launched in 2012, the Miroma Bunbilla Pre-entry to Medicine program was developed to address this issue (Holliday, O’Mara & Watts 2015, p. 24). The program has proven highly successful:

*The first year we brought this program, even though it was only as a trial and it wasn’t assessable, we had one person fail one subject, so it really turned everything around for us.* (Director, Wollotuka Institute)

The Miroma Bunbilla program aims to:

- strengthen the selection process for potential Aboriginal and Torres Strait Islander medical students;
- ensure Aboriginal and Torres Strait islander students accepted into the Joint Medical Program have the required skills to graduate; and
- provide appropriate support for Aboriginal and Torres Strait Islander students to graduate from the Joint Medical Program. (Holliday, O’Mara & Watts 2015, p. 25)

Indigenous applicants to the Joint Medical Program are contacted by phone and invited to participate in the Miroma Bunbilla program. During the week-long program participants receive on-campus accommodation and meals at no cost. With the guidance of assigned tutors, participants engage in two problem-based learning tasks, attend lectures and tutorials, liaise with current students in the Joint Medical Program, visit the anatomy laboratories, and prepare and present a 10 minute viva. The program has been developed to ‘maximise the experience for participants and to measure the student performance with assessment, feedback and evaluation’ (Holliday, O’Mara & Watts 2015, p. 26). The pre-entry program provides students with an understanding of
the depth of knowledge required for a medical degree (Holliday, O’Mara & Watts 2015, p. 28). Those students who are not offered a place in the Joint Medical Program as a result of the pre-entry program are provided with feedback and recommendations:

We get an idea of where they’re at. Is it a young person who needs a bit more maturity in life so, Just go and do stuff for a year and come back. If it’s around the Science stuff that they just don’t get Science concepts, a conversation might be, If you go and do a year, if you get into the university and do a year of Science, then come back and see us next year, your chances are really good. (Director, Wollotuka Institute)

For those Indigenous students who accept an offer in the Joint Medical Program, Wollotuka Institute has a range of support initiatives, including camps for students and their families to meet and form connections, regular barbecues, and an effective mentoring program which provides:

Aboriginal and Torres Strait Islander medical students with opportunity to meet experienced and accomplished health professionals to build professional networks through relationship building and mentor/mentee relationships. Four events were held in 2014 and were well attended and received by students and mentors alike. (University of Newcastle 2015)

Wollotuka Institute has also been successful in embedding Indigenous perspectives into curriculum, ‘so when students come on board they know that the universities take Aboriginal and Torres Strait Islander culture, knowledge, seriously, and I think that really makes a big difference as well’ (Director, Wollotuka Institute).

There are plans to trial a similar pre-entry program in Nursing.

According to one Director, one of the keys to Wollotuka’s success is the personal bonds formed between students and staff: ‘I try to make sure I have a personal relationship with the students where they know they can just come and talk to me if they’re got a problem’. This presents a challenge if student numbers increase substantially: ‘when you believe that part of your success has been about creating a family environment, as you get bigger and bigger and bigger how do you keep that feel’?
Links to the DEMO framework in this case study:

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Assembling resources</td>
<td>People rich</td>
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<tr>
<td></td>
<td>Wollotuka Institute has nurtured strong connections between staff and students.</td>
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<td><strong>Financial support and/or incentives</strong></td>
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<td></td>
<td>Most engagement initiatives are free (Aim High’s Girls Choices and LIVE IT programs incur a $50 registration fee). Pre-Entry to Medicine program is free, including meals and accommodation.</td>
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<td><strong>Early, long-term, sustained</strong></td>
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<td>Engagement initiatives begin at Year 4 and continue through to Year 12 and the transition to University</td>
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<tr>
<td>Engaging learners</td>
<td>Recognition of difference</td>
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<td></td>
<td>Wollotuka Institute offers a rich cultural program designed to provide a safe, friendly and welcoming environment to prospective students on campus.</td>
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<td><strong>Enhanced academic curriculum</strong></td>
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<td>The Pre-Entry to Medicine program deliberately exposes participants to the challenges of first year Medicine so that prospective students have a realistic understanding of the expectations before they enrol</td>
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<tr>
<td>Working together</td>
<td>Collaboration</td>
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<td></td>
<td>89 schools participated in Wollotuka’s S2U program in 2014, indicating strong collaborative networks with schools. The Joint Medical Program is collaborative with the University of New England.</td>
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<tr>
<td>Building confidence</td>
<td>Communication and information</td>
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<tr>
<td></td>
<td>Wollotuka explicitly endeavours to develop strong connections with and among students and their communities.</td>
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<td></td>
<td><strong>Familiarisation/site experiences</strong></td>
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<td>A range of on-campus experiences are offered to school students, starting at Year 4. Pre-entry to Medicine program is a comprehensive robust on-site experience, both academically and culturally.</td>
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The DEMO framework also identified three themes that typify an equity orientation in universities. Each of these perspectives is evidenced at the University of Newcastle.
Researching ‘local knowledge’ and negotiating local interventions: Many of Wollotuka Institute’s community outreach activities demonstrate a commitment to engaging at the community level to ‘make the interface between university and school more permeable’ (Gale et al. 2010, p. 74). For example, the Indigenous Education Statement (University of Newcastle 2015a) mentions the following initiatives at various locations in high schools and in the wider community:

- an invitation to provide mentoring for young Indigenous students at a local high school
- participation in a high school’s Careers Day
- stalls at NAIDOC events in Newcastle, Central Coast and Lake Macquarie
- native bee workshops, including discussion of traditional bee knowledge
- Caring for our Country Cultural event, held in bushland surrounding the Callaghan campus

Unsettling deficit views: The Pre-entry to Medicine program maintains high intellectual challenge and expectations while nevertheless providing cultural validation in a supportive environment.

Building capacity in communities, schools and universities: Gale et al. (2010, p. 74) refer to developing ‘cultures of possibility’. Through their comprehensive school engagement activities, Wollotuka Institute and the Centre of Excellence for Equity in Higher Education build capacity for equity groups (Indigenous students) from Year 4 onwards.
Western Sydney University

Context
Greater Western Sydney is home to one of the largest Indigenous communities in Australia (Western Sydney University 2016). The campuses of Western Sydney University are located on the traditional lands of the Darug, Tharawal, Gandangarra and Wiradjuri nations (Western Sydney University 2015). The University’s Indigenous Education Policy includes (but is not limited to) the following objectives:

- Increase Indigenous undergraduate enrolment rates to levels commensurate with those of other Australians.
- Improve Indigenous undergraduate progression, success and completion rates to levels commensurate with those of other Australians.
- Ensure the inclusion of appropriate Indigenous content in curriculum across the University.
- Raise the prominence of Indigenous culture across the University.
- Increase Indigenous community engagement and outreach. (Western Sydney University 2016)

The University’s Schools Engagement Strategic Plan 2014-2016 includes the following foci:

- Build Aboriginal and Torres Strait Islander students’ skills and confidence, aspirations and attainment, and higher education preparedness and participation
- Help to address students’ needs in specific subject areas, particularly science, technology, engineering and maths (Western Sydney University n.d.-a)

These two strategic foci currently overlap in some schools engagement initiatives.

Schools engagement initiatives
A range of programs for Indigenous school students has been developed, expanded and enhanced since implementation of the first Schools Engagement Strategic Plan (2008-10). All the programs are underpinned by cooperative, productive stakeholder relationships and collaboration for mutual benefit. This significantly increases their effectiveness and distinguishes them from ‘outreach’ programs, with that descriptor betokening a one-way process. The close involvement of Indigenous Elders and educators in program design and/or delivery is regarded as crucial in this context.

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4 Western Sydney University is transitioning to the term Aboriginal and Torres Strait Islander peoples when referring to Indigenous peoples.
**Pathways To Dreaming**

Beginning in Year 8 and continuing through to the completion of schooling, *Pathways To Dreaming* is designed to engage Indigenous students in education. The initiative, which started in 2009, aims to build students’ academic and study skills, and raise their awareness of further education and career options. ‘Students are mentored by Western Sydney University students and alumni who act as older friends to support and encourage them to achieve their aspirations’ (Schools Engagement 2015). This initiative is not specifically STEM focused, but does include some STEM subjects: ‘On-campus workshops and field trips’ cover a range of subjects including ‘cultural awareness and knowledge, the sciences, river ecology, creative writing, mathematics, marketing, nursing, law and more’ (Western Sydney University n.d.-b). In 2015, 452 students from 22 schools participated in the program.

> It’s had a lot of positive impacts. We’ve got some of the students who are at Uni here now with us, and some of them are actually mentoring in the program themselves … It doesn’t have a specific focus on STEM because they try out sort of a lot of different Uni subjects, so they’ll come for a workshop day and do two or three different workshops that will be run by academics or other experts, and that has included Maths workshops fairly regularly.

> We’ve had a couple of post-grads running some fun things, you know, rope tricks and different types of calculations, and group work with coloured cardboard, fun things to engage them in the Maths, and similarly with the Science and Engineering. They play with the robots over at Engineering. With the Science they do ‘Cool Science’, things like the slime and making ice-cream, and all those sorts of things when they’re in Year 8. They’ve done ecology, you know like going out to the river and getting samples and stuff like that. (Manager, Schools Engagement, Western Sydney University)

The volunteer mentors, who may be Indigenous or non-Indigenous, visit students in their schools. In addition, ‘the cohort at each school devises and implements a group project, with mentors facilitating that process’ (Schools Engagement Unit 2016). A team of mentors visit the school for at least one hour once a month to mentor individuals, small or larger groups depending on the ages and number of students at the school.

*Pathways To Dreaming* is supplemented by a Western Sydney University partnership with the Australian Indigenous Mentoring Experience (AIME) program, a national initiative designed to support Indigenous students through high school and into university, employment or further education (Badanami Centre for Indigenous Education 2016). AIME is not specific to STEM subjects. It generally operates in different schools to *Pathways To Dreaming*. 
Heartbeat

The Heartbeat program for Indigenous school students focuses on health, medicine and related sciences.

_It started off coming out of [the School of] Medicine because Medicine wanted more Aboriginal students to enrol as doctors … and then we thought that that’s not going to be for everyone, so we’ve sort of broadened it out, and the School of Science and Health, and the School of Nursing came on board as well._ (Manager, Schools Engagement, Western Sydney University)

The program offers

a suite of linked events and aims to: raise students’ awareness of health issues, inspire students to take up careers in health, medicine and related-sciences, present the university as a place for them.


Students spend a day on campus each year, under the guidance of Indigenous university students who are studying health-related degrees, as well as local Elders and Indigenous educators as well as non-Indigenous academics. Partners in the program include the Australian Indigenous Doctors’ Association, the Tharawal Aboriginal Medical Service, St John Ambulance (NSW), the South-Western Sydney Local Health District and the Western Sydney Local Health District.

Examples of STEM-related activities offered within the program include:

- Healthy Food Choices: Students learn about the Food Pyramid. (Years 3/4)
- Health Care: Students test vital signs and learn about hygiene. (Years 3/4)
- Human Heart: How the heart works and checking heart rates. (Years 3/4)
- Aboriginal Science: A walk and talk about the plants on campus - including their medicinal and bush tucker uses. (Years 5/6)
- Chemistry: What chemistry is and what it is used for, including an experiment. (Years 5/6)
- Food Science: Examining the sugar, salt and fat content in everyday foods and drinks. (Years 5/6)
- Sensory Physiology: Students are seated in a computer lab, looking at optical illusions, look at their own eyes and learning about colour blindness - exploring why people see particular things. (Years 7/8)
- Simulation Lab: Students see the nursing simulation lab used for training. They learn basic life support simulation training and tested their CPR skills. (Year 9)

A website was launched in 2015 featuring an interactive educational game called *Lightning Runners* which draws extensively on traditional Indigenous knowledge, particularly in regard to sustainability, and is linked to *Heartbeat*’s themes. This enables more regular connection between participants and the university, as well as allowing students not participating in the program to learn from the game.

The first cohort of Year 3/4 of Indigenous students started the *Heartbeat* program in 2010. Students in participating schools return to campus each year to build on their knowledge. No cohort has yet completed the program beyond Year 10, and the program for Year 11 and 12 students is under development. It therefore remains to be seen what impact the program will have in encouraging university participation in Medicine or allied health disciplines. However, students are surveyed at the end of each event and usually around 70 per cent express interest in a career in the health professions.

In 2015, 668 students from 32 primary schools and 12 high schools took part in a *Heartbeat* event in 2015 and, since 2010, over 1,300 students have taken part in the event.

**Walking Tall Together**

Walking Tall Together was a three-day on-campus event held during the school holidays for Indigenous students in Years 9/10. The program was designed to engage motivated students to consider tertiary study by introducing them to university life through educational and Indigenous cultural activities. The activities on offer included some STEM-related academic workshops in forensic science, natural science and robotics. Four camps were held in 2015, but the program is not funded for 2016. A resource booklet for parents and guardians of Indigenous students, providing information and advice on how best to assist their children with education and what to expect at university, was launched in March 2016.

**Partnerships for Success: Ngara Wingara**

In partnership with the Graham (Polly) Farmer Foundation, Western Sydney University offers the *Partnerships for Success: Ngara Wingara* after-school academic and cultural program for Indigenous secondary school students. The program is based on a model developed by the Foundation and provides tailored one-on-one tutoring to selected aspiring students to help them achieve their goals.

*Essentially the program has four aims. One is that we work with whatever the students bring in from school, so whether it’s homework or assignments, things like that. The second thing we look at is academic skills development about how to write to essays, what’s a Science report, sentence structure, paragraphs, all that sort of thing. The third thing we look at is broadly career counselling, so getting them to start thinking about what they want to do when they finish school, whether that be employment, TAFE, or university. (Co-ordinator)*

Funding is a mix Federal Government, HEPPP funding and philanthropic donations. The program is not specifically STEM related, but can be so, depending on the aspirations and needs of the students. Western Sydney University has joined
Partnerships for Success in the last two years, but the Graham (Polly) Farmer Foundation has been running successful educational programs for school students using this model across Australia since 1997. The program has a steering committee with Indigenous Elder/community, Department of Education, school, local council and youth organisation representation.

Summary: Case study characteristics

Higher Education pathways
Some students who have been through the Pathways To Dreaming program are now at university and some now mentor in the program. Heartbeat is yet to have a cohort reach university age. Students in Walking Tall Together and Partnerships for Success: Ngara Wingara have been provided with extensive information about higher education options.

Capacity building
Students have the opportunity to return over several years, building capacity for university study and familiarity with the university environment.

Attracting STEM students
Heartbeat has a health and science focus. Pathways To Dreaming is not STEM-specific, but includes some STEM-related activities. Walking Tall Together included STEM activities. Partnerships for Success: Ngara Wingara students can access tutoring and assignment help in STEM subjects.

Indigenous presence
Indigenous mentors, campus guides, academics and Elders participate in the engagement initiatives, providing a visible Indigenous presence on campus.

Community engagement
As the Manager (Schools Engagement) commented:

We don’t tell the schools what they should have, we listen to the schools and we come up with something together, so that’s why it’s an Engagement Plan ... All our Aboriginal programs have close involvement of Aboriginal Elders and Aboriginal educators, so we see that as really important for the authenticity of the program, and to make those links between the students and the Elders. Students learn a lot from the Elders.

All the programs benefit from the input of other partners and stakeholders, such as the Heartbeat partner organisations. The Western Sydney Local Health District runs the Year 9 event at Westmead Hospital, giving students direct experience of the health service environment.
Sustainability

In terms of long-term sustainability, Australian Government HEPPP funding contributes to the support of these programs. In some cases internal division of this funding may influence the long-term sustainability of individual programs.

Figure 6: From the Heartbeat program (image courtesy of Western Sydney University)
Figure 7: From the *Heartbeat* program (image courtesy of Western Sydney University)

Figure 8: From the *Pathways To Dreaming* program (image courtesy of Western Sydney University)
Conclusion and future directions

This report has considered six case study sites that represent hopeful initiatives within the Higher Education sector to promote increased Indigenous participation in STEM courses in Australian universities. The programs and initiatives were viewed through the lens of Gale et al.’s (2010) *Design and Evaluation Matrix (DEMO)* that identifies enabling conditions for successful university outreach/engagement programs that aim to improve university participation low socioeconomic communities. Gale et al. (2010) identified ten key enabling characteristics grouped under four strategies. They added a further three themes that reference equity concerns: *Unsettling deficit views*; *Researching ‘local knowledge’ and negotiating local interventions*; and *Building capacity in communities, schools and universities*. These themes were not integrated into the matrix: However, it is suggested that these three themes do not fully capture important aspects of an equity agenda for Indigenous students and a further strategy encompassing four characteristics, which should be integrated into the matrix, as proposed:

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusivity and equity</td>
<td><em>Inclusive, engaged, respectful partnerships</em></td>
</tr>
<tr>
<td></td>
<td><em>Culturally responsive curricula and pedagogy</em></td>
</tr>
<tr>
<td></td>
<td><em>Professional learning for cultural and linguistic diversity</em></td>
</tr>
<tr>
<td></td>
<td><em>Recognition, validation of diverse epistemologies</em></td>
</tr>
</tbody>
</table>

While the DEMO provides a robust research and evaluation matrix for the case studies researched for this report, incorporating a richer set of equity themes that take into consideration a history of Indigenous struggle in the higher education and schooling sectors over many decades would strengthen the model. In addition, it is suggested that the strategy *Building Confidence* could strengthened with the addition of a further characteristic: *Creating inclusive learning environments*. Consequently, the matrix has been adapted and termed the *Design and Research Matrix for University Equity (DEMUE)* (Figure 6).
### Conclusions and future directions

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assembling Resources</strong></td>
<td><em>People rich</em></td>
</tr>
<tr>
<td></td>
<td><em>Financial support and/or incentives</em></td>
</tr>
<tr>
<td></td>
<td><em>Early, long-term, sustained</em></td>
</tr>
<tr>
<td><strong>Engaging learners</strong></td>
<td><em>Recognition of difference</em></td>
</tr>
<tr>
<td></td>
<td><em>Enhanced academic curriculum</em></td>
</tr>
<tr>
<td></td>
<td><em>Research driven</em></td>
</tr>
<tr>
<td><strong>Working together</strong></td>
<td><em>Collaboration</em></td>
</tr>
<tr>
<td></td>
<td><em>Cohort-based</em></td>
</tr>
<tr>
<td><strong>Building confidence</strong></td>
<td><em>Communication and information</em></td>
</tr>
<tr>
<td></td>
<td><em>Familiarisation/site experiences</em></td>
</tr>
<tr>
<td></td>
<td><em>Creating inclusive learning environments</em></td>
</tr>
<tr>
<td><strong>Inclusivity and equity</strong></td>
<td><em>Inclusive, engaged, respectful partnerships</em></td>
</tr>
<tr>
<td></td>
<td><em>Culturally responsive curricula and pedagogy</em></td>
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<tr>
<td></td>
<td><em>Recognition, validation of diverse epistemologies</em></td>
</tr>
</tbody>
</table>

*Figure 9: Design and Research Matrix for University Equity (DEMUE)*

Also, it is considered that the original DEMO underplayed the importance of long-term sustainability for equity initiatives; sustainability needs to be built into initiatives from the outset. There is a need for robust frameworks for evaluating and researching equity strategies that have historically been unsustainable for various reasons including a decided lack of ‘real’ commitment to equity across the sector.

The final section of this chapter is framed around the following dimensions of the DEMUE model, and which are particularly relevant to the case studies:

- Strategy: Assembling resources
- Strategy: Building confidence
  - Characteristic: Creating inclusive learning environments
- Strategy: Inclusivity and equity

Each of these dimensions is discussed with reference to the case studies and implications for policy. Reform strategies for Indigenous STEM programs are proposed. A set of policy initiatives for accelerating Indigenous STEM programs is presented, concluding with a blueprint for research to further understandings of best practice in Indigenous STEM education.
Conclusions and future directions

Assembling Resources

Indigenous STEM outreach/engagement programs in Australian universities that forge productive and successful learning environments for Indigenous students are characterised by a complex system of funding that is provided in different ways.

Financial support and sustainability

Several of the Indigenous STEM programs offered at the case study sites are funded from the Federal Government’s Higher Education Participation and Partnerships Programme (HEPPP) (e.g. University of Newcastle, some programs offered at Western Sydney University, UniSA College). However HEPPP is a proposal-driven funding program that is difficult to secure support for ongoing well-established STEM programs Indigenous STEM outputs are not featured in large-scale policy strategies such as Closing the Gap and as a consequence of funding uncertainty, many Indigenous STEM programs are unsustainable, or on shaky ground at best without the establishment of multi-level agreements within government departments and agencies.

Trusts, foundations and corporate philanthropy

Philanthropy plays a role in supporting several case study programs. The ASSETS program has been stabilised following the cessation of government funding by the BHP Billiton Foundation which has supported CSIRO with $28.8M to renew the program. Curtin University’s IAESS and IAEPP programs are funded by Engineering Aid Australia which is in turn funded via engineering organisations, philanthropic foundations and individual donors. The Graham (Polly) Farmer Foundation contributes to several initiatives including Follow the Dream: Partnerships for Success at Curtin University and Partnerships for Success: Ngara Wingara at Western Sydney University. Clearly, philanthropy has an important role to play in moving Indigenous communities forward in STEM. The leadership and managers at several case study sites expressed concern regarding the lack of secure long-term sustainable financial support to continue their work. However, philanthropic funding is limited when compared with the overall funds needed to advance Indigenous participation in STEM in Higher Education. There is a need for innovation and collaboration between philanthropic organisations, the private sector and governments in order to maximise the impact of limited financial resources.

Implications for policy

University Indigenous STEM outreach and engagement programs are important avenues for Indigenous students to become familiar with higher education contexts and to bring their traditional knowledges and cultures into dialogue with STEM education and thus encourage increased rates of study and employment within STEM fields. However, such programs are not offered in every state or territory. The absence of a National Indigenous STEM policy or strategy, despite an identified need for such an approach (see, for example, Expert Working Group on Indigenous Engagement with Science 2013; Anderson 2014, p. 12), perpetuates a situation where the focus on increasing Indigenous participation in higher education STEM programs is patchy at
best. The resources required for Indigenous STEM programs are often limited, insecure and unreliable. Governments need to establish a national strategy and play a larger role in providing centralised and sustainable funding to support existing and future Indigenous STEM outreach/engagement programs in universities. A national coordinated effort would provide the basis for a rigorous and consistent exploration of the cultural, institutional and organisational factors that discourage Indigenous peoples from studying STEM, and that limit their opportunities to pursue STEM careers. The roll out the Federal Government’s *National Innovation and Science Agenda* (Department of the Prime Minister and Cabinet 2015) should include workplace training opportunities, including local Indigenous community orientation to the benefits of STEM.

**Building confidence: Creating inclusive learning environments**

Leadership, university educator quality, culturally responsive curricula and pedagogy, program structures, and student mentoring and support are identified within the case studies as central to Indigenous STEM program effectiveness and student achievement. Creating inclusive environments builds the confidence of Indigenous students through their diverse abilities and their social and cultural backgrounds. It also builds connections between the institutional context of Western science and other more familiar ways of knowing, being, and learning that can easily be discounted on commencement of study, often to the detriment of Indigenous students.

**Program leadership**

Creating inclusive learning environments starts with effective and responsive leadership. The program leaders who were involved in these six case studies were committed to changing the status quo in terms of the numbers of Indigenous students enrolling in STEM-based higher education degrees, and the outcomes and completion rates. These are passionate educators, often undertaking extra work in a voluntary capacity, and mentoring the next generation so that there was succession planning. There was an impressive and palpable sense that these leaders are motivated by a desire to see significant and positive change in communities above self-interest or career advancement. Across the six case studies the majority of managers of the STEM programs are non-Indigenous, yet the leadership created, nurtured and managed the prevailing culture including its norms and attitudes that promote Indigenous student engagement and learning. A number of structural models for governance and leadership are recognised within the case studies, and more broadly, with consistent factors including: a strong commitment to Indigenous participation at all levels of leadership and governance, and a commitment to the values of equity and excellence for Indigenous Australians in higher education.

Examples of models that prioritise these values include: Indigenous ambassadors, project management groups, Indigenous advisory committees and governance and policy advisory structures that are ancillary, but linked to core university management
structures. The CDU Whole of Community Engagement initiative took a distributed leadership approach whereby senior community members across six very remote Northern Territory communities are employed to build local community capacity for engagement and decision making, including the shaping of university program approaches, working from the community and back to the institution.

Innovative governance models exist globally where universities form strategic alliances with Indigenous communities. These alliances could leverage university partnerships with Indigenous community organisations as co-administrators, equal in status with responsibilities divided into teaching/learning and community/programs and funding. Such an approach has the potential to provide visible models in Indigenous communities of how STEM programs can be developed and aspired to across social, cultural and knowledge contexts.

Mentoring and Indigenous presence
The presence of Indigenous role models, campus guides, university students, educators, community based leaders and Elders was a significant aspect of most of the case studies (e.g. ASSETS, Curtin University’s IAESS and IAEPP programs, University of Newcastle, Western Sydney University and CDU’s WCE initiative). Indigenous school students visiting on campus or participating in summer schools had opportunities to meet and engage with Indigenous university students as role models. There was a mix of voluntary and paid positions for Indigenous university students as campus guides, mentors and house parents. The visible presence of Indigenous facilitators and educators provides the opportunity for prospective students to see university and STEM as relevant to them.

In contrast, the CDU WCE initiative employs local community ambassadors with university experience to provide inspiration and encourage university engagement amongst younger members of the partner communities. In both examples, the presence of Indigenous mentors is critical to building confidence and support for current and prospective students to participate and succeed in university programs.

English as the primary language of STEM instruction
Proficiency in English literacy and numeracy is considered foundational to academic success in STEM and a strong predictor of transition from school to university. The literacy gap still poses a significant barrier for Indigenous transition from school to university as identified in the case studies (see, for example, CDU case study, p. 50). Indigenous students represent diverse languages, histories and experiences in formal schooling contexts. It is important for STEM educators to be aware of the wide range of backgrounds, experiences and perspectives of Indigenous students. This awareness needs to be translated to curriculum development, pedagogy, and all aspects of university life to ensure that culturally and contextually responsive practices provide the supportive learning contexts that encourage participation and completion of Higher Education programs.
Across Australia, there are various approaches to Aboriginal language programs that teach Indigenous children to read in their first language. Less-recognised languages such as Kriol and Aboriginal English are also spoken as first languages. English as a Second Language (ESL) methodologies shape pedagogical practice in state and territory schooling, but there are no requirements to equip educators of Indigenous students in university programs with a wider repertoire of effective STEM literacy and numeracy strategies relevant in bilingual and ESL learning contexts.

The development of local language programs for STEM engagement needs to sit alongside explicit English language instruction that orients ESL (and/or English as an Additional Language – EAL) speakers to Western scientific and mathematical concepts that are dependent upon foundational STEM-related language acquisition. A coordinated national approach to Indigenous STEM should consider the philosophical, epistemological and language foundations of Indigenous Knowledge systems and Western STEM programs, and structure resource development, teacher training and professional accountability measures for competency in language instruction into a coordinated national Indigenous STEM approach.

**STEM programming**

Programing found to improve Indigenous success emphasised flexibility and the need for it to be personalised to particular levels of learners. Learning activities should be related to Indigenous students’ strengths, and this was particularly evident in those programs offering residential schools. Student refreshers in STEM basic principles are required to scaffold key mathematics and science concepts and formulas; again this was evident in summer school programs, as well as through tutoring provided through the Graham (Polly) Farmer *Partnerships for Success* programs conducted through Western Sydney University and Curtin University.

**Pedagogies for STEM**

Instructional methods effective in Indigenous STEM pedagogies include inquiry based learning; collaborative learning; case study; problem-based learning; peer learning; place-based learning activities related to contemporary and localised Indigenous challenges. Open-ended problem-solving tasks and PBL featured in the IAESS program at Curtin University and in the Miroma Bunbilla Pre-entry to Medicine program run by the University of Newcastle’s Wollotuka Institute. Combined with individual and group support from STEM educators, science activities can offer a high degree of student autonomy, allowing students to draw on their cultures, languages and prior knowledge. Student presentations made at the end of the ASSETS program were scientifically and mathematically rigorous and demonstrated the value and the potential of the inquiry approach.

**Indigenous STEM teaching resources**

Nurturing Indigenous student achievement relies on the quality of educators and the availability of excellent learning resources directly relevant to STEM. However,
relevant and targeted Indigenous STEM reference material and teaching resources are scarce and there is an urgent need for the development of such materials.

**Transition**

All of the Indigenous STEM outreach/engagement programs investigated aimed to familiarise students with university cultures, pathways and careers. Many Indigenous students who transition from school to university are the first in their family to go to university. University life and study is new and different for both individuals and their families. While some students adjust quickly, others require significant support to succeed to make a successful transition to university. Residential summer schools at university, such as those offered through the ASSETS program and the IAESS/IAEPP programs held at Curtin University with the support of Engineering Aid Australia all provide bridging experiences between school and university. Further research is required to document whether the summer school experience, through deliberate immersion in university facilities and programs, supports student transitions through to Higher Education and whether this improves overall university student access, retention, success and satisfaction. Indeed, irrespective of the discipline, there remains a pressing need to increase the ‘evidence-base about what does and does not work in relation to Indigenous pathways and transitions into higher education’ (Frawley, Smith & Larkin 2015, p. 10).

**High expectation relationships**

A philosophy of high expectations for students and staff (see Stronger Smarter Institute Limited 2014) was characteristic of several of the case studies (e.g. ASSETS, Curtin University’s IAEPP program, University of Newcastle’s Miroma Bunbilla Pre-entry to Medicine program). The program’s leaders create and set the high expectation culture for student improvement. University educators are skilled to promote learning while fostering high expectations of all learners that is both respectful and nurturing. This addresses both ineffective practices and deficit stereotypes of Indigenous students’ abilities.

**Implications for policy**

Indigenous STEM outreach and engagement programs facilitate the transition of Indigenous students to university and/or STEM-related jobs. However, improving overall Indigenous school completions and numeracy and literacy would increase STEM participation beyond what could be expected of such interventions. Without significant improvements in literacy and numeracy, the school-to-university pathway will remain inaccessible for high numbers of Indigenous school students and Indigenous STEM outreach/engagement programs will continue as a labour-intensive model to bridge the divide between STEM programs and the lived experiences of many Indigenous young people. The case studies indicate that there is a positive effect for Indigenous learning and aspirations when students are able to bring their traditional cultures into STEM education through a curriculum that shows the strong link between Indigenous culture and science (e.g. University of Newcastle, CDU). These case studies
also found quality relationships with Indigenous students and their communities play a crucial role in the success of Indigenous learners. The lesson here for schools challenged by low attendance or success is that Indigenous STEM outreach/engagement programs which are culturally compatible reinforce student belonging, identities and increase motivation to excel (e.g. ASSETS, University of Newcastle). Ensuring the next generation of Indigenous students receive the STEM skills needed from mainstream public schooling is critical to ensuring the development of Australian talent required for STEM jobs and Australia’s future competitiveness.

**Inclusivity and equity**

Successful STEM outreach/engagement programs serving Indigenous students require meaningful engagement with Indigenous communities. The engagement practices found in the case studies to be most effective are:

*Inclusive, engaged, respectful partnerships*

Involving Indigenous communities in STEM programs and ensuring their participation in day-to-day operations is critical to success. Indigenous collaboration and partnerships differed at each case study site but were achieved through genuine consultation with stakeholders including local Indigenous Elders and educators. Noteworthy practices include creating a recognisable Indigenous ‘presence’ in the STEM program using: Indigenous educators and support staff; Indigenous Ambassadors; mentors; house parents in residential programs; Indigenous invited speakers; and other Indigenous support personnel. The influence of culture on success in academic performance of Indigenous students is harnessed and strengthened through placed-based cultural integration of local Indigenous into programming. Evaluations confirm that Indigenous parents and community leaders appreciate the presence of summer university outreach Indigenous STEM programs in their communities that accelerates Indigenous support, community STEM awareness, and enhances the program’s reputation.

* Culturally responsive curricula and pedagogy*

STEM courses and curricula that draw on the life experiences and knowledge of Indigenous students strengthen connections with STEM curricular content. Regardless of individual learning styles, good pedagogy is critical to Indigenous student achievement. Indigenous perspectives can be embedded into STEM via the use of Indigenous environments, cultural camps and excursions (e.g. ASSETS program, Curtin University’s IEASS program, programs run through the Wollotuka Institute, University of Newcastle).

*Professional learning for cultural and linguistic diversity*

There is a lack of research evidence on the professional development activities of leaders, teachers and staff in these programs. Noteworthy examples of professional development practices include non-Indigenous staff learning about Indigenous
histories, knowledges and localised cultures in particular. However there is little evidence of recruitment and induction of program teachers to teach Indigenous students or in Indigenous community contexts. This inhibits capacity building of STEM and community support with within the local Indigenous groups.

**Recognition and validation of diverse epistemologies**

The CDU case study highlighted dynamic examples of scientific engagement within a dual epistemological approach and across disciplines. This includes environmental sciences, education, health and research.

**Implications for policy**

This research suggests that senior leadership of Indigenous STEM programs require additional support from government networks and funding agencies to build opportunities and capacity for Indigenous families and communities to actively support their children’s learning and participation in STEM. Transition strategies and alliances could be encouraged and resourced between schools and university outreach Indigenous STEM programs. Governments must play a larger role in supporting multi-agency collaboration between Indigenous communities, universities and state and territory education authorities in the development of programs for Indigenous STEM education. To ensure successful school to university transition, in-school STEM support strategies known to be beneficial for student engagement and retention should be linked to university outreach Indigenous STEM programs. Schools should gather systematic student STEM data to inform transition-to-university programs. This coordinated approach would require schools to develop and monitor STEM interventions and support in partnership with university outreach Indigenous STEM programs. Governments need to require all schools and districts to develop comprehensive Indigenous STEM intervention strategies and to report annually on indicators related to the success of these interventions.

As argued above, Indigenous communities and organisation should be located within partnerships, rather than being located as an external target for outreach and engagement back in to the institutions to enable visible and shared approaches to STEM projects, courses and employment that builds aspiration within STEM for young Indigenous Australians. A multifaceted strategic approach is required.

**Reform strategies for Indigenous STEM programs**

- **Stabilising strategies**

  Stabilise all existing university Indigenous STEM outreach/engagement programs and personnel via new and existing funding sources. Human resources and financial support is required for the continuation of all existing programs.
Conclusions and future directions

- **Growth strategies**

  Expand university Indigenous STEM outreach/engagement programs via financial investment. Develop multi-site programs across schools, universities, and Indigenous communities in every state and territory that cater for urban, rural and remote jurisdictions. Currently the total number of university Indigenous STEM engagement programs is limited. There are no STEM programs run by Indigenous Communities.

**High-impact priorities for Australian policy makers**

Policy priorities of strategic importance in strengthening success of Indigenous STEM participation include:

- Develop a National policy and strategy on Indigenous STEM.
- Embed Indigenous STEM workforce targets in the Federal Government’s *National Innovation and Science Agenda*.
- Improve Indigenous school completion, numeracy and literacy rates (as advocated in *Closing the Gap* policy).
- Fund the continuation of Indigenous STEM outreach/engagement programs in universities via the Higher Education Participation and Partnerships Programme.
- Foster research to address the under-representation of Indigenous peoples within the STEM workforce.
- Support STEM Programs within Indigenous communities.
- Establish partnerships with Indigenous communities to address STEM learning.

**A blueprint for research**

At present, Australia lacks a coherent and coordinated policy-focused research agenda to inform the delivery of Indigenous STEM education and ultimately, jobs. The following research priorities are proposed:

- Improve measures and data collection for multiple sector purposes (school, university, adult education).
- Collect baseline data and monitor for changes over time.
- Fund high quality international comparative studies of Indigenous STEM research.
- Establish a website and data-base encapsulating existing Australian Indigenous STEM programs.
- Pilot Indigenous STEM collaborations between schools and universities programs of sufficient breadth to inform decisions about scaling up.
Conclusions and future directions

- Develop new culturally relevant STEM curricula, pedagogy, assessment, and teacher preparation programs.
- Research Indigenous parent and community involvement in STEM.
- Resource STEM research that works across dual-epistemological spaces and methodologically privileges Indigenous Knowledge, peoples and priorities.

Conclusion

There are many challenges to closing the Indigenous STEM gap in schools to ensure positive transition to pathways and STEM careers. Yet the evidence indicates that there are promising and scalable models of success in university outreach Indigenous STEM programs. This research confirms that much progress has been made, but coherent and strategic Indigenous STEM policymaking across levels of government is needed to build capacity in the field and bring isolated successes to scale. Notable strategies to strengthen Indigenous STEM school to university transition include a national Indigenous STEM policy, comprehensive state and territory action plans and resources dedicated to closing the STEM achievement gap. To address the Indigenous STEM education gap sustainable sources of funding dedicated to meet this challenge are required. Complimentary initiatives are required that include improved data collection, increased dialogue and alliances among the various sectors involved, and the sharing of data and information on best practices. This research confirms the need to increase the visibility of pathways from school mathematics and science to real 21st century jobs.
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CSIRO Indigenous STEM program

With the support of the BHP Billiton Foundation, CSIRO are implementing an important new education program aimed at increasing participation and achievement of Aboriginal and Torres Strait Islander students in STEM. There are six elements to the program, which caters to the diversity of Aboriginal and Torres Strait Islander students as they progress through primary, secondary and tertiary education, and into employment.

Program elements

1. *Science Pathways for Indigenous Communities*: Targets primary and middle school students in remote Indigenous communities and uses on-country projects as the context for learning science linked to Indigenous ecological knowledge.


3. *PRIME FUTURES*: Targets foundation to Year 9 students in mainstream metropolitan and regional schools and uses the YuMi Deadly Mathematics approach to improve student outcomes in mathematics. It aligns with the Australian Curriculum and encourages schools to involve parents and community in mathematics learning. It uses a train-the-trainer model for teacher professional development.

4. *ASSETS*: The Aboriginal Summer School for Excellence in Technology and Science is a nine-day residential program for high-achieving Indigenous Year 10 students with an ongoing leadership, cultural engagement and support program to nurture students through Years 11 and 12. ASSETS uses I2S2 Program and Prime Futures as feeder programs.

5. *BSc (Extended) The University of Melbourne*: Year 12 Indigenous student involved in the ASSETS mentoring and leadership program will be encouraged to go on to study tertiary STEM courses, including the BSc (Extended) at The University of Melbourne. Mentors throughout the program will assist students with the transition.

6. *Excellence Awards*: Recognises, rewards and promotes the achievements of Indigenous school students across Australia in science, technology, engineering and mathematics.
Appendix

Project Aims and Goals

The overarching goal of the CSIRO project is to support students from primary school through to tertiary education. Pathways will be provided that improve Aboriginal and Torres Strait Islander participation and achievement in STEM. The aspirational goal is to increase Indigenous representation in STEM-related professions.

Outcomes

- Improved integration of programs for Indigenous students moving through school and into STEM related tertiary study or employment.
- Improved teacher, teacher assistant and student capacity in science and mathematics.
- Increased number and improved achievement of students studying science and mathematics at school and university.
- Indigenous school students recognised and rewarded for high achievement in STEM.

Quality of Life Indicators for Students

- Improved mental and emotional well-being through becoming aware of a future pathway. Improved autonomy and decision-making relating to future careers.
- Increased enjoyment, satisfaction and self-belief from feeling valued and understood as an Indigenous learner.
- Improved self-confidence and self-belief leading to better qualifications and wider employment options.
- Increased pride in Indigenous culture and identity leading to improved local community strength and spirit.

The implicit motivation for CSIRO Indigenous STEM program is to achieve parity in educational outcomes for Indigenous students in STEM subjects. This is facilitated through building a culture of high aspiration amongst educators and students. Moreover increasing family and community understanding of the benefits of pursuing the enabling subjects of science and mathematics at school level and on into tertiary education.

Sources:

http://www.csiro.au/en/Education/Programs/Indigenous-STEM/Program-Info/Overview