Teaching Indigenous students science
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Abstract

How teachers teach science is based upon their understanding of the nature of science and their beliefs about teaching and learning. This study investigated one science teacher’s beliefs and practices when teaching science to Indigenous students. The research was designed as a case study (Creswell, 1998) framed in a self-study research methodology (Loughran, 2004). A teacher knowledge filter (Keys, 2007) provided the framework to analyse the teacher’s beliefs and practices. The findings challenge current classroom practice, and have implications for teaching Indigenous students across other curriculum areas.

Introduction

Teaching Indigenous students science is a challenge for non-Indigenous teachers. Teachers and pre-service teachers are constantly reminded of the importance of incorporating an Indigenous perspective in their teaching (Mellow, & Corrigan, 2004) Nevertheless, many feel inadequate in their understanding of Indigenous beliefs and experience difficulty in reconciling an Indigenous perspective with science (Aikenhead, 1999). Non-Indigenous science teachers need to reconcile an Indigenous perspective of understanding the world with their western perspective to create a ‘culturally safe classroom’—a concept reframed from the nursing industry in New Zealand (Papps, 1996, 2005). This is a learning environment where Indigenous students feel emotionally safe with their beliefs, and teachers who have reconciled their western views of science with an Indigenous perspective. To create culturally safe science classrooms teachers need to carefully examine their beliefs about the nature of science (NOS) and teaching practice.

Teachers need to appreciate that science is a subculture of western society (Aikenhead, 1999, 2001). It is foundational to modern western thought, the process by which western knowledge is generated, and often viewed as the only valid way of knowing (Lee, 2000). Science deals with only the physical observable world; the metaphysical-spiritual world is not within its domain of knowledge (Lee, 2000). Unfortunately, many science teachers including primary teachers do not fully understand these characteristics of science, nor have they closely examined their own views of the NOS and often hold conflicting views within their own minds (Mc Comas, Clough & Almazroa, 2000; Irez, 2007; Lederman, Wade & Bell, 2000). Not understanding the NOS is a catalyst for potential conflict between Indigenous students who
hold a spiritual view of the world and science teachers who hold beliefs such as scientism (Cobern & Loving 2000) where science is seen as the only valid way of knowing and as a perfect discipline.

Coupled with teachers’ beliefs about the NOS is teachers’ craft knowledge—teachers’ beliefs and practices about teaching and learning science in the classroom (Feldman, 2002; Munby, Russell, & Martin, 2001; Keys, 2007, Shulman, 1987). Teachers’ craft knowledge develops over the duration of the teacher’s first learning experiences in science through to their tertiary training, and is reinforced during their professional teaching experience (Walls, Nardi, von Minden, & Hoffman, 2002; Waters-Adams, 2006). Waters-Adams (2006) found that teachers’ beliefs concerning the NOS were a determining factor in their classroom practice and that teachers’ confidence was influenced when: “there existed a resonance between their ideas about how to teach science, their understanding of the nature of science, and their general beliefs about how they should be teaching children” (p. 939). Aikenhead (1999) found teachers had difficulties reconciling their understanding of science with the incorporation of Aboriginal knowledge in the classroom. The teachers were unable to acknowledge science as a subculture of a western knowledge. Their beliefs about science and its relationship to other cultural views proved a major challenge that either precluded Indigenous students’ views of the world or unintentionally facilitated assimilation by failing to acknowledge science as an accepted component of western society.

Ultimately a change in teacher practice can only take place when teachers understand and acknowledge the relationship between their beliefs and practice, and realise the impact this has on student learning (Keys, 2005, 2007). Teachers’ beliefs about the NOS and practices of teaching science are therefore critically important in developing culturally safe classrooms. There is little evidence of research—particularly in Australia (e.g., Christie, 1991; Chigeza, 2007)—that has specifically examined teachers’ beliefs and practices when teaching science to Indigenous students.

**Purpose of the study**

This study aimed to investigate a teacher’s beliefs and practices when teaching science to Indigenous students and in particular, to understand what craft knowledge the teacher found useful in making science lessons more meaningful and how this was underpinned by her beliefs about science teaching.
Context and participants of the study

The research was funded by the Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SIMERR) program. Participants were a non-government school situated in Darwin, the science teacher and her Year 8 Indigenous science class. The school has a Year 8–12 residential house parent program that caters for more than 100 Indigenous students who represent a cross-section of multiple Indigenous language families in the Northern Territory from remote communities. For literacy and numeracy reasons Indigenous students were allocated to their own class but at the same time integrated in every aspect of the school program. The Year 8 science class was the Year 8 homeroom class with a class teacher who taught the literacy and mathematics program. Specialist teachers gave other content-specific lessons such as science. There were four 40-minute lessons of science per week. The science teacher, Anila (pseudonym), was an experienced secondary science teacher with 17 years teaching experience. Research was conducted over the full duration of the 10-week school term. The science topic was states of matter.

Research method

The research was designed as a case study (Creswell, 1998) framed in a self-study research methodology (Baird, 2004; Loughran, 2004). A teacher knowledge filter (Keys, 2005, 2007) provided the framework to analyse the teacher’s beliefs and practices. The purpose of self-study is improving the individual’s practice, and the type of evidence that is used depends on the context in which the person is working (Baird, 2004). Because self-study research is about how we understand ourselves in practice and the implications for learning and those around us, this was a suitable theoretical framework in which the teacher could examine her beliefs and practices when teaching science to Indigenous students.

The Knowledge Filter Model (KFM) was chosen as the framework for the teacher to examine and critically reflect her beliefs and practices within the classroom (Keys, 2005, 2007). The KFM assisted in data analysis by helping to determine whether certain beliefs stated by the teacher were consistent with her practice or whether she had stated ideals yet to be realised. The KFM looks at teachers’ beliefs in three domains: expressed beliefs, entrenched beliefs and manifested beliefs.

Expressed beliefs are those expressed but not necessarily followed through in the classroom or as a conscious part of the teacher’s daily routine. If they are it is for a stated purpose such as videotaping a lesson or a school executive’s visit.
Entrenched beliefs are both verbally and non-verbally expressed. These underlie teachers’ strategies, demonstrate these strategies, and explain why teachers may not implement their expressed beliefs. Teachers refer back to entrenched beliefs to justify their teaching strategies. Entrenched beliefs are formed over time, in some cases since high school. They deal with the nature of the subject matter and directly affect the way a subject is taught. Entrenched beliefs underlie manifested beliefs and are critical in reforming teacher practice.

Manifested beliefs are enacted unconsciously as the overt manifestation of teachers’ practical theories. Teachers demonstrate these beliefs repeatedly through their various strategies as part of their daily routine. Manifested beliefs reaffirm teachers’ entrenched beliefs and show these beliefs in action.

**Data Collection**

Data was collected from three sources:

1. Lesson observations: 32 lessons were videoed recorded and transcribed.
2. Students: science note books, assessment activities and transcripts of audio recording of focus group.
3. Science teacher’s reflective journal, transcribed audio recording taken from the planning and critical reflection sessions, anecdotal notes of conversations with the teacher and logging the essence of these conversations.

**Data analysis**

Confidence in the validity of findings was achieved through triangulating data and subjecting the findings to external critiquing identifying common themes and issues: There were three stages in this process:

1. The science teacher and I met each week to plan and evaluate the unit of work. This involved critically reviewing video footage of the lessons and discussing our views of the NOS and teaching. The teacher knowledge filter (Keys, 2007) was the basis of our analysis. Common issues were identified and the sessions were audio recorded and fully transcribed.

2. Research observer—The transcripts of critical reflection sessions together with video footage of the science lessons were sent to an independent research observer whose job was to conduct a comparative analysis of the data. This was done by reading and comparing transcripts from the critical reflective sessions, the teacher’s journal and viewing the video recordings of the science lessons. The outcome was to identify common themes and video incidents that illustrated the themes. The critical incidents
identified in the video footage were coded and professional edited together creating 3–5 minute video segments of the phases of teaching a science unit.

3. Outside reference group—The video clips were then presented to two groups of experienced secondary teachers who had taught Indigenous students. The teachers were asked to view video footage and comment on the teaching. These sessions were audio recorded and fully transcribed. Feedback provided at these sessions verified the issues and experiences that emerged from the data analysis.

Findings

Four themes emerged from the findings that challenge teachers’ practice, understanding of scientific concepts, engaging students, group work and the role of the teacher aide. Each theme is discussed below. The teacher’s critical reflection is followed by a video incident classroom example, annotated by a research observer’s descriptions in brackets, reference group comments, and a synthesis of the findings.

Understanding of scientific concepts

The science teacher, Anila, was found to place more emphasis on learning scientific terminology than on understanding scientific concepts. She justified her beliefs on the grounds of improving students’ literacy levels. Classroom observation and further discussions revealed a conflict between reconciling Anila’s beliefs about the NOS and how science should be taught, with understanding the role of literacy in science.

Critical reflections

Anila—They need to learn the language well, … even though they know how to think scientifically they should know how to express it…I don’t much stress on grammar or sentence. But certain words like take for example—solid. I feel that they should know the right way of spelling it and stuff like that….I need to read (the words) first…they should know how to express it.

Video Incident

Week 1 Session 3—Observations [Anila has students read aloud words on board, checks knowledge of each item. She then explains words they are unfamiliar with. Anila’s actions appear to support an entrenched belief that literacy is important in teaching science. Anila persists in trying to elicit correct scientific terminology despite the students’ reluctance to use unfamiliar words].
Week 4 Session 11 Anila—The water is disappearing because wet clothes are becoming dry. What do you think is happening to the water? It is usually converted into gas. So which word do you use for that when wet clothes become dry? Which word do you use? I gave you a clue. I said that the liquid—water in the clothes will turn into a gas. So which word do you think we'll use. Is it condensation? Yeah, that one [Students point to the board].

**Reference group**

Teacher One—The key to any sort of education with Indigenous people… is that language has to be at the forefront of the teachers’ thinking.

Teacher Two—It’s just something that I think we need to be really aware of when we’re presenting any information and that’s not just with Indigenous kids. I think it’s with everyone… particularly having trouble with the language.

**Synthesis**

The outside reference group supported the actions of Anila emphasising the importance of language in class. Yet they were unable to find how to provide an understanding of a scientific concept and at the same time meet students’ literacy needs. Anila and the other teachers were faced with a conundrum. How can a science teacher effectively provide an understanding of scientific concepts to Indigenous students with low literacy level without the lesson resorting to rote learning and copying down scientific terminology? Teachers’ practice is underpinned by their beliefs about science and how it should be taught (Keys, 2007). Science teaching which focuses first on learning specific scientific terms-content knowledge is generally a traditional approach (Bybee, 1997; Yager, 1991, 1995) The conundrum is not just concerning the type of activities but the teacher’s struggle to reconcile their beliefs about science with how it should be taught when faced with low literacy levels. Is science purely about learning specific content, or about understanding the concept and how the concept came about?

**Engaging students**

Findings revealed that students were content with copying, cutting and colouring—the 3Cs of learning. Anila was unable to explain this behaviour. While Anila believed the Indigenous students needed a more hands-on approach, the lessons oscillated between the 3Cs and a hands-on approach. Members of the reference group shared similar experiences and suggested a possible explanation.
Critical reflections

Anila—These kids love stuff like making posters. Let them get some magazines and ask them to cut out solid, liquid and gasses and ask them to put it on a poster… I think we have some magazines from the classroom. So if I postpone measurement until next week and just concentrate on this… to know exactly know what is a solid, liquid and gas. They learn it very well if it’s visual… because you have involved hands-on experience for them. They learn a lot of stuff like that. …. I could also see why teachers resort to saying okay lets do bookwork because it was basically like a disengagement we’re (the students are) not going to engage..

Video incident

Anila—We are going to sit in groups and then I’m going to give you some poster paper (and) some magazines…[Explains the group task. Students respond better to this practical task than the first task, which involved the students standing in front of their peers and answering factual science questions. Students now show enthusiasm for the poster task. [20:57 onwards]

Reference group

Teacher Four—When kids first come here (to this school) I ask, “You’ve done this, haven’t you?” And for them, Maths, is doing worksheets. If you start to talk, or if you start to do things with measurement or weight that’s not Maths.

Teacher Six—When they (students) come to our school we get them at around about 12, 13 and 14 years old. They’ve already got a pre-determined idea about what school is about. School is about “doing work” and that includes things like worksheets and … getting right answers and there’s usually only one right answer and that’s the one I’ve got to get. … I’m not sure where that comes from.

Homeroom teacher of the Year 8 science class—When the students want to complete something, they say; “Oh stop talking Ms and let’s write it down… be quiet and we’ll just copy it off the board.” I don't know what kind of training they get before they come into school here but, just even the whole concept of, they just want to write everything off the board and then they’ll do it.

Synthesis

These Indigenous students demonstrated learning through copying, cutting and colouring—the 3Cs, obviously a learned behaviour pattern acquired prior to their secondary education. There are two possible explanations: First, students are often given worksheets in community schools to keep them busy. The reference group and homeroom teacher admitted to using this as a behaviour management strategy. The second reason could be a cultural practice as alluded to by
teachers in the reference group. “I asked the students about how they were taught by their families in community to do specific things they needed to learn and I was told that they were shown and explained as they were shown. If necessary again and again until they were ready to go off and try for themselves… they learned first by observing the person who was teaching them until there was a readiness for them to go off and do it and that’s how things happen out at the community.” The scope of the research prevented further exploration of this issue. Nevertheless this finding highlights that the Indigenous students believed learning equals copying, cutting and colouring, and teachers need to find creative appropriate strategies to counteract this perception.

**Group work and independence**

When Indigenous students were asked to work as a group they relied on one person to speak on their behalf. One student spoke while the rest of members nodded in agreement. Open collaborative discourse proved to be a challenge. The students needed to be encouraged to either work independently or as a pair to ensure they were engaging in the topic. This behaviour has implications for programs that place strong emphasis on the importance of group work (e.g. Australian Academy of Sciences—Primary Connections, 2006).

**Critical reflections**

Anila—They always like to work in groups. They don’t really prefer to work by themselves. Even doing normal class work they like to have someone else beside them. I feel that they actually work better if the groups are smaller. In big groups they get sidetracked easily. Maybe, work in small groups, in pairs or in threes. I believe there are some activities, which should be done by students alone.

**Video Incident**

Anila—I want you to make three groups. In each group you should have one green, one blue, one purple and one white sheet of paper. Find a group and you need to sit in such a way that your group has one green, one blue, one purple and one white. Go find colours and go sit in your groups. Hurry up. Joel has purple, Stephen you can join Joel. Stephen—“What purple? I don’t got purple”. Anila—“No...in one group you need one single colour of each. You need to find one blue and one white. [The task is unclear. Colours were written on the board and no demonstration was provided. Students ask for clarification and the teacher directs groups. Groups become disruptive during the practical task. They appear ‘bored’ and not focused. Teacher aides and teacher direct the students through the activity and then break up into informal groups].
**Reference group**

Teacher—I found that actually the students doing it as a group usually meant that one person did it and the others sat and watched… Then I saw what was happening and said, well I want each of you to go away and find the information…

Teacher Two—We have to be careful about the relationships that exist within each group. If there is someone in that group who is the elder one or who is the more senior person, even though they might not be the same age, or in a family situation, or where they could be the mother they would just be expected to take that role. So with group work I would imagine some of those issues would need to be carefully worked through.

Teacher Three—The elder would be the one who has to speak even if this other (student) might know the answer.

**Synthesis**

Group work is a strong component in contemporary science education (Yager, 1991; 1995). Yet these means of working collaboratively may appear foreign to Indigenous students. It should not be taken for granted that such ideas will work in an Indigenous context. The findings of this study show that these students may actually learn more productively if they are taught to either work independently or in small groups, no greater than 3, while taking into consideration the cultural relationships between the students. It is important to maximise on the cultural situation rather than try to force a western approach of group learning onto Indigenous students.

**The role of the teacher aide**

The teacher aide was found to influence class participation. The Indigenous students were reliant on the teacher aide to provide answers and exhibited a lack of confidence whenever the teacher aide was present in the classroom.

**Critical Reflection**

Phil—My observation of the lesson today—I noticed that as soon as the teacher aide entered the room the students became very dependent….I suddenly felt this shift that they were hoping that the teacher aide was going to provide them the answers…I felt a sense of resignation by the students…

Anila—Yeah. I understand what you’re saying...We can prolong them form coming into the class. We can tell them (teacher aide) to stay away and come back into the science lesson only when required.
Phil—The TA has worked with you a lot in the classroom?

Anila—Yes, all the time and she knows them more than me [Teacher aide was the assigned home room teacher aide]

**Video Incident**

Anila—How would you get it? How would you get 1 kilo? [Teacher aide repeats teacher's question to one student then says the girl's answer aloud for the rest of the students to hear].

Anila—What do you use? Teacher aide—Measuring cups is what she means. [Teacher aide discusses answer with student and calls it out. Teacher aide crosses the classroom. A student asks: “What's this one?” Teacher aide replies; “That's pasta. This is the first group...chocolate and pasta go together.” Teacher aide assists students to 'group' items and to write correct spelling].

**Verifying the findings with outside reference group**

Teacher five—Was that teacher assistant (TA) in there the first day? No. [The reference group viewed the first and second lesson and immediately recognised a change in the behaviour of the students when the teacher aid entered the classroom in the second lesson]. The students started to focus on what the teacher aide was doing and not what you were doing. If you’re going to be working with a TA and you particularly want the students to have a certain experience then you need to make sure that the people that are working in there with you understand that as well.

Teacher six—Often times a lot of assistant teachers think that their job is an assistant for the kids. They think the way you help the kids is to help them to write the answer. Not everybody has got the same idea and understanding about the nature of learning and it varies.

Teacher Two —They need to know what the methods are as well. We’ve been doing accelerated literacy and we’ve been sending our teacher assistants to the workshop as well because they need to understand what the foundations for accelerated literacy are.

**Synthesis**

The role of the teacher aide is critical in the teaching of Indigenous students. Many community schools rely heavily on Aboriginal and Islander Education Workers (AIEW) assistant teachers to bridge the gap between western teachers and Indigenous students. However, the finding of this study indicate that assistant teachers need to be provided understanding of contemporary approaches to teaching science and an opportunity to examine their own practices within the classroom to avoid undermining the learning that is taking place. This raises concerns as to how
teacher aides are trained and potential influence that they can have on the science lesson because of their own understanding of the nature of science and how science should be learned.

**Concluding remarks and recommendations**

The key findings of the study reveal four concerns regarding teaching science to Indigenous students:

When secondary science teachers are faced with low literacy levels they can either provide a reading comprehension of scientific terminology or find simple activities to provide a meaningful experience of investigating a scientific concept. The teachers’ beliefs about science and how science should be taught determine the outcome of this dilemma (Keys, 2007; Waters-Adams, 2006). Science teachers need to develop a repertoire of enquiry based teaching and learning strategies that support students with low literacy levels.

The second concern is engaging students in meaningful learning experiences as opposed to the copying, colouring and cutting—the 3C’s. This learned behaviour of the students was not uncharacteristic of other teachers’ experiences. The Indigenous students seemed to equate this process with learning or used it to disengage from the lesson. There is a need to work closely with community school based teachers to find practical strategies of moving students toward a pro-active approach to learning.

Group work is strongly advocated in contemporary science teaching but the results of this study challenge this view. It was found that Indigenous students contributed more to the learning task when they were in small groups or individually. In groups greater than three one student was relied upon to provide the responses and engage in the activity while the others observed. Cultural norms and practices appeared to be the motivating factor behind this behaviour. Family hierarchy and relationships dictate students’ responses within the classroom. Teachers need to carefully consider how they organise group learning and participation in the classroom and even possibly structure learning to allow individual autonomy and maximise students’ engagement.

The fourth is the role of the teacher aide. This study has demonstrated how a teacher aide can influence classroom behaviour and impact students’ participation in class. Teacher aides, assistant teachers or the Aboriginal Islander Education workers (AIEW) are critical in bridging the gap between western teachers and Indigenous students. Teacher aides need to be provided professional development in contemporary approaches to learning science. In the same way that science teachers have acquired their beliefs and practices of science teaching so too teacher aides—from personal experience as a student in science classroom.
This case study highlights some of the challenges faced by science teachers when teaching Indigenous students. It demonstrated how a teacher’s beliefs about what is science and how it should be taught influenced the dynamics of the classroom. It illustrates how important it is for teachers to examine their beliefs and assumptions of science when teaching Indigenous students. Anila often commented on how she had found the critical reflection sessions a rewarding experience providing her an opportunity to critically reflect on her teaching practice. To create a culturally safe learning environment for Indigenous students, teachers need opportunities to critically reflect on their beliefs and practices.
References


