

Principles of an Indigenous Community-Based Science Program

Hiria McRae^a

Corresponding author: Hiria McRae (hiria.mcrae@vuw.ac.nz)

^aSenior Lecturer, Te Kura Māori, Faculty of Education, Victoria University of Wellington, New Zealand.

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Abstract

This paper describes a set of principles found within existing indigenous community-based science programs, identified as possible contributors to the success of indigenous students in science education. The examination of what makes these types of programs successful is an area of research that is yet to be thoroughly explored. These principles could support indigenous communities to develop, examine and enhance community-based science programs that could benefit all involved.

Introduction

Aims of science education

One view of the purpose of science education is to prepare students for a science-related career, such as medicine, engineering or research (Boon, 2012), as well as becoming contributors to community, national and global economic development (Ramirez, Luo, Schofer, & Meyer, 2006). In recent years, science education commentators described another main aim of the current science curricula: for students to engage confidently with any socio-scientific issues they may become involved with in their lives (Boon, 2012; Cowie, Jones, & Otrell-Cass, 2011). Positive student engagement with science education, specifically their attitudes, interests and self-belief, is also viewed as an important aim that contributes to student involvement in science-related careers and projects (Woods-McConney, Oliver, McConney, Maor, & Schibeci, 2011).

These aims focus on science education as being important in equipping students with skills and knowledge to interact with science in society for themselves and their communities. Therefore, as reciprocal members of society, every student should have the opportunity for a science education that supports them to engage confidently with current science-related issues (Cowie et al., 2011). In his summary of historical definitions of the purposes of science education and meanings of scientific literacy, DeBoer (2000) states that:

Ultimately what we want is a public that finds science interesting and important, who can apply science to their own lives, and who can take part in conversations regarding science that take place in society... Some will find the study of science compelling enough to pursue scientific careers; others will provide leadership regarding science-based social issues. The important thing is that everyone should have an opportunity to learn enough so they will not be left out of this dimension of our modern experience (p. 598).

These aims are admirable due to their potential benefits and opportunities for students and their communities; however, it is how these aims are achieved that creates concerns about indigenous students (Eisenhart, Finkel, & Marion, 1996).

Indigenous students and science education

Sutherland and Dennick (2002) identified that a key concern for indigenous students and science education is how the science curriculum is developed with limited consideration or total disregard for indigenous knowledge:

Science curriculum is assimilative in its own right because it gives the impression the Western view of nature is the only legitimate way of learning about the natural world, thereby reducing indigenous knowledge to inferior and non-scientific (p. 2).

Aikenhead and Elliot (2010) agree that most school science programs in industrial countries are focused on acquiring Western or Eurocentric knowledge and skills. They further assert that school science teaches what it is to be a scientist or possess a science identity based on Western beliefs and values with minimal recognition of indigenous perspectives of our world. Sutherland and Dennick (2002) add that it is the difference in how and why Western and indigenous knowledge is acquired that may hinder indigenous student engagement with school science. They argue that Western attainment of knowledge is about gaining commodity-earning access to power, where indigenous knowledge is learnt to be a contribution to the collective. Therefore, it has been difficult for many indigenous students to engage with science education as their worldview, values and identity have differed from the curriculum content and delivery of school science (Costa, 1995). For many indigenous students around the world the experience of science education is difficult, as their cultural worldviews and identities are scarcely visible in their programs (Aikenhead & Elliott, 2010).

Some science education commentators argue that science has its own culture, and a socio-cultural approach to science teaching and learning is beneficial for indigenous students (Aikenhead, 1997, 2001; Bang & Medin, 2010; Cowie et al., 2011). Moreover, there is the potential to engage and sustain student participation in science education if a student's indigenous culture is acknowledged in the science classroom (Aikenhead, 1997; Barnhardt & Kawagley, 2004, 2005; McKinley, 2007; McKinley & Stewart, 2009; Woods-McConney et al., 2011).

Indigenous community involvement in school science, assumes the inclusion of indigenous culture, as part of what is being delivered (curriculum content) and how it's being delivered (pedagogy). The insertion of indigenous perspectives and understandings into science education is an example of culturally responsive schooling (Castagno & Brayboy, 2008) that has the potential to improve educational outcomes for indigenous students (Hindle, Hynds, Meyer, Penetito, Savage, & Sleeter, 2011).

Indigenous community-based science programs

Formal education systems have historically not met the needs of indigenous students in science education, so solutions have been sought from schools, universities and educators working with indigenous communities (Aikenhead, 2001; Barnhardt & Kawagley, 2005; Datta, 2018; Johnson et al., 2014). Indigenous community-based science education programs have shown improved academic results for indigenous students where schools have worked alongside members of local indigenous communities and other supporting agencies (Aikenhead, 2001; Barnhardt & Kawagley, 2005; Johnson et al., 2014). Other achievements for indigenous students and their communities have also included improved student attendance, increased

student interest in science and mathematics careers, and increased indigenous community involvement in science and mathematics education (Barnhardt, 2005; Dublin, Sigman, Anderson, Barnhardt, & Topkok, 2014).

Research already exists about how examples of indigenous community-based science education programs operate and the resulting benefits, opportunities and challenges for indigenous students and their communities (Aikenhead, 2001; Barnhardt, 2005; Barnhardt & Kawagley, 2005; Johnson et al., 2014). There is also research about the factors that support the successful facilitation of indigenous community-based education (Bishop 1996; May, 1999; Nee-Benham & Cooper, 2000) that may be applicable to the science education setting. The aim of this paper was to identify common principles of existing indigenous community-based science programs and examine why they are possible contributors to the success of indigenous students in science education.

Methodology

A seminal long-term operating indigenous community-based science program was used as the exemplar to begin identifying possible key factors that contributed to the successful positive engagement of indigenous students with science education. This example was the Alaska Rural Systemic Initiative (AKRSI), a collaborative project aimed at improving educational outcomes of Alaska Native students, involving the University of Alaska Fairbanks, the Alaska Federation of natives and the National Science Foundation and almost 200 rural schools (Barnhardt & Kawagley, 2005). This project has operated since 1995 and has served a minimum of 20,000 Alaska Native students since its inception. AKRSI advocates continue to examine opportunities to build on the positive outcomes for all stakeholders involved (Barnhardt, 2012). The rationale for choosing this initiative as an exemplar was because it is a current national project that continues to successfully support indigenous students, teachers, schools and their communities.

Literature describing the AKRSI project was sourced (Alaska Native Knowledge Network, 1998; Barnhardt, 2005; 2012; Barnhardt & Kawagley, 2005) and first examined by identifying broad themes (Mutch, 2005) contributing to successful outcomes for indigenous students. Next, these initial themes were refined (Mutch, 2005) by examining if and how they considered indigenous culture, including identity, knowledge and language to reveal possible aspects of cultural responsiveness. A draft set of principles were collated from the analysis of this one initiative, ready to examine other possible examples of indigenous community-based community science programs. The main criterion for finding further literature, about possible examples of similar programs, was research involving indigenous peoples, including students and their communities, working in collaboration with school science programs. Other examples sourced, included empirical studies and literature reviews from North America, Australia and New Zealand that examined aspects of indigenous student engagement with science learning and indigenous community involvement with science learning in schools.

Findings

Principles of Indigenous community-based science education

Analysis of the AKRSI project and other related projects revealed a common set of principles. The principles identified are: partnerships and power-sharing strategies; shared values and aspirations; culturally responsive pedagogy; resourcing; collaboration; and local context. These principles are first defined in the following sections and then aligned with examples of research in the area of indigenous science education programs.

Partnerships and power-sharing

The partnerships and power-sharing principle is defined as, students, teachers, schools and indigenous communities are all part of the decision-making processes of **what** is included in science education programs, and answers the question – **how content is chosen**.

A relationship has been identified between indigenous student positive engagement with school science and the autonomy to direct their own learning in partnership with their teachers (Woods-McConney et al., 2011). In their retrospective analysis of PISA data for Aotearoa New Zealand and Australian indigenous and non-indigenous students, Woods-McConney et al. (2011) found that students saw self-directed, practical activities as beneficial for their science learning. However, students identified that these types of activities were those they least frequently experienced showing a lack of student autonomy.

Research in the area of indigenous science learning has identified that indigenous students engage with school science when their cultural perceptions of science concepts are acknowledged by teachers (Snively & Corsiglia, 2001). In his work with teachers and indigenous communities in Canada, Aikenhead (2001) observed positive results for students when teachers involved local indigenous elders and their knowledge about the immediate environment as a fundamental part of the science teaching unit. Students and teachers were learners together, which modelled power-sharing and life-long learning. Local elders and other members of the local community with specialised knowledge were seen as teachers also.

In their review of literature about North American indigenous communities' perceptions of science learning, Brayboy and Castagno (2008) identified a common partnership and power-sharing teaching strategy. This strategy suggests that to engage indigenous students in science, teachers need to act as 'cultural brokers' (Aikenhead, 2001). Teachers would need to view science knowledge as a cultural body of knowledge. This strategy would also involve teachers first identifying, then learning about their students' culture. Science learning experiences would acknowledge teacher and student cultural backgrounds and prior knowledge. Students would also have an opportunity to debate and explore the power relationships between indigenous knowledge and science (Brayboy & Castagno, 2008).

In their observations of indigenous Alaskan communities, Kawagley, Norris-Tull and Norris-Tull (2010) reported that local indigenous elders wanted their children to be provided with science programs that included a wide range of learning experiences delivered in partnership with schools and indigenous communities. Teachers also promoted a common indigenous view about the interrelatedness of people with their immediate physical environment, which is another example of partnership and power-sharing as humans are caretakers rather than directors of the environment. Brayboy and Castagno (2008) surmise that it is not the role of the school to teach the indigenous culture or language of the local community; however, it is the role of teachers, curricula and schools to develop and maintain an intimate relationship with the local indigenous community. The shared benefit is the production of indigenous students who are "academically prepared, connected to and active members of their tribal communities, and knowledgeable about both the dominant [culture of their school] and their home cultures" (Brayboy & Castagno, 2008, p. 734).

In Glynn, Cowie, Cass and Macfarlane's (2010) New Zealand-based project examining teachers' use of Māori concepts in their science classrooms, one teacher described how they asked students to assist with the preparation of a class trip for themselves and a junior class. The students gave suggestions of what content they were to learn in relation to the culture of local Māori who were situated in the class trip location. This showed the teacher sharing

management and teaching decisions with their students, and positioned other community members as teachers. Students were also encouraged to ask their own learning questions and the teacher's role was to provide the resources. McKinley, Richards and Stewart (2004) agree schools and Māori communities working together to teach science also models to students that Māori knowledge is an integral part of their science learning and not an addition.

Wood and Lewthwaite's (2008) study about Māori science education aspirations and realities in Māori medium classrooms showed how one Māori medium school decided to separate their Māori medium science learning environment from their English medium science classroom, and provided different teachers and a different subject name. Parents and wider family members were all included in the planning and content of their children's science learning. One teacher commented that the focus was on providing a balanced view of science and Māori knowledge in the science classroom and to not privilege one body of knowledge over another. The teacher also stated that the Māori worldview was the foundation and that the science perspective supported student understanding.

Shared values and aspirations

The shared values and aspirations principle is defined as the inclusion of an indigenous worldview in science education programs, including cultural perspectives about identity, knowledge and language and addresses the question – **what content is to be included.**

School organisational change, especially when schools come to acknowledge both Western science knowledge and indigenous knowledge in their science programs, has also supported positive engagement from indigenous students in science education (Cobern & Loving, 2001). In his project, Aikenhead (2001) asked the local community what they wanted in their science program, which resulted in the inclusion of local knowledge from indigenous elders and Western science content. This approach recognised indigenous knowledge as a valid and fundamental component for each science teaching unit, alongside Western science concepts (Aikenhead, 2001). Barnhardt (2005) reported that, in his experiences with Alaskan communities, the inclusion of cultural core values was an important component of education initiatives. Having an understanding of the values of their own culture and other cultures' allows all students the opportunity to engage, interact, and critique a wide range of knowledge systems (Barnhardt, 2005).

Brayboy and Castagno (2008) agree that the epistemological and socio-cultural views of an indigenous community need to be acknowledged and included in a successful indigenous science program. In Aikenhead's (2001) project about collaborative units, the objective nature of Western science was made explicit and the physical environment was explored separately to gain new knowledge. In their discussion piece about differences between Western and indigenous science, Metallic and Seiler (2009) identified how indigenous cultures viewed physical and spiritual dimensions of the environment as being interconnected. Aikenhead (2001) stated that indigenous practices in regards to the sustainability of physical resources involved spiritual and cultural values unique to a particular indigenous community and their environment. Brayboy and Castagno (2008) assert that when indigenous knowledge is included in a science program, "the role of culture, subjectivity, and perspective in making sense of the world" is recognised (p. 736). In her study about teacher attitudes to the inclusion of indigenous knowledge in the Australian science curriculum, Baynes (2015) found that teachers appreciated the time and opportunity to examine and define their values and aspirations in relation to indigenous science.

Students involved in science programs that worked collaboratively with local Alaskan indigenous elders learnt about correct processes to engage with local indigenous elders to see value in local indigenous knowledge and heritage (Barnhardt, 2005). Students collated interviews with elders about local indigenous knowledge systems and practices, and shared and extended what they learnt at regional and national science camps and fairs (Barnhardt & Kawagley, 2005). In Aikenhead's (2001) work with indigenous students in Canada, students reported that the opportunity to have their local knowledge included in their science learning also provided an opportunity to share the indigenous knowledge they had gained at home from their extended families. This practice saw their knowledge and their communities' knowledge as being valued in the science classroom.

In the New Zealand setting, McKinley et al. (2004) reported how a group of students from a Māori medium science classroom setting believed that the inclusion of Māori contexts in their science learning was only in the form of narratives and that valid content was from Western science bodies of knowledge. This is a difficult observation if an aim of Māori science education is for students to acknowledge both Māori and science knowledge as equitable (Stewart, 2011). Both the New Zealand national curriculum documents acknowledge the inclusion of Māori knowledge in the science curriculum to differing degrees (Ministry of Education, 2007; 2008). The Māori medium curriculum, 'Te Marautanga of Aotearoa' (Ministry of Education, 2008) explicitly aims to include Māori and iwi (tribal) worldviews in science learning. In contrast, the English medium 'New Zealand Curriculum' implicitly acknowledges the inclusion of exploration of culture and science, but not Māori culture specifically. Many teachers in Wood and Lewthwaite's (2008) study in Māori medium science classrooms were proactive about ensuring science knowledge was not privileged over Māori knowledge.

Furthermore, the study by Glynn et al. (2010) described how a teacher who aimed to enhance their students' understanding of Māori and science worldviews about environmental ecology and sustainability became more aware of the privileged position of science knowledge compared to Māori knowledge. The teacher organised their students to research information from a range of sources to ensure they were provided with a balance of Māori and science perspectives of sustainable practices. It was also reported that all teachers in this study worked toward ensuring that local Māori knowledge was respected at all learning sites, in and out of the classroom (Glynn et al., 2010).

Culturally responsive pedagogy

The culturally responsive pedagogy principle is defined as practices that recognise the interchange of teacher student roles in science education programs as a means to understand each other's' cultural backgrounds and associated bodies of knowledge. It considers the question – **how will content be delivered?**

Culturally responsive pedagogy is part of the delivery of culturally responsive schooling and requires teachers to acknowledge and respect the cultures of all of their students in their classroom practice (Gay, 2010; Ladson-Billings, 2001; Savage, 2010). Culturally responsive pedagogy, practice and schooling have been promoted as key teaching approaches to improve the academic achievement and school engagement of indigenous students (Brayboy & Castagno, 2008). Research identifies that one of the main reasons why indigenous students disengage with science education is the lack of content or pedagogy that reflects their culture (Abrams, Taylor, & Guo, 2013). The dominant culture of many science classrooms is viewed as Eurocentric (Aikenhead, 2011; Cowie et al, 2011), based on Western science principles that are sometimes in opposition to indigenous scientific views (Abrams et al., 2013). Curriculum

content and pedagogy that make connections with the learner's culture (Bishop & Glynn, 1999) have been promoted as a way to engage indigenous students with science education (McKinley, 2005). Science classrooms where teachers and students are able to equally share their stories and experiences in relation to a science concept or topic support students to connect easily with the learning (Metallic & Seiler, 2009).

A successful strategy in Aikenhead's (2001) work was to begin a cross-cultural science unit with a clear indigenous knowledge framework outlining key concepts, ideas and values first, after consultation with local indigenous elders, as well as specifying the Western science foci. Similarly, a set of cultural standards was created to support the Alaska Rural Systemic Initiative (AKRI), which provided clear guidelines on how resources could support the inclusion of local culture, knowledge and the environment into formal education programs (Barnhardt & Kawagley, 2005). These clear guidelines and frameworks supported teachers with identifying the prior or lived knowledge that their students brought to the science classroom, including a broad range of ideas, beliefs, values and experiences (Snively & Corsiglia, 2001). A further output from the AKRI was the ocean science fair model which allowed students to integrate Western science and indigenous knowledge to examine ocean, aquatic environment and climate change issues within their communities (Dublin et al., 2014).

Understanding the indigenous language of students also supports understanding local cultural practices and knowledge (Aikenhead, 1997, 2001; Bishop & Glynn, 1999; McKinley, 2001; Waiti & Hipkins, 2002). Some translations of an indigenous term into another language may obscure or misinterpret the actual meaning and understanding for students and teachers (Aikenhead, 2001). The use of indigenous languages in the science classroom encourages students and teachers to explore different perspectives due to the varied structures of languages representing different worldviews (Metallic & Seiler, 2009).

Glynn et al. (2010) provided narratives from Māori and non-Māori teachers who participated in a project where they were encouraged to include Māori pedagogical strategies in their science teaching. The teachers shared their teaching role with local Māori elders and members of the wider community to support their teaching of Māori worldviews in science, and also learnt from their Māori students who brought their prior knowledge to the classroom (Glynn et al., 2010; Wood & Lewthwaite, 2008).

Wood and Lewthwaite (2008) reported in their research about Māori medium science classrooms that it was common for teachers to seek or be given support from other teachers with more science or Māori knowledge. This models to students that teachers are learners too, and that other people in the wider school community can also have the role of a teacher, including themselves and their wider family community.

Resourcing

The resourcing principle is defined in this paper as the accessing of appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programs. It considers the question - **what support is needed?**

Funding from a range of sources was very important for the successful progress of indigenous community-based initiatives (Aikenhead, 2001; Barnhardt & Kawagley, 2005). Substantial funding allowed the production of teaching units to be shared with other schools and teachers within the community and provided capacity, capability, implementation and monitoring support. In his work developing cross-cultural science teaching units, Aikenhead (2001) saw

the importance of having sufficient funding that provided time for teachers to be released to research, write and create resources. In his review of examples of indigenous community-based education, Corson (1999) also endorsed funding as key to administering professional development for teachers and community members as a means of strengthening community involvement and partnership.

Other important resource examples from the Alaska Rural Systemic Initiative included a website that collated examples of existing items to support the developing curriculum framework (Barnhardt & Kawagley, 2005). A national coalition was also established of science-focused providers' collated professional development and curriculum resources to support the implementation of the initiative aims. Development of new resources by participating teachers included community-based science curriculum resources and quality-assured units in partnership with local elders, as well as workshops focused on mathematics and science unit-building and performance standards (Barnhardt, 2005). Management of these activities included regional associations set up to manage each area's implementation and on-going development of the initiative and pedagogical practices (Barnhardt & Kawagley, 2005). More recently, Johnson et al. (2014) developed a range of educational resources in collaboration with schools, local indigenous elders and cultural experts to improve the quality of earth science education in a specific indigenous community. The implementation of these resources in schools in this community has resulted in improved indigenous student achievement in science education (Johnson et al., 2014).

People resources were clearly important as previously mentioned, including local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community (Aikenhead, 2001; Barnhardt, 2005). Communication tools between people were therefore essential for a successful program, such as newsletters, websites and regular regional meetings, which were used to disseminate the latest information, developments and materials (Barnhardt, 2005).

In Glynn et al.'s (2010) New Zealand-based research, accessing a range of resources, such as local conservation workers and specialised science laboratories, was an important aspect for one teacher in their science learning. Local Māori elders and members of the wider Māori community were also seen as valuable resources to offer knowledge about local stories and flora and fauna, and were accessed by all teachers involved in this research (Glynn et al., 2010).

In many Māori medium science classrooms, teaching science through the medium of Māori language and including Māori content and context are priorities; however, it is very difficult for teachers to manage. There are limited Māori medium science resources available to teachers and so extra research, planning and preparation, including translating, are common and onerous tasks (McKinley et al., 2004). Limited access to resources is of particular concern at the senior science level in Māori medium science classrooms, with limited teacher capability in specialised science and Māori knowledge, as well as lack of fluency in the Māori language (Stewart, 2011). Parents have moved their children from Māori medium to English medium as a result of this issue to allow their students access to wider science content knowledge and learning experiences (McKinley et al., 2004).

Wood and Lewthwaite (2008) reported in their research in Māori medium science classrooms that one Māori medium school used a teacher rotation system. Fluent Māori language-speaking teachers with both Māori and science knowledge were rotated around the school to support less knowledgeable teachers and their students. This is an innovative strategy to address one of the many diverse issues facing Māori science education.

Collaboration

The collaboration principle is defined as collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programs. It considers the question - **who delivers content?**

A key component common in successful indigenous community-based science education programs is having students, teachers and schools working alongside indigenous communities (Aikenhead, 2001; Barnhardt, 2005; Barnhardt & Kawagley, 2005; Datta, 2018; Kawagley et al., 2011). One example of an indigenous community working collaboratively with a formal education system is described by the Alaska Rural Systemic Initiative (Barnhardt & Kawagley, 2005). The motivation for this initiative was for the Native Alaskan community to address past failures of outside endeavours to achieve the educational wellbeing of the Native Alaskan people in partnership with government education systems. The key outcome of this initiative was to promote both indigenous and Western knowledge as complementary elements of school curriculum and pedagogy. The application of this project reflected this outcome with key topics including ‘Native Ways of Knowing and Teaching’, ‘Culturally Aligned Curriculum’, ‘Indigenous Science Knowledge Base’, ‘Elders and Cultural Camps’ and ‘Village Science Applications’ (Barnhardt & Kawagley, 2005). Key facilitators of the initiative included education providers, indigenous community members, a university, and substantial funding from science- and community-focused organisations, which were co-ordinated by a national team.

Barnhardt and Kawagley (2004) stated that the inclusive national and regional management framework of their initiative allowed for clear and comprehensive systems, which contributed to affirmative reciprocal partnerships for all involved. A summary report evaluating the success of this initiative identified case studies that highlighted improved student achievement (Kushman & Barnhardt, 1999). The report also stated that these case studies provided positive examples of indigenous bicultural and bilingual education aimed at meeting indigenous community needs and aspirations (Kushman & Barnhardt, 1999).

In his work in cross-cultural science teaching for indigenous students in Canada, Aikenhead (2001) was supported by science teachers, technical support people, local indigenous elders and other local community members to develop cross-cultural science teaching units. The aim of the project was to allow all students, including indigenous and non-indigenous students, to see relevance and meaning for them in science learning and to have a voice in what and how they learnt. The project progressed well when members met face to face and worked together in the community setting. More recently, in his work with an indigenous North American community, Datta (2018) also endorses collaboration with indigenous communities and their multiple forms knowledge as well as ‘honouring and creating space for indigenous knowledge systems to flourish’ (p.62).

There are increasing examples of Māori tribal groups working with science organisations (Cram, 2002; Ramstad et al., 2009) and Māori teachers participating in science professional development (Royal Society of New Zealand, 2013). However, there are limited documented examples of iwi, schools and science institutions working on projects collaboratively (McKinley et al., 2004), even though some may have done or may currently be doing so. The research explored in this section provides examples of schools working with their Māori communities on science projects.

Glynn et al. (2010) described how the process of constructing relationships with teachers, students, parents and Māori communities was the focus for a group of teachers aiming to

include a Māori worldview in their science teaching. Teachers reported that a key result of this approach was the building of trusting and respectful relationships with their students. The collaborative assessment approaches described in their research included teachers and students modelling new learning to each other, having collective ownership of new knowledge gained and working together towards meeting the needs of their community. Wood and Lewthwaite (2008) also reported in their research with Māori medium science classrooms that input from parents and the wider Māori community was very important and was actively sought by some schools.

Local context

Finally, the local context principle is defined as, the inclusion of local phenomena, including local indigenous communities and associated local issues in science education programs. It considers the question - **where is the program delivered?**

Globally, the indigenous communities' intimate knowledge of particular locations, because of their long-term inhabitation of these environments, is beginning to be valued by others who care for the sustainability of our natural resources (Barnhardt & Kawagley, 2005). Indigenous knowledge of the local natural world has recently been included in scientific studies based in Alaskan communities and explored as fundamental for school science programs (Kawagley et al., 2010). Commentators on culturally responsive schooling have also advocated the importance of students having a good understanding of the indigenous language, culture and history associated with their immediate location to ensure the sustainability of the culture of the community (Alaska Native Knowledge Network, 1998). For indigenous students, culturally responsive schooling or pedagogy supports their learning by providing a connection between their cultural home environments that might not be the culture of their school (Brayboy & Castagno, 2008). It is therefore fundamental to identify appropriate knowledge that is associated with the culture of indigenous communities to ensure students have the opportunity to contribute to the maintenance of their particular community.

Science education scholars also agree that the most effective science curriculum needs to be connected to the local community (Aikenhead, 2001) and they need to work with indigenous elders and local community members, using local resources and participating in their activities (Brayboy & Castagno, 2008). In his description of a range of indigenous education initiatives, Barnhardt (2005) identified that pedagogy associated with place allows indigenous students to be taught through their culture and immediate location as a means of connecting with broader environments. Local indigenous elders and advisors have been identified as important contributors to the development and delivery of cross-cultural science units, providing support for teachers and students with their knowledge of local culture relevant to the context of the unit topic (Barnhardt, 2005). The most successful units, programs and resources were those that considered the unique culture of a specific community, including language, culture, history and protocol. In some cases, this was also an opportunity for indigenous students to share their knowledge of the local cultural history and environment (Aikenhead, 2001; Dublin et al., 2014).

Glynn et al. (2010) reported that students saw the importance of researching the stories and history of the local Māori people before visiting a new area. Their field trip focused on learning about landforms and a range of Māori tribal perspectives about the same landmarks. The students were reported as showing an interest in local Māori stories and science explanations about particular areas (Glynn et al., 2010).

An interesting argument about the value of including local Māori knowledge in the science classroom was given by a parent in McKinley et al.'s (2004) Māori-medium based project. The parent disagreed with local Māori knowledge being taught alongside science knowledge, as their child was not from the school area and it was the role of their own Māori tribal community to teach their children their affiliated Māori knowledge. This is an important issue for schools to acknowledge and recognises the diversity of Māori students that exists in diverse settings in New Zealand. Wood and Lewthwaite (2008), in their research in Māori medium science classrooms, reported that some teachers saw it as vital to include local Māori knowledge and learning experiences, as well as outside Māori community experiences, to promote the existence of varied Māori perspectives.

Conclusion

This paper has examined some examples of indigenous community-based science programs that have supported positive engagement of indigenous students in science education. A common set of principles has been identified which includes: partnerships and power-sharing strategies; shared values and aspirations; culturally responsive pedagogy; resourcing; collaboration; and local context. The purpose of identifying these principles was to establish the factors that contributed to the successful implementation and positive results of indigenous community-based science programs. More specifically, the purpose was to explore approaches that indigenous communities and schools could use to develop, examine, and enhance community-based science programs to benefit all involved, including students, teachers, parents and the wider community. There is minimal evidence of Māori community-based science programs where schools, iwi (tribes) and science organisations work together for shared outcomes. However, examples of school science programs that make connections with Māori students' culture, knowledge and lived experiences are beginning to emerge (Glynn et al., 2010; McKinley et al., 2004; Wood & Lewthwaite, 2008). One emerging multi-partnership Māori science program in Aotearoa New Zealand, is Massey University's (www.massey.ac.nz) Pūhoro STEM Academy for Year 11 to 13 Māori students, aimed at advancing Māori leadership and capability to deliver a world class science community, funded by local and national government organisations. An emerging iwi-based program is Rotorua tribe Ngāti Whakaue's Matakōkiri project (www.taumata.org.nz), aimed at supporting Ngāti Whakaue students to engage with science by linking science learning to local Māori knowledge, language, culture and identity.

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