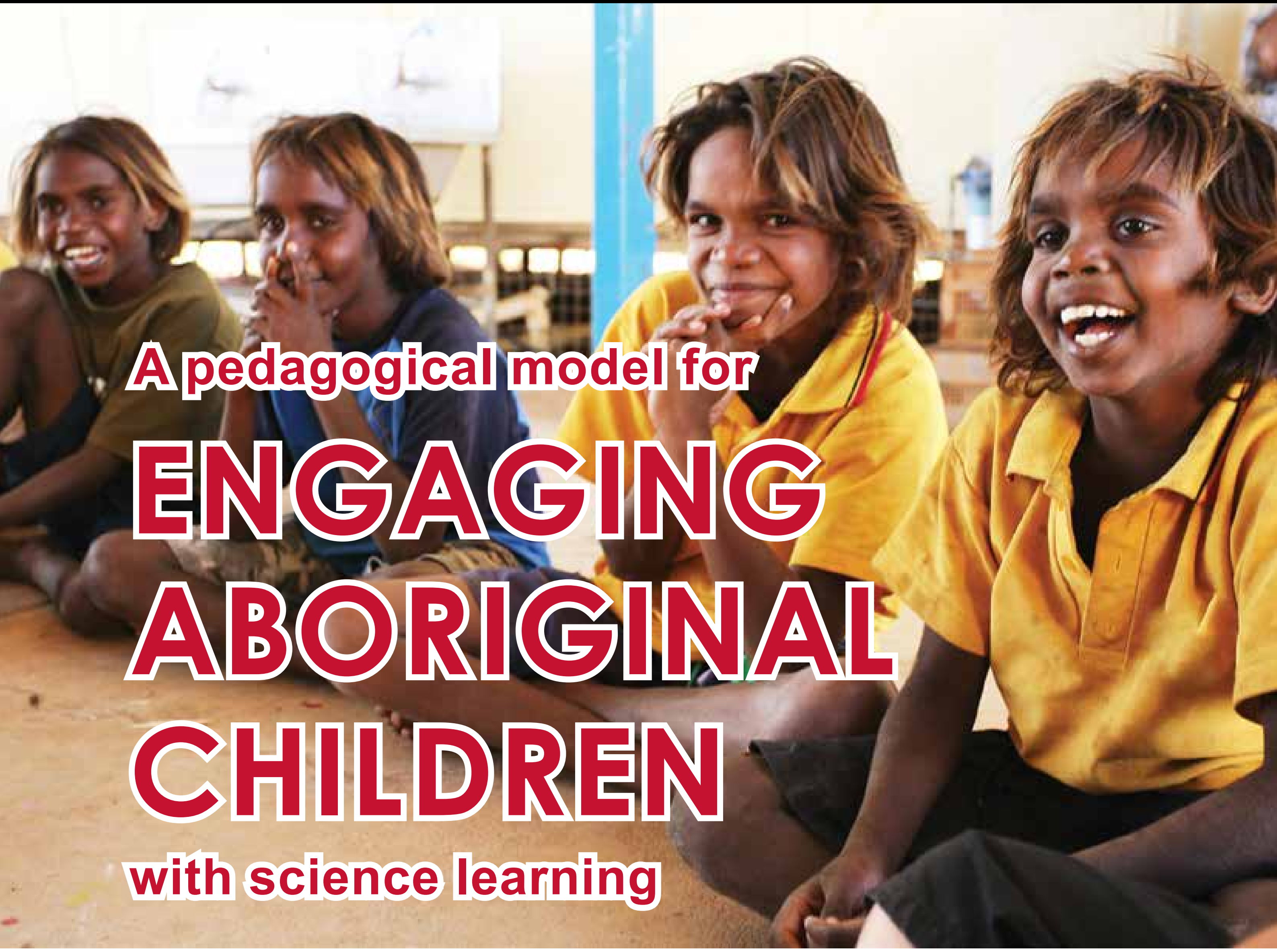


A pedagogical model for ENGAGING ABORIGINAL CHILDREN with science learning

Mark Hackling, Matt Byrne, Graeme Gower and Karen Anderson

Aboriginal children experience social and educational disadvantage and many are not engaged with schooling or learning, which results in significantly lower levels of educational attainment. The Aboriginal Education Program delivered by Scitech to remote Western Australian schools has been shown to significantly increase student ratings of their enjoyment of science, curiosity about science phenomena and their rating of science as a favourite subject. Teachers reported that student focus and engagement was very high during the Scitech activities and that student attendance and behaviour was better than usual (Hackling, Byrne, Gower, & Anderson, 2012). This study investigated the practices used by the Scitech presenters that generated high levels of student engagement. Analysis of classroom observations and transcripts of classroom dialogue from lessons that generated high levels of engagement showed that a set of 11 pedagogies underpinned this engaging practice. The pedagogical practices addressed: relationship-building, facilitation of effective hands-on activity work, participation in classroom discourse and connecting the science activities to the student's experiences and local context. The findings of this study elaborate the Primary Connections Indigenous perspectives framework (Australian Academy of Science, 2008), and provide a model to underpin approaches to teaching Aboriginal children, and possibly other children, who are not engaged with learning science.

INTRODUCTION

Many rural and remote primary schools in Australia have higher Aboriginal student enrolments and lower school attendance rates compared with metropolitan schools. Low attendance rates reduce student educational opportunities. Generally, rural and remote schools have relatively poor performances on national literacy and numeracy tests compared with larger schools in regional and metropolitan areas. The NAPLAN (literacy and numeracy) and NAPSL (scientific literacy) tests reveal that the achievement of Indigenous students is significantly lower than that of non-Indigenous students and achievement levels decline with increased remoteness (ACARA, 2013a; ACARA, 2013b). Poor educational outcomes are a cause of decreased employment opportunities and are correlated with poor health, increased engagement in risky behaviours, lower life expectancy and increased likelihood of negative encounters with the justice system (Beresford, Partington, & Gower, 2012; Steering Committee for the Review of Commonwealth Service Provision, 2009).

Science provides opportunities for students to be physically engaged through hands-on activities and intellectual engagement leading to learning. Primary students enjoy science and have positive attitudes towards science. However, in many Australian primary schools students get little opportunity to do science because of the crowded curriculum (Angus, Olney, & Ainley, 2007) and teachers' low confidence for teaching science (Hackling, Peers, & Prain, 2007).

Parsons and Carlone (2013) explain that patterns of behaviour, language use, and use of space and time that characterise the culture of schooling reflect the values and beliefs of the dominant culture. This means that students from non-dominant groups must take up the behaviours and language of a second culture to be successful in school. An additional cultural border crossing involves accommodating the culture of school science, with its own language and ways of generating, testing and representing ideas. Negotiating the meaning of science concepts where there are no equivalent concepts in the students' first languages and cultures provides an additional barrier to learning science (Chigeza, 2008). Instruction that supports students from non-dominant cultural groups to be successful in school science needs to value the students' languages and cultural backgrounds, take account of the nature of science and connect science to the experiences of students (Lee, 2004). Without this cultural connection to school science, student engagement will be limited. Gower and Byrne (2012) consider teacher's cultural competence as the capacity to support Aboriginal students in navigating the cultural border crossings between Indigenous and non-Indigenous cultures and knowledge systems.

Ladson-Billings (1995) identified differences in language interaction patterns between North American cultural groups and noted that teachers needed to take a culturally responsive approach that combined aspects of interaction from the different cultures. In Australia, Partington and McCudden (1990) observed that some students possess significant advantages over others in that they are able to participate in classroom discourse more fully than other students. Some students "seemed more skilfully attuned to the teacher's movements, gaze and demeanour, and were able to gain the teacher's interactional attention more frequently" and Aboriginal students in the class appeared "unable to judge the most propitious occasion for raising hands or initiating discussion with the teacher, they remained relatively passive throughout the lessons" (p. 47). Teachers must therefore develop the cultural competencies to connect with Aboriginal children and to engage them in classroom discourse and science learning.

Engagement is a multidimensional concept comprising behavioural, emotional and cognitive components (Fredricks, Blumenfeld, & Paris, 2004). From this perspective, students are engaged when they are behaviourally involved in learning tasks, experience enjoyment in science learning and are actively processing science ideas that motivate them to learn more. Student engagement in learning science predisposes students to continue their studies of science, which is a goal of science, technology, engineering and mathematics (STEM) education initiatives in Australia and most Western developed countries.

SCITECH'S ABORIGINAL EDUCATION PROGRAM

Scitech is a not-for-profit organisation based in Perth whose mission is to increase interest and participation in STEM education. Scitech's Aboriginal Education Program (AEP) was developed to increase interest and participation by Aboriginal Western Australians in science and technology. The AEP provides accessible and culturally relevant science programs for Aboriginal students, their teachers and Aboriginal and Islander Education Officers (AIEOs) who work with schools and Indigenous communities (Scitech, 2009). The AEP is an outreach program for rural and remote schools with high Indigenous enrolments and provides activities for students and professional learning workshops and resources for teachers and AIEOs.

The AEP is the most significant initiative addressing the science education needs of Indigenous students in Western Australian remote schools and has the potential to offer a model that can be implemented throughout Australia and beyond. An evaluation of the AEP (Hackling, Byrne, Gower, & Anderson, 2012) revealed that the Scitech visit had a statistically significant impact on student's rating of their enjoyment of science, curiosity about science phenomena and their rating of science as a favourite subject. These findings were corroborated by teacher interview data, which also reported that: "student focus and engagement was very high during the activities, student attendance and behaviour was better than normal, and that the visit by the Scitech presenters had been beneficial for all students" (p. iii).

Very little research has been conducted on the opportunities for learning created by outreach programs for Indigenous students in remote schools. Given the large gap between the science achievement of Aboriginal and non-Aboriginal students and the importance of scientific literacy for future health and employment outcomes, research is needed to better understand how these programs increase opportunities for science learning and to maximise their effectiveness. This research contributes to the current body of knowledge about effective teaching of science to Aboriginal students.

PURPOSE

The purpose of this study was to identify pedagogical practices that are particularly effective in engaging Aboriginal students in learning science.

"Instruction that supports students from non-dominant cultural groups to be successful in school science needs to value the students' languages and cultural backgrounds, take account of the nature of science and connect science to the experiences of students."

Fig 1: The Scitech team on the road.

RESEARCH CONTEXT

The Scitech AEP visited 13 primary and district high schools in the Mid-West Education District of Western Australia in June–July 2011. Of those 13 schools, five with Indigenous enrolments of greater than 70% were selected as case study schools. A team of three Scitech presenters with science communication backgrounds travelled with two researchers to the schools. The Scitech presenters conducted sessions for students during the school day and professional learning workshops for the teachers after school. The presenters completed cultural competency training in preparation for the tour to help them develop relationships with Aboriginal children. Prior to departing on the tour, the Scitech team developed a set of lessons for children of different age groups based on the theme of natural and processed materials, which were trialled in a Perth metropolitan primary school. These sessions were observed by the researchers who provided feedback to the presenters on how their pedagogy could be enhanced. During the tour, the researchers facilitated end-of-day reflection sessions in which the presenters reviewed their practices and identified enhancements that could be made. The ongoing feedback and reflections on practice throughout the tour assisted the presenters, who were not teacher-trained, to develop their pedagogical repertoire and effectiveness.

RESEARCH METHODS

Access to the schools was negotiated and informed consent obtained for the collection of research data. Two researchers travelled with the Scitech team; one Aboriginal and one not. The non-Indigenous researcher who was involved in data collection completed cultural competency training prior to his involvement in the research.

Each of the sessions presented to the students was audio recorded. Each presenter carried an audio recorder with an external microphone so that when talking to the whole class or to individual students, the discourse could be recorded. The two researchers made field notes on a template record sheet to document their observations of the activities, transitions within the sessions, the presenters' behaviour and the ways in which students were engaged with learning. A sample of the sessions that generated the highest levels of engagement were transcribed verbatim and analysed to identify the practices that generated high student engagement.

The approach to analysis involved a form of collaborative ethnographic microanalysis (Erickson, 2006) in which the two researchers who observed the sessions, a senior science education researcher and a research assistant, worked together to analyse the transcripts and field notes. The analysis involved reading the transcripts, identifying significant events, discussing contextual factors by drawing on field notes, identifying significant teaching practices, and comparing sections of the transcripts to identify repeated use of a teaching practice to establish which practices consistently gave rise to high levels of student engagement. Each of these analysis sessions was audio recorded. The recordings and notes taken during the discussions were used to describe the pedagogical practices used by the presenters within the context of the teaching–learning episodes and the documentary evidence of student engagement. Active and sustained participation in activities and classroom discourse and positive behavioural and emotional responses were used as indicators of high-level engagement. A combination of 11 pedagogical practices was identified in four different lessons that generated the highest levels of engagement in science learning.

PEDAGOGICAL PRACTICES

The analysis revealed a set of 11 practices that enabled the presenters to establish productive relationships with the students and engage them in science learning.

Relationship-building through cultural competency

Through their earlier cultural competency training, the presenters were aware that relationship building is a key means of promoting Aboriginal student engagement in learning (Gower & Byrne, 2012). The presenters therefore sent a short video clip about themselves to the schools that could be shown to the students so that they would get to know the presenters prior to their arrival. On arrival at the schools, the presenters made a concerted effort to learn the names of all students, which facilitated their capacity to engage students in classroom discourse and the science activities. This served to ensure that students felt recognised and acknowledged. Some examples that arose included:

> *Karlee, what's your prediction?*
>
> *Oh, we need that spoon, Rodney. Mix it around with your hands.*

At the end of one activity, an opportunity arose for a presenter to show interest in the students and their siblings:

> *Student: I can really trick my brother with this.*
>
> *Presenter: Yeah. Where's your brother today?*
>
> *Student: Right there!*
>
> *Presenter: I forgot whose brother's who. Do you want me to put some air in it?*
>
> *Student: Karlee's my sister. Jacinta is my sister. My brother, Kyle is my brother.*
>
> *Student: I've got seven brothers and sisters.*
>
> *Presenter: You've got seven brothers and sisters. That's very lucky.*

Relationship-building is particularly important when working with Aboriginal students. Aboriginal students learn in and through relationships and thus getting to know them is the starting point for anyone hoping to work effectively with Aboriginal children (Gower & Byrne, 2012).

A collaborative, active and inclusive approach

Throughout the activities, the presenter conveyed a message of inclusivity to the students. From the outset when students were offering their predictions about what they thought would occur, the presenter ensured that every student contributed. She checked by asking:

> *Presenter: Has everyone had their prediction? Karlee, what do you think?*
>
> *Student: I think it will go soft.*
>
> *Student: I've got one more, one more.*
>
> *Presenter: Do you think it will go soft? Right, shall we do our experiment?*

In addition, the presenter conveyed a message of collaboration indicating that she and the students would be working together. She constantly used the word 'we' throughout the activity. The following examples demonstrate her approach.

> *What are we up to now?*
>
> *If you think we need more water we can put more water in.*
>
> *Maybe we need to redesign the experiment if it's not enough water.*
>
> *Shall we put in a little bit more?*

Ensuring that all students offered a prediction and the frequent use of the personal pronoun 'we' helped ensure that students felt included. The collaborative approach to practical investigations supported the student's sense of being engaged and supported by others in their learning.

Student ownership and agency in learning

At the beginning of one activity the presenter posed a number of short questions to the students as motivation. The questions were as follows:

> *Presenter: Well, now that we're all warmed up, are we ready to be scientists?*
>
> *Are we ready to ask questions?*
>
> *Are we ready to make predictions?*
>
> *Are you ready to do tests?*

The responses from the students were an enthusiastic: "Yes". By posing these questions, the presenter was giving a clear message to the students from the outset that they were going to be taking on the role of 'scientist' and that a scientist engages in a scientific process that involves thinking and action.

Throughout the activity, the presenter used a non-directive rather than an authoritative approach and took opportunities to give students ownership and agency in the activity. At various times during the activity she used the following strategies: sought input from students; provided opportunities for students to be responsible for the direction of the experiment; and, redirected questions back to students. To exemplify the way that the presenter used the strategy of seeking input from students, she initially asked all of the students to offer predictions about what they thought would occur during the experiment. She used questions such as:

> *Alright, what is your prediction?*
>
> *Karlee, what do you think it will do?*

During the activity, the presenter continued to seek input from students with questions such as:

> *Do you think that's enough* [water]?
>
> *How many more* [spoonfuls of water] *do you want me to add?*

In her introduction to the experiment that illustrated the absorption of water by a white powder, the presenter had indicated to students that they were to add six spoonfuls of water to the powder. During the experiment, the presenter encouraged the students to make judgements about adding more water to the powder and asked them to continue to observe what happened. In doing so, the presenter gave the students ownership for directing the experiment by allowing them to decide how much additional water they should add rather than directing them how to conduct the experiment.

The third strategy that the presenter used to give students agency with the activity was to refrain from giving answers to the students' questions and to redirect their questions to other students, giving them opportunity for input. The following interaction exemplifies this strategy:

> *Student: What happens if it had a little air inside of it?*
>
> *Presenter: I don't know. What do you think? Do you think we could put air inside it?*

This strategy encouraged students to make more predictions and explore ideas on how to test these predictions through further experimentation. As Tytler (2007) has argued, teachers need to use more inquiry-based approaches in science to give students agency in their learning that will enhance their engagement in science education.

Direct access to materials for hands-on activities

In the activities, all students had immediate access to the materials required for experiments and worked collaboratively together in groups of three. The design of three-to-a-group reflected the small group sizes which allowed all students to play an active role. For example: one student to tip the bucket of water; another student to hold open the bag containing the powder; and, a third student to place spoonfuls of water from the bucket into the bag.

In using a hands-on approach, the presenter encouraged the students to use their senses of sight, smell and touch to make their observations. Each of the senses was used throughout the activity. Students made comments such as "It's growing" and "Mine does look like porridge" as their initial observations. They also commented: "Oh, it really smells" and "Oh it smells like sultanas". The presenter encouraged the students to feel the product of the experiment.

> *Presenter: I'm going to pull it up. I don't mind getting my hands dirty because we've got to use our hands to feel it, don't we?*
>
> *Student: It's got a little air inside of it.*
>
> *Presenter: Alright, do you want to roll that up into a ball?*
>
> *Student: It's like play dough.*

The high ratio of materials to students and the small group sizes (2–3 students) ensured all students could have direct access to the materials and could play an active role in experimenting, which enhanced their engagement with learning.

Few and simple instructions communicated multimodally

The presenters aimed to get students on-task as quickly as possible. The instructions were therefore kept simple and included a maximum of three steps. To exemplify this, one presenter said,

> *Now it is time to test to see what will happen. So I'm going to bring you a cup with the white powder and a bucket of water. And what you need to do is take one teaspoon at a time of the water and put it into the cup, and you have to use something in your body to make observations.*

The use of only a few steps meant that the students could remember what to do, the presenter did not need to repeat the instructions and students could quickly move into the activity. On other occasions, the instructions were illustrated through demonstrating the procedure with the materials the students would use; the explanations and instructions were multimodal, reducing reliance on the spoken word and enhancing the quality of communication (Kress, 2009).

Low key responses for behaviour management

The presenters used a number of widely recognised behaviour management techniques during their presentations to promote student engagement in the sessions. These 'low key techniques' (Bennett & Smilanich, 1994) were used and refined during the tour through the schools to promote student time on task and to refocus attention when students became inattentive or their behaviour became unproductive during the sessions. The presenters were very enthusiastic and warm and used student names wherever possible to 'win the students over' early on in the sessions. A 'signal to begin', for example, "Is everyone listening", and/or the use of a shaker was employed at the commencement of instruction to focus the students' attention on the presenter.

The presenters recognised the importance to 'be on the alert' and to know what was happening at all times during the presentation by scanning the class, which often helped minimise unproductive behaviour before it escalated. During sessions where individual students or groups of students were becoming off-task, the presenters would use 'proximity' which involved moving towards the off-task student in an effort to re-engage them in the activity. The use of 'minimal non-verbal signals' such as pausing to wait for student attention and looking at students who were misbehaving without interrupting the flow of instruction helped to maintain the smooth flow of the sessions and minimise disruptions.

An interactive–dialogic communicative approach within a supportive classroom climate

The presenters encouraged student contributions and participation. They employed words of praise as well as restating student's responses to signify acknowledgement and acceptance. The words of praise included 'Well done', 'Fantastic', 'Awesome' and 'Excellent'. These words encouraged ongoing contributions by the students.

An example of the presenters' use of restating a student response and then following up with the addition of another word of acknowledgement is as follows.

> *Presenter: And what happened when you tipped all of it in?*
>
> *Student: It went all soggy.*
>
> *Presenter: It went all soggy. Interesting.*

At all times, the presenters adopted a non-judgemental and encouraging approach and the students' continuing responses to questions was an indication of their confidence to contribute to discussions. The following interaction demonstrates how a presenter encouraged all students to participate in the discussions.

> *Presenter: If there anything else that's a solid? Brandon?*
>
> *Student: The table.*
>
> *Presenter: The table. Yes.*
>
> *Student: Chair.*
>
> *Presenter: Chair, yes. Shaneece?*
>
> *Student: Table?*
>
> *Presenter: Table, yes.*
>
> *Student: Fridge.*
>
> *Presenter: Fridge. Todd?*
>
> *Student: The door.*
>
> *Presenter: Excellent. A door is a solid.*

The communicative approach was interactive with turn taking shared between presenter and students, and dialogic in that a range of student ideas was explored.

A high proportion of open questions

With a focus on student involvement in the scientific process, the presenters employed a large number of open questions to elicit student input and engagement. The type of questions progressed from open prediction questions to open description questions to open explanation questions. To exemplify this, at the beginning of the activity, the presenters used questions such as, "What do you think will happen?" and "What do you think it would do if we added water to it?" to elicit predictions from the students. This then progressed to the use of "What happened then?" and "What do you think is happening?" Towards the end of the activity, the presenters began to use questions to elicit explanations such as, "Why do you think it's growing?" and "Where do you think the water went?" In each case, the students responded and there was never a time when the students did not offer a response.

One of the key characteristics of productive classroom talk is the use of open questions that engage students in higher-order thinking (Alexander, 2006). Open questions offer students opportunities to explore their own ideas and to construct ways of explaining them. The open questions were carefully sequenced to support a discourse of inquiry scaffolding predictions, observation and description of events and then explanation of those events. The use of open questions, combined with the non-evaluative discourse moves described earlier, support the sustained engagement of students in discussion. As Mercer (2000) would argue, talking time is thinking time, so that these sustained student conversations created opportunities for engagement in learning that have been demonstrated in other research to lead to achievement gains (Siraj-Blatchford et al., 2003).

Focus on vocabulary building

Many of the words used to describe and explain science phenomena are not part of everyday discourse in the communities from which many of the Aboriginal students come. The presenters, therefore, emphasised vocabulary building as a means of providing the students with tools to engage in the activities. In one activity, the presenter included both process words, which included: 'questions', 'predictions', 'experiment', 'observations' and 'test', as well as the content word 'absorb', because the absorption of water by a powder was the focus of the activity. Where appropriate, the presenters explained the meaning of words, for example:

> *The first thing that we have to do when we do an experiment is to use our eyes to make 'observations'. And that just means to talk about what we see.*

and

> *Before we do the test we have to make a guess. And the special word that we use is we have to make a prediction.*

After these terms had been introduced, the presenter continued to use the words 'observations' and 'prediction' in her questions to students to reinforce their use in a scientific context. At one point in the activity, the presenter further clarified the meaning of the word 'prediction' in this exchange:

> *Presenter: Let's have a think about some things we put in there. Let's have a prediction. What's a prediction again?*
>
> *Student: Estimate.*
>
> *Presenter: Yep, an estimate or a guess. We're going to have a guess about what we think is going to happen next.*

The presenters used opportunities during the activities to encourage students to consider the characteristics of substances and scaffolded the brainstorming of adjectives that students could use for describing their observations. The presenters used review times at the end of sessions to reinforce the key content and process vocabulary covered in each activity using oral language. In doing so, they used a wide variety of strategies to address the acquisition and retention of scientific vocabulary.

First, they involved the students in constant repetition of key words. For example, in order to reinforce the pronunciation and retention of the word 'absorb', the following interaction occurred.

> *Presenter: Absorb. Awesome. Well done. The powder absorbed the water. It sucked in the water. Do you guys all know that word?*
>
> *Students: Yeah.*
>
> *Presenter: Yeah. So can we all say it together?*

Students: Absorb.

Presenter: One, two, three...

Students: Absorb.

Presenter: So what did the powder do?

Students: Absorb.

Presenter: It absorbed the water. Well done.

Notably, the presenter wrapped up the repetition of the word 'absorb' by using it in a sentence to describe what occurred in the experiment that the students had done. The presenters used repetition of the words in varied and interesting ways as a means of ensuring the students understood the meaning of the words, the key idea being developed and could pronounce the words so that their confidence in using the words would increase.

Another strategy employed by the presenters was to reframe student responses using more scientific language. As an example, one of the students offered a prediction about the experiment saying that: "I think it might stay at the bottom or stay at the top and still have the water". The presenter rephrased the student's comment by saying "Oh right, so you think that they won't mix". Another student predicted that, "It will go all watery and the sugar might go away", to which the presenter responded: "Oh excellent. So you think it might dissolve in the water and disappear. Excellent!"

Use of movement, gestural and sound cues

An important feature of the presenters' teaching was the incorporation of movement into the sessions. They used a role-play strategy to demonstrate the proximity and movement of molecules in each of solids, liquids and gases. This activity was revisited during the review at the end of the day. The review activity took the form of 'The Molecule Game' where the students had to act out the relationship between solids, liquids and gases. When the presenter called out the word "gas" the students had to act like gases and move around the room individually in a random manner waving their arms around. When the word "solid" was called, all the students had to move together and huddle in the middle of the room holding each other similar to a 'group hug'. Some of the activities were conducted outside of the classroom to create opportunities for movement and this enhanced student attention and engagement.

The presenters also used gestural and sound cues that they associated with key words such as prediction, observation and experiment to enhance engagement and to focus student's attention on key steps of inquiry. The use of movement, role-play and gesture provided an embodied element to the learning experience and reduced the dependence on language as a representational form by providing multimodal representations of science phenomena.

Links made between science activities and familiar contexts and experiences

The presenters made many links between the classroom science and real life situations that would have been within the students' experience. In this way, the presenters provided illustrations of the notion that 'science is everywhere'. In the activity involving the absorption of water by a white powder, connections were made to things that soak up water and student responses included: paper towels, cloths, sponges and nappies. These references to everyday objects, experiences and contexts help students to make meaning from new classroom experiences through connecting them to existing knowledge. Connecting classroom experiences to everyday contexts also helps students to transfer classroom learning about science into their lives outside of school. Connecting school science to the world they live in would help enhance student's perceptions of the relevance of science and their interest and engagement in learning.

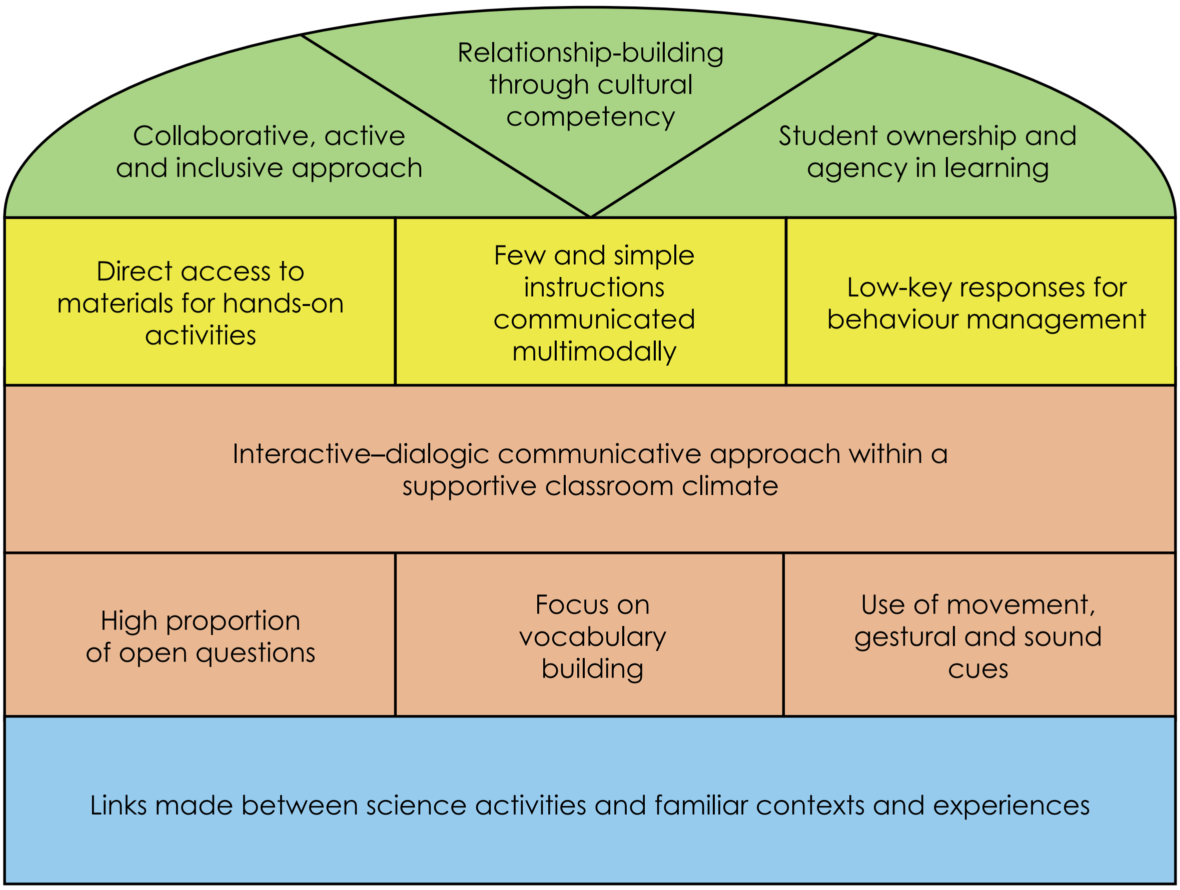
DISCUSSION

Analyses of field notes and transcripts of discourse were used to identify lessons in which the students were highly engaged in science learning. A number of themes emerged through analysis and interpretation of these lessons, which revealed a connected set of pedagogical practices for engaging Aboriginal children with science learning (see Figure 1).

The first three practices: relationship-building through cultural competency; a collaborative, active and inclusive approach; and, student ownership and agency in learning ensured that students were connected with the presenter, the other children and played a key role in directing the activities which enhanced engagement. The cultural competency training completed by the presenters gave them the interpersonal and inter-cultural skills required to build relationships with the children (Byrne & Munns, 2012; Gower & Byrne, 2012). To engage children with each other in learning a collaborative, active and inclusive approach was adopted. Children worked both in small groups and as a whole group. The presenters elicited responses from all children so that everyone was included in the discussions and there were sufficient materials for all children to physically participate in the activities. Students were asked to make their own predictions and to make decisions about the experimental procedures and therefore played a key role in deciding how the experiments would be conducted; that is, they participated in a form of open inquiry.

The next three practices: direct access to materials, few and simple instructions and low-key responses provided a pedagogical framework for engaging students through hands-on science activities. For all of the activities there was a high ratio of equipment to students so that each student had direct access to the materials and could engage physically in manipulating the materials and making observations. As Satterthwait (2010) has argued materials-centred learning supports peer interaction, object-mediated learning and creates embodied experiences. While students explore materials their conversations provide opportunities for children to explore their thinking about the natural phenomenon exemplified by the objects with which they are working. To ensure that the students could move into the activity quickly, the presenters gave essential instructions

Figure 1: Pedagogical practices for engaging Aboriginal students with science learning.



in an efficient and multimodal manner. Instructions were few and simple and were communicated through verbal explanation and illustration through manipulation of the materials that the students would use. Communicating important instructions in a multimodal form provided additional cues for ESL/ESD students. To maintain attention to instructions and engagement with activities, low-key behaviour management responses were employed. Proximity, pauses and eye contact were used so that the flow of the session was not interrupted (Bennett & Smilanich, 1994).

A set of four pedagogies, identified in the beige band of Figure 1, was employed to maximise student engagement in classroom discourse. As Lemke (1990) has argued, learning science requires students to learn to talk the language of science. Science has its own specialised social language with its technical vocabulary, representational forms and ways of making claims and arguing about truth (Mortimer & Scott, 2003). From a sociocultural perspective (Vygotsky, 1978), ideas and explanations need to be constructed through talk on the social plane of the classroom so that they become available for individual students to internalise and make their own. Social constructivists argue that students construct their own meaning for experiences by interpreting them in terms of their prior knowledge through conversation with others (Driver, Asoko, Leach, Mortimer & Scott, 1994). Talk is the central representational form through which learning is transacted and teachers need to match the communicative approach to the phase of scientific inquiry to develop a discourse of inquiry that sustains student engagement in learning (Hackling, Smith & Murcia, 2010).

The presenters used an interactive–dialogic communicative approach; interactive in that students and the presenter took turns in creating a conversation; and, dialogic in that the range of student ideas was explored rather than canonical science explanations being presented (Mortimer & Scott, 2003). The interactive–dialogic communicative approach is well suited for engage and explore phases of inquiry (Hackling et al., 2010), which was the focus of the activities; the presenters engaged the students with interesting phenomena and explored the student's explanations of the observations that they made. Focussing on the student's ideas enhanced engagement and the students' senses of agency in learning about the science phenomena. A high proportion of open questions were used to encourage students to contribute to the conversation and to elicit and explore students' ideas (Alexander, 2006). The questions were also carefully sequenced to support a discourse of inquiry. Open questions that elicited predictions were followed by questions that focussed attention on the phenomenon and elicited descriptions of observations, and finally, questions were used to elicit explanations for the observations.

Language is a tool to think about and reason with science ideas and to formulate explanations (Lemke, 1990; Vygotsky, 1978). To be able to discuss science ideas, students need to develop the technical vocabulary of science. The presenters focussed on building the vocabulary of critical science processes such as predictions, observation and experiment. Vocabulary building develops student's capacity to think about and explain phenomena (Beck, McKeown & Kucan, 2008) and is particularly important for ESL/ESD students.

Video-based classroom research reveals that teaching and learning is highly multimodal. The development of student explanations involves object manipulation, gesture and talk (Hackling, Murcia & Ibrahim-Didi, 2012) and as Flewitt (2006) has noted "children use the full range of material and bodily resources available to them to make and express meaning" (p. 1). The presenters introduced gestural and sound cues for each of the science process terms to focus attention on them and to increase the range of semiotic resources available for meaning making.

The final pedagogical principle involved making links between science activities and familiar contexts and experiences. The presenters related the student's observations of the science phenomena to everyday objects and experiences. Contextualising the science activities into the everyday experiences of the children enhances perceptions of relevance and facilitates the transfer of learning beyond the classroom. Learning is situated in the contexts of the tasks (Hennessy, 1993), and the social and cultural settings of the classroom (Aikenhead, 2001; Cobern, 1996; Costa, 1995) so that making links between classroom science and the world of the students outside of school will support the cultural border crossings described by Aikenhead. This strategy relates to the first pedagogical principle of building relationships through cultural competency, which depends on an understanding of the culture of the children, their families and community.

CONCLUSIONS

The purpose of this study was to identify pedagogical practices, which are particularly effective in engaging Aboriginal students in learning science. The research was pursued in the context of a tour through remote and rural schools by a team of Scitech presenters that provided enrichment activities for students and professional learning workshops for teachers in these primary and district high schools. The lessons taught to students in five of these schools, which had high Aboriginal student enrolments and generated particularly high levels of student engagement, were analysed to identify those pedagogical practices that consistently generated high student engagement.

Analysis of field notes from classroom observations and transcripts of classroom dialogue revealed that a set of 11 pedagogical practices underpinned the success of the presenters in achieving high levels of student engagement. The pedagogical practices addressed relationship building, facilitation of effective hands-on activity work, participation in classroom discourse and connecting the science activities to the student's experience and local context:

- Relationship building through cultural competency; a collaborative, active and inclusive approach; and, student ownership and agency in learning ensured that students were connected with the presenter, the other children and played a key role in directing the activities which enhanced engagement.
- Direct access to materials, the use of concise and multimodal instructions, and using low-key behaviour management techniques ensured a high level of engagement through hands-on science activities.
- A combination of an interactive–dialogic communicative approach, a high proportion of open questions, scientific vocabulary building and the incorporation of gestural and sound cues for science terms generated productive classroom discourse that supported learning.
- Actively seeking connections between the science activities and the contexts and experiences familiar to the children would facilitate transfer of learning beyond the classroom to the lives and culture of the children and their community.

This coherent set of pedagogical practices makes a significant contribution to the literature, further elaborating the Primary Connections Indigenous perspectives framework (Australian Academy of Science, 2008) and provides a model to underpin approaches to teaching Aboriginal children and possibly other children who are not engaged with learning science. Engagement in learning is the first and most crucial step in eliminating the impacts of social disadvantage on educational outcomes.

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