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# Engaging excellent Aboriginal students in science: An innovation in culturally-inclusive schooling

by Carol Aldous, Alan Barnes, Julie Clark

A summer school in Science and Technology was held in January 2008 for nineteen Indigenous students commencing year 11 who were identified as having high academic potential in science and mathematics. Known as the Aboriginal Summer School for Excellence in Technology and Science (ASSETS) the summer school was held at the Australian Science and Mathematics School, Flinders University, Adelaide South Australia. Selected on merit, the Indigenous students came from around the nation to participate in the ten-day innovative program. Student engagement and involvement with the concepts and conduct of science was high and the activity intense. Learning was deep and its impact on students' was profound. This paper reports on the nature of learning and teaching of science to Indigenous students at this school and seeks to answer the question 'What was so innovative about the program that its impact was not merely successful but also profound?'

## Introduction

For many students, ASSETS is life-changing. One student wrote:

*When I came to ASSETS I was being recognised for being Aboriginal—it was something to be proud of. ASSETS provided me with role models to look up to, respect and follow. It boosted my self esteem and confidence ... being accepted into ASSETS. ... I can still picture the look on Dad's face. ... It was the first time my Mum and Dad had ever verbalised how proud they were of me.*

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

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. Through the activities of the South Australian hub of the national program for Science ICT, Mathematics Education for Rural and Regional Australia (SiMERR-SA) it was then reinitiated in 2007-2008.

In describing the original conception of the ASSETS program, Barnes (1993) explained that gifted Aboriginal students were always under-represented in mainstream science and technology summer schools. This gap had led

in part to a disproportionately small number of Aboriginal people in science, mathematics and technology-related professions. ASSETS therefore sought to address this gap by offering Indigenous students a challenging, well-supported experience of experimental and discovery projects.

In this program Aboriginal students with academic promise were to be recruited from around Australia. Students from all secondary schools (government and non-government; city, regional, rural and remote) were eligible to attend. The students were expected to have an aptitude and interest in science, ICT and mathematics and be moving into Year 11 programs with significant emphasis in these areas. The earlier ASSETS ten-day program was to be:

*A balance of academic curriculum, excursions, cultural and social activities, and recreation. This holistic approach ensures that participants not only have the opportunity to improve their academic skills but are able to visit places of scientific and technological interest, meet interesting people, practice [sic] social skills, display pride in their Aboriginal cultural heritage and relax with their Aboriginal and non-Aboriginal fellow Australians (Steen, 1996).*

Reporting on past ASSETS programs Clark and Merrotsy (2008) identified

outcomes for students that could be 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 Aboriginal peer group of academic skills and abilities as having
- an impact on career choice.

ASSETS graduates have selected study in a myriad of fields such as music, psychology, design, health care, apprenticeships, the Navy and architecture. In addition, a number of students have pursued careers in science. In 2006 an ASSETS graduate completed a PhD in a science-related field and is now working full time as a research scientist.

While ASSETS2008 was designed to achieve similar outcomes, the educational, institutional and Indigenous context had changed from that of the 1990s. Much of the Aboriginal political infrastructure of the early period had gone, presenting a challenge to recruitment and support, and legal

frameworks for working with children had tightened around duties of care and other matters. Moreover, anecdotal evidence indicated that interest in intensive 'summer' schools had declined. On the positive side however, there was now in place new pedagogies around science teaching (Aldous, 2006) that seemed more appropriate to Indigenous students, especially those executed at the Australian Science and Mathematics School. The challenge for ASSETS2008 was to design a program that could be sustained throughout the 21<sup>st</sup> century.

## Science and culture

Innovative programs like ASSETS need to deal with the teaching and learning of science in diverse cultural contexts. While there may be many viewpoints on what 'culture' means, for the purpose of this paper the term culture embraces language, community, family, school classroom, peers and environment.

Having access to and participation in a relevant and meaningful science education is regarded as a democratic entitlement of all children under the age of compulsion in Australian schools. Governments spend large sums of money conducting studies that monitor the progress and achievement of the nation's children in science. Two of these, the Trends in International Mathematics and Science Study (TIMSS) (ACER, 2006; 2008) and the Program for International Student Assessment (PISA) (Thompson & De Bortoli 2008) indicate that overall Australia's students perform comparatively well, being among the top ten of OECD nations in scientific literacy (Thompson & De Bortoli 2008), albeit with a declining relative position. The PISA program, for example, investigates how well fifteen-year-old students are able to apply their science knowledge and skills to real life problems. The TIMSS program, on the other hand, investigates how well Year 4 and Year 8 students have achieved a country's intended curriculum in science and mathematics. Of concern therefore is the finding that relative to Australia's non-Indigenous children Australia's Indigenous students are performing at a lower level. Reporting on the Australian perspective in the PISA study, De Bortoli and Cresswell (2004) stated that:

*Australia's Indigenous students performed at a lower level than the non-Indigenous students in the three assessment areas-reading literacy, mathematical literacy and scientific literacy. Their results were below the OECD mean (De Bortoli & Cresswell, 2004 p.vii.)*

In an Australian education review of contemporary research on Indigenous education outcomes, Mellor and Corrigan (2004) conclude that

Indigenous students' disadvantage cannot solely be explained by socioeconomic and English-language background status, and that culture plays an important part. This view is based on the finding of a study of Year 3 and Year 5 literacy and numeracy tests, in which Indigenous students were less successful than individuals from low socioeconomic backgrounds and less successful than students from non-English speaking backgrounds (MCEETYA, 2001).

Indeed, according to the Taskforce on Indigenous Education Employment, Training and Youth (IEETY) there is a need for:

*Educators to have better pedagogical understanding in recognition of children's ... cultural and linguistic diversity (Mellor and Corrigan, 2004, p. 13);*

and further that there is a need to:

*... encourage Indigenous children to move fluently among and between cultures ... to emphasise high expectations and code switching strategies, which ... can accelerate improvements in the education outcomes for Indigenous students (Mellor & Corrigan, 2004, p. 13).*

## Establishing border crossings into the culture of science

In the light of these recommendations by the IEETY Taskforce it is interesting to find prominent science educator Aikenhead (1996) proposing that learning science is akin to learning a new culture. Furthermore, the ease with which the culture of science is acquired, he hypothesises, is related to how well science instruction aligns with 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. (Aitkenhead, 1996).

Every culture is comprised of individual groups each defined by a set of beliefs, norms, behaviours and expectations (Furnham, 1992). Such groups of individuals form a series of subcultures within an overarching larger culture. Viewed from this perspective, science can be described as a subculture of a much larger social structure. Subcultures identified as strongly influencing student's understanding about science include the (1) family; (2) peer group; (3) classroom; (4) school; and (5) physical, social and economic environment (Furnham, 1992), although in the current context sport (with its focus on physiology) and TV, with its recent focus on investigative criminal sciences

might also be added. Thus learning science from this perspective entails the learner moving in and out of a series of subcultures. To facilitate the transition into and out of the science subculture Aikenhead (1996) proposes what amounts to a series of 'border crossings'. The fluency with which students move between subcultures, switching language conventions, moving back and forth between the science-world and life-worlds is all important.

The opportunity to identify the presence of such border crossings into the culture of science arose in the context of ASSETS2008. A study was thus conceived that would investigate Indigenous student engagement in science. Some 19 Indigenous students from around Australia, identified as having high academic potential in science and mathematics, attended the school. The findings of this study are reported in this paper. Evidence will be presented to show that the innovation involved the construction of a schooling program that was culturally inclusive. In particular, it will be shown that a series of so-called 'border crossings' were created enabling students to cross into science and back again at a number of places including peers, family, school, classroom and environment.

## Purpose of study

Working with best-practice schools in the federally-funded Australian School Innovation in Science, Technology and Mathematics (ASISTM) initiative, Tytler, Symington, Smith and Rodrigues (2008, p18) define innovation as:

*... the process of assembling and maintaining a novel alignment of ideas, practices and actors (to respond to site-specific issues) and/or to pursue a vision (Tytler, Symington, Smith and Rodrigues 2008, p.18)*

Since the ASSETS2008 program involved assembling a novel arrangement of ideas, practices and actors to pursue a vision concerning increased engagement and participation of Indigenous students in science an innovation framework was adopted for the analysis of this study. The purpose of the study was to identify those attributes of innovation that enabled successful student engagement in science learning and teaching to be demonstrated among 19 commencing Year 11 Indigenous students. The research questions were:

1. What factors enable successful student engagement in science learning and teaching to be demonstrated through ASSETS?
2. What was so innovative about the ASSETS program that its impact was not merely successful but also profound?

## Methodology

### Case study design

Creswell (1998) recommends qualitative research for studies involving 'how' or 'what' questions. A case study is an in-depth study, described from the participants' point of view, of a particular instance of a phenomenon in a natural setting (Gall, Borg, & Gall, 1996). Whether viewed as an object or a method, Creswell defines a case study as "an exploration of a 'bounded system' or a case over time through detailed, in-depth data collection involving multiple sources of information rich in context" (1998, p. 61). Soy (1997) explains that case studies provide understanding of a complex issue.

This particular study is based on a system that is bounded by both time and activity parameters. Given the research questions, an interpretative case study approach was selected as the basis for study design. In order to address the research questions, multiple qualitative methods, including written materials, informal interviews and observations, were employed to provide data from varying perspectives.

### Sources of data

In order to triangulate the data, multiple sources were used for this study. These sources were students, academic tutors, residential staff, program coordinators and mentors.

Students and tutors provided written feedback at the conclusion of the ASSETS program and in addition, informal interviews were conducted with tutors. Non-participant observers took notes during the sessions and these were discussed at debriefing meetings following the program. A detailed description of the participants is given below. Feedback on the summer school was sought in the areas of: ways of learning and teaching, culture and program materials, staff cultural perceptions and staff perception of student motivation/ engagement. Given that the summer school was an innovative program the data were analysed using an innovation framework.

### Framework for analysis

An innovation framework based on best practice exemplars from the Australian School Innovation in Science, Technology and Mathematics (ASISTM) projects (Tytler, Symington, Smith & Rodrigues, 2008) was used as a framework for analysis. This framework comprised six major dimensions. These included

- The ideas and issues being explored or promoted
- The actors (individuals, organisations, resources,

environment recruited in support of the project

- Practices (scientific, technological, pedagogical) to support the new alignment of ideas/ actors'
- Intended and actual outcomes
- Sustainability of the innovation in some form and
- Transferability of the ideas and practices beyond the local sites.

(Tytler, Symington, Smith & Rodrigues, 2008, pp.9-10)

These six dimensions formed the framework against which the identification of factors forming the innovative program could be analysed and compared. Since space does not permit a fuller discussion, these dimensions have been grouped under the following headings: (1) Ideas and actors; (2) Practices and outcomes; and (3) Sustainability and transferability of the innovative program.

### Participants

The cohort for this study included students commencing Year 11 the following term. They were recruited nationally within Australia via a merit selection process involving academic ability, teacher and community recommendation and recognition of a broad range of outside achievements. This multi-faceted approach was based on the Collis and Fromberg (1992) (cited in Montgomery 2001) mathematics profile indicating that academic potential according to school and teacher recommendations played an important role. In addition, students provided a written statement explaining why they wanted to attend the program.

### Location

The 2008 pilot of the new ASSETS was hosted at the Australian Science and Mathematics School (ASMS), based on the campus of Flinders University, in conjunction with Wiltja, a residential accommodation facility for young Indigenous students in South Australia.

### Program description

The ASSETS2008 program comprised two components: an academic component and a residential, social component.

#### Academic component

The academic curriculum provided students with authentic and engaging scientific experiences. Key pedagogies were problem solving and an inquiry approach. Teaching staff were supported by Aboriginal educators with a background in the sciences. These experiences were conducted over a ten-day period in three parts.

### Part 1 Initial exposure

The first part of the program involved

introducing students to different areas of science and to the processes of scientific inquiry. The students were exposed to a range of teacher-directed activities, guest speakers and workshop sessions in three areas: *Environmental Science*, *Electronics/ Robotics and Health Science*.

### Part 2 Expert projects

In the second part of the program 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. Groups of three were arranged as 'Expert Inquiry Groups' which required students to develop more complex understanding of the project areas. Groups were involved in data gathering to answer an inquiry question.

### Part 3 Final presentation

The final presentations of the groups brought together all aspects of the program. The Expert Inquiry Groups presented the findings from their investigations to their peers and ASSETS staff.

#### Residential Component: Wiltja

The residential component complemented the intense academic activities of the day with a rich offering of social activities 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 copious amounts of good food. Females and males had separate accommodation and staff members were present at all times. Of critical importance was the fact that Wiltja staff were trained in youth work and had considerable experience with Indigenous teenagers. A feature of the evening program was the presence of Aboriginal role models and discussions about identity, leadership and positive attitudes.

### Stakeholders

The major stakeholder in ASSETS2008 was the National Centre of Science, Information and Communication Technology and Mathematics Education for Rural and Regional Australia (SiMERR, 2008) which provided the bulk of the funding. The South Australia hub of SiMERR developed the program. Its members were the ASMS, Flinders University and the University of South Australia (which ran the original ASSETS programs). An important feature of ASSETS2008 was the development of relationships with appropriate institutions

and possible stakeholders who could provide long-term sustainability and credibility in an era lacking Indigenous educational infrastructure, including members of a variety of higher education Indigenous centres. One stakeholder of note was the *Dare to Lead* program:

... an initiative of the Principals Associations in Australia, focusing on accelerating the improvement of educational outcomes for Aboriginal & Torres Strait Islander students, & supporting the goals of reconciliation for all Australian students (*Dare to Lead 2008*)

## Results

### Ideas and actors

#### Program materials

All the program materials engaged students in authentic scientific enquiry with content similar to that experienced by students of science across the world. The Kidnapped Forensic investigation, for example, introduced students to numerous analysis techniques including DNA testing. In this session, students were confronted with a fictitious scenario that included a crime scene, suspects and evidence. The students were required to collect and analyse DNA samples, hair, fibre and soil. The scientific content and analysis techniques required a high level of engagement and precision from the students. In addition, the students learned to work and contribute to projects as reliable team members. This activity set a high standard of ongoing scientific enquiry for the remainder of the program. Indigenous educators provided parallel support to assist students' engagement with the science of the academic program.

One particular project, the Warriparinga Wetland Project promoted clear connections between science and the Kurna (traditional landowners of the country) culture. This environmental investigation was run by the Indigenous educators. Students selecting this investigation assessed the water quality at various sites using indicators such as turbidity, temperature, dissolved oxygen, pH, salinity, nitrate level and phosphate level. Following the analysis of the initial data, specific research questions were developed by the students for the main project investigation. The project was supported by the Living Kurna Centre. The popularity of this investigation supports the view that a border crossing involving the environment and indigeneity can be rewarding and profound.

Support for student engagement in science also came through the residential component of the program. The academic program director made the following comment at the

conclusion of the project:

*The pure science learning was surrounded by an affirming process of what it means to be Indigenous. The most important learning was the sense of culture and self and this was very visible in the students' presentation!*

#### Academic staff perceptions

The staff of the academic program indicated a high degree of satisfaction with the pedagogies implemented and their outcomes. Enquiry pedagogies are a feature of the ASMS academic environments and seemed to work well with these Indigenous students. Although staff members were acutely aware of various deficits in the educational background of some students they were impressed by their general positive approach. A feature of ASSETS2008 academic program was the involvement of two Indigenous staff who were able to engage students in the environmental science area. The staff helped in the border crossing by showing students that they did not need to leave their heritage, identity and their personality behind when they adopted more of the language and practices of science. Indeed the science could help enhance that heritage by bringing traditional knowledges to the wider community.

The academic program director observed that students 'grew strength and courage and inquisitiveness out of all the support programs'.

#### Residential staff perceptions

Residential staff provided support to students at Wiltja. They developed quite strong relationships with some of the students and generally held them in high regard. Their experience of Indigenous youth allowed them to see situations arising early and to respond in the best way. This was especially true of events occurring 'at home' and their impact on particular students' mood and attitude. Moreover the staff commented on the need to meet the challenge of students of very considerable academic potential.

#### Practices and outcomes

Students at ASSETS 2008 were exposed to Indigenous cultural experiences and opportunities throughout the whole of the program. In accordance with Aikenhead's (1996) 'border crossing' concept, the students' background culture and the culture of science were specifically addressed by all program leaders. Numerous opportunities were provided for students to reflect on their cultural roots and understandings alongside the culture and exploration of science.

While it is too early to comment on

the long-term impacts on students, post summer school interviews with them indicated a very high level of appreciation and personal satisfaction with the program. Many commented that this was the best thing to have happened to them, that the science was actually interesting and that they had discovered something about themselves and their capacity for learning during the summer school. There was particular satisfaction in the enquiry approach to science used at ASMS and in working on problems as a group. Many students envisaged new career possibilities in the sciences. The final closing ceremony evidenced high levels of emotional engagement with Indigenous role models and staff at Wiltja. In final presentations, students depicted themselves as future Indigenous leaders, many in the fields of science and medicine.

#### Sustainability and transferability

There is no doubt the summer school was a success from the perspective of all its participants and the various stakeholders. However the study had a goal to develop a summer school model that could be sustained through the 21st century. One key to this model was to identify pedagogies for teaching science, and environments for learning science, that made for easier border crossing for Indigenous students. This was substantially achieved by the adoption of enquiry pedagogies used in science by the ASMS and embedding Aboriginal academics in the program. The latter is now more feasible across Australia than in the 1990s. Another key was to address issues of student support, security and duty of care. This was achieved by participants being accepted as students in a South Australian SACE course (constituting the summer school), hence addressing duty of care while on the premises of ASMS and being in a residential program that had direct responsibility for Aboriginal students and the experience and legal frameworks for dealing with them. Another key to this model was alignment with structures that seemed to have a medium-term future in the current political context. The *Dare to Lead* program was not only useful in the recruitment process but could provide a longer-term home to the program. A key stakeholder for sustainability would be universities. Indeed the Vice Chancellor Academic for Flinders University commented that the program was "... an outstanding opportunity for our best and brightest Aboriginal students to be challenged and engaged in the sciences".

## Discussion and conclusion

### Factors enabling successful student engagement in science

ASSETS is a holistic program which engages students at every level, incorporating academic work, well-being, culture, sport and recreation, and identity. To be a success such a program had first to engage with existing institutions and structures and ensure high standards of security and safety for students and staff. It also had to engage with existing Indigenous structures to ensure credibility and involvement. Critical to such a program was the identification of talented students and the use of a standard test familiar to teachers and educators.

Notwithstanding the identification of talented Indigenous students, a number of factors can be identified as assisting student engagement in science. These were:-

- The constant presence of Indigenous mentors throughout the academic component of the program
- The delivery by an Indigenous academic, of a science unit
- Program sessions related to Indigenous culture and anthropology
- The use of culturally-appropriate accommodation at Wiltja
- Running in parallel, a leadership program involving Indigenous role-models during evening activities at Wiltja and
- Relating a science unit to an environmental project at the Living Kaurna Centre.

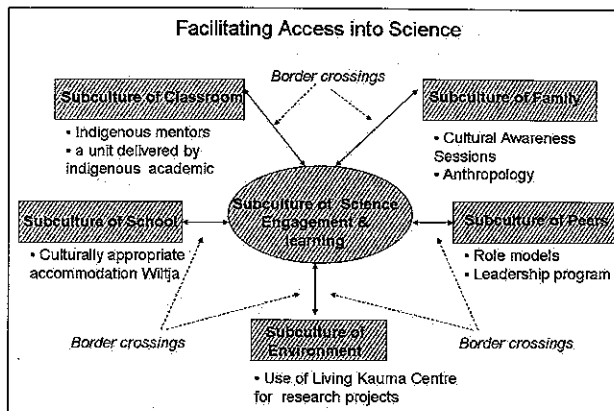
### Innovation in the ASSETS program

In a report prepared for the research and evaluation division of DEST Schwab (2001) asserted:

*'The engagement of Aboriginal students at the late secondary level is clearly related to their sense of self-esteem, and the most successful programs seem to be ones that validate and celebrate Aboriginal culture' (Schwab, 2001, p. x).*

Thus in addressing the issue of why the factors described above facilitated student engagement in science consideration needs to be given to notions of student identity and self esteem. As displayed in Figure 1 each factor identified above can be found to facilitate 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.

The use of Indigenous mentors and teachers, for example, facilitated entry into the subculture of science from the subculture of the classroom.



**Figure 1. Model of innovation facilitating border crossings in ASSETS 2008**

The inclusion of sessions in cultural awareness and anthropology enabled access into science from the subculture of the family. 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.

There is no doubt that a number of such border crossings can be used to dramatically expand the career horizons of Indigenous students. One particular student, who liked the sciences and was a keen sportsman, stated that through ASSETS he could now see how science knowledge could be used to solve real-life problems. For the first time in his life he had seen examples of people with an Aboriginal background succeeding in the field of science and technology. Other border crossings seem worthy of research and investigation, such as those of direct mentoring of Indigenous students in schools and the mentoring of Indigenous students in transition to tertiary study.

Thus it will be those Indigenous students who become confident in their capacity to appreciate and learn science without compromising their cultural heritage and identity, who ASSETS will see as having had a profound impact on their lives.

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