ACCOMMODATING INDIGENOUS STUDENTS' CULTURAL RESOURCES IN SCIENCE CLASSROOMS: AN APPROACH TO ENHANCE LEARNING AGENCY

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ABSTRACT

This paper reports on a research study conducted with 44 Torres Strait Islander Year 9 students in a wholly Indigenous school in Far North Queensland. Using a socio-cultural lens, the study investigated how students employed their vernacular and formal science language to engage with the concepts of energy and force and documented the cultural resources students drew on to learn and (re)produce knowledge. The large majority of students struggled to understand and represent concepts of force and energy as taught in Standard Australian English (SAE), but when Torres Strait Creole descriptors used for everyday ways of knowing were employed in the classroom, the students were better able to demonstrate their understanding of physical science concepts. Classroom experiences conducted only in SAE do not adequately facilitate all Indigenous students' negotiations from their everyday ways of knowing to demonstrating conceptual understanding of formal curriculum or science concepts. Teaching and learning frameworks that accommodate the multiple language and cultural dimensions of older and emerging Indigenous cultures was shown to enhance conceptual learning. However, the practice of standardised assessment conducted wholly in SAE remains a significant obstacle to measuring student achievement levels in science.

Keywords: *Indigenous students, concepts of force and energy, classroom science, socio-cultural lens, agency, cultural resources*

INTRODUCTION

A disposition towards accommodating Indigenous perspectives in the science curriculum is widely accepted in Australia. The Queensland Studies Authority launched a statement in April 2008 acknowledging the importance of understanding, maintaining and promoting the diverse Indigenous languages and assisting schools and communities to work in partnership and to recognise and value local Indigenous languages and knowledge systems. While fostering a disposition towards accommodating Indigenous perspectives in the curriculum are noble steps in the right direction, there is a need to further explore the elements of Indigenous students' cultural resources and how these elements can be employed to combat deficit models (Boykin, 1994) and address capacity building perspectives.

This study employs a socio-cultural analytic lens to explore the notion of agency, elements of cultural resources, deficit model and capacity building perspectives. The study sought to affirm the cultural resources of Indigenous students when learning school science. The study examines how a group of 44 Torres Strait Islander Year 9 students employed their vernacular and formal science language to engage with the concepts of energy and force, and how the elements of their cultural resources can be used more productively in the science classroom.

Affirming students' cultural resources

Sewell (1992) analyses relationship between resources, agency and power. Power occurs through acts of accessing and using resources learned through engagement in practices, in an attempt to further accumulate resources. Humans engage in acts of agency when they transpose resources learned in one context to another. Thus, contexts in which one's resources are valued, recognized and legitimized are empowering, and contexts in which one's resources are marginalized or forbidden are dis-empowering.

Bourdieu's (1984) cultural sociology suggests that an individual's habitus and cultural capital informs their agency. Habitus refers to a set of dispositions: patterns of thought, behaviour, and taste created and formulated as a result of internalization of culture or objective social structures through the experience of an individual or group. Cultural capital is associated with culturally authorised attributes, skills and awards an individual acquires, which include knowledge and forms of language. Jenkins (2002) observes that Bourdieu was characterising the concepts of habitus and cultural capital to communicate a theoretical stance, a certain way of looking at the world. In this study, 'cultural disposition' is used for habitus. Bourdieu's cultural sociology suggests that habitus is the site of interplay between structure and practice, and that while structure and practice can be observed directly, habitus cannot. In this sense, habitus can be understood as a person's mental and inner processes formulated as a result of cultural disposition.

Beginning with the perspective that communities of Indigenous groups are places with multiple strengths, Yosso (2005) challenges Bourdieu's interpretation of cultural capital for these groups. Yosso conceptualises the notion of the capital of Indigenous groups as forms of community cultural wealth, including aspirational, navigational, social, linguistic, familial and resistant capital nurtured within communities. Gee (2005) suggests students' lived experiences are foundations for academic learning, and they must be recognised, respected and valued. Accordingly, the community cultural wealth and experiences of Indigenous students can be acknowledged in the science classroom.

This study reconciles Bourdieu's and Yosso's notions of capital as 'cultural resources' of the students. Rogoff (2003) suggests that human development occurs on at least three levels: personal, interpersonal and cultural/institutional, and that these three levels are inherently interwoven in all human activities. This study attempts to distinguish the interwoven elements of cultural resources (cultural disposition, community cultural wealth and cultural capital), which informs the agency of the students. Chigeza (2010) finds it helpful to use the computer analogy to explain these elements of cultural resources, though it is much more complex than the analogy. Cultural disposition is like computer hardware, the framework that informs a student's patterns of behaviour created as a result of cultural experience. Community cultural wealth is like the software in the computer, the array of cultural knowledge, skills, abilities and contacts possessed by a student's community. It is important to highlight that the student is not expected to know or have acquired most of this community knowledge. Cultural capital is like a handful of computer programs that an individual has learnt to use, and refers to a student's acquired skills, awards, knowledge and forms of language.

It is important to realize that these elements of cultural resources are interwoven and expressed through language. Bourdieu's position is that language and culture are unthinkable without the other. Mirolli and Parisi (2006) assert that language is used to communicate, reflect, categorise and for other cognitive functions. According to Vygotsky (1978), the most important moment in child development is when the child begins to use language not only for social communication, but for controlling his or her own actions and cognitive processes. Thus a student's own language(s) comes to serve as their primary tool of manoeuvre when learning. It thus becomes imperative to pay particular attention to the student's language when learning school science.

Negotiating meaning is central to learning from a socio-cultural perspective. According to Nakata (2002), the negotiation of meaning by Indigenous students occurs at the cultural interface, which is the intersection of western and indigenous domains. Nakata suggests that the cultural interface is a place of tension, which requires constant negotiation: where there are so many woven, competing and conflicting discourses. Accordingly, at the cultural interface, Indigenous students learning school science use their cultural resources to engage with learning.

Capacity building perspectives

Boykin (1994) suggests that pedagogies based on the deficit model fail to acknowledge, legitimise and build upon the students' cultural resources. The deficit model blames the student, without looking at the learning environment or instructional practices (Biggs, 2003), and thus explains failure in terms of poor motivation, low interest and low ability levels of students. In this study, the deficit model is one that disregards the three elements of cultural resources: cultural disposition, community cultural wealth and cultural capital, and the token approach as valuing only one or two elements of the cultural resources. Taylor (2005) writes that Indigenous students' place is built on historically derived social constructions of deficit and disadvantage that are replicated through policy implementation processes. These traditional approaches can be replaced by those that acknowledge and value these students' cultural resources.

Acknowledging and valuing elements of the cultural resources of the students becomes important. Sutherland (2003) suggests that when the idea of capacity building was introduced as a goal in development education, a multitude of policies that acknowledge, value and reflect people-centred approaches were created. The idea of capacity building, originally argued for by Freire (1970), is closely associated with programs in developing nations; hence the goal of capacity building recognises historically oppressive policies and seeks change.

Capacity building in science education links the concepts of science with the everyday lives of the students and their community (Sutherland, 2003), and creates negotiated spaces through praxis. From a capacity building perspective, Eade (1997), emphasises that: 1) students' experiences and knowledge play a central role, 2) awareness learning, self esteem, and the capacity for political action are mutually reinforced, and 3) marginalised students have the right and the capacity to organise and challenge authority in order to create learning environments that are not oppressive. Hence, a capacity building perspective, as a goal in science education, affirms the students' cultural resources.

A capacity building perspective shifts approaches to education from a deficit model to one of building existing capacity, where arrays of cultural knowledge, skills, abilities and contacts possessed by Indigenous students are recognised and acknowledged. In this study, a capacity building perspective satisfies two conditions: 1) acknowledge and value all the three elements of cultural resources of Indigenous students, and 2) use these elements of cultural resources as springboards to build the Indigenous students' capacity. Acknowledging and valuing the elements of cultural resources implies using the Indigenous students' cultural disposition to inform pedagogy (in this case capacity building), community cultural wealth as context to situate learning experiences, and cultural capital as currency the students use to make meaning. Thus, using the students' elements of cultural resources suggests an attempt to help the Indigenous student negotiate from their: 1) cultural disposition to move towards a more scientific disposition, 2) community cultural wealth as contexts of experience to scientific contexts, and 3) acquired cultural capital to acquire scientific capital. Bourdieu's cultural sociology views agency and structure as dialectical – structure influences human action, and humans are capable of changing the social structures they inhabit.

It is important to realise that communicating and representing the knowledge of Indigenous peoples include: storytelling, ceremony, songs, ritual and sharing a diversity of languages and dialects – what Martin (2008) describes as multi-literacies. Therefore, a capacity building perspective in science education can affirm these students' lived languages, experiences and knowledge in the science curriculum. A capacity building perspective can acknowledge the multiple strengths that these students bring to science classrooms, and serve the larger purpose of greater social and racial justice (Chigeza & Whitehouse, 2010).

Indigenous students in school science

'Underachievement' on benchmarked science assessment by Australian Indigenous students has been extensively reported. The OECD Program for International Students Assessment (PISA) 2006 results showed that 40% of Australian Indigenous students performed below the OECD "baseline" and the Third International Mathematics and Science Studies (TIMSS) reported Australian Indigenous students have significantly lower average scores than non-indigenous students, and that the gap is much wider in the lower secondary school. The 2006 National Year 6 Science Assessment Report acknowledges only 49% of Queensland students were at or above proficiency standard, compared with the national average of 54%. Australian Indigenous students whose first language is not English and who live in regional, rural and remote areas of the country performed most poorly.

Following 'poor results' from the 2008 National Assessment Program – Literacy and Numeracy, Professor Geoff Masters was commissioned to review Queensland curriculum and educational standards. Masters (2009) reports Indigenous students from the Torres Strait and Cape District perform among the lowest five per cent of students nationally. The report suggests by Year 9, the 'gap' in achievement level of students in literacy, numeracy and science between non-indigenous Queensland students and Indigenous students living in very remote parts of the state is, on average, equivalent to six to seven years of school. The report emphasis there are factors beyond remoteness underlying these 'achievement gaps', which include higher proportions of students from lower socio-economic backgrounds and higher proportions of Indigenous students speaking English as a second language.

Klenowski (2008) argues that equity in relation to standards-based assessment is a socio-cultural issue. One strongest factor in generating inequity in terms of secondary school science achievement by Torres Strait Islander students is that the Queensland Studies Authority science curriculum is taught and assessed using SAE "at the expense of every other [language] variety possessed by Aboriginal and Torres Strait Islander people" (Malcolm, 1998 p. x). McTaggart and Curro (2009) suggest that Indigenous ways of knowing and language awareness needs to permeate right through the Key Learning Areas, the curriculum, in teacher education and educational research practice.

A classroom research study

A classroom research study richly informed by Kemmis and McTaggart (2000), and that employed a socio-cultural analytical lens, was conducted by Philemon in his two science classes with forty four Torres Strait Islander Year 9 students between 2007 and 2008 in a wholly Indigenous school in Far North Queensland. The 44 students (23 girls: G1, G2... and G23) and (21 boys: B1, B2... and B21) come from the Torres Strait and Cape Districts and board in the school. Kemmis and McTaggart perceive practice as reflexive and to be studied dialectically. The purpose of the study was to explore how the students employed their everyday knowledge, vernacular and formal science language to engage with the concepts of energy and force. The study also explored how the structure of the mandated Queensland Studies Authority science curriculum learning outcomes enhanced or limited the agency of the students. Qualitative instruments were employed to capture the students' socio-cultural interactions and science learning in the science classroom. Kemmis and McTaggart suggest classroom action research typically involves use of qualitative, interpretive modes of inquiry and data collection by teachers with a view to make judgements about how to improve their own practice.

The study sought to affirm the cultural disposition of the students by adopting a capacity building perspective, and attempt to facilitate the students to negotiate from their everyday ways of knowing to becoming competent on school science ways of knowing on the concepts of energy and force. Affirming the students' community cultural wealth meant situating the learning activities in the students' community everyday cultural ways, and attempting to move towards school science ways. Affirming the students' cultural capital meant using individual student's acquired skills, knowledge and forms of language in the science classroom and helping individual students to negotiate into scientific skills, knowledge and language. The study sought to facilitate the students to negotiate from their everyday cultural ways of talking, thinking, knowing and doing on the concepts of energy and force, to school science ways of talking, thinking, knowing and doing using four contexts to situate learning activities: 1) the Kup Mauri, 2) the traditional drum and didgeridoo, 3) the marbles game, and 4) the sports field. These contexts attempted to use the students' cultural resources to transform the physical science subject matter, and encourage the students to use their community knowledge and languages to explore the physical science concepts.

What was observed in the classroom

When learning, the students were observed to talk and explain science to each other using a combination of direct action (gestures) and a variety of Creole languages. Only 7 students were proficient in SAE, and the majority of students struggled to understand science concepts as taught in English. However, when Creole terminology or language was used in the classroom, the students were better able to talk about science in ways they could not do in the official language of instruction.

Science learning using the Kup Mauri

A Kup Mauri is a traditional sand oven. It is a shallow hole on the ground with a layer of smooth rocks. You set a wood fire to heat the layer of rocks to high temperatures. Heat energy transfers from the fire to the rocks. You wrap the food in coconut or banana leaves, or aluminium foil. Normally meat (e.g. pork) is put next to the hot rocks and vegetables at the top. Students used their community knowledge and languages to explore the concept of heat energy transfer using the Kup Mauri including the rationale to cover the food with an insulating material (coconut or banana leaf, or aluminium foil) to explore how heat energy transfers through conduction and convection. Students investigated physical properties of traditional materials used and modern material substitutes and compared this traditional oven with the conventional ovens in terms of energy efficiencies. Extension activities were related to the thermal flask (how we keep our coffee warm).

The following is a verbatim extract of dialogue that Philemon (P) had with four students (B1, B2, B3 & G1) learning about energy transfer with the Kup Mauri in March 2008:

P: Why do you put pork at the bottom and vegetables at the top?
B1: Its more hot so you put pork, if you put vegetables it burns.
P: So we can learn about heat distribution in the Kup Mauri oven.
B1: Mister we can learn science when cooking Kup Mauri, that's cool.
B3: No science is them big words, I hate them.
P: Yes we can learn science when cooking Kup Mauri, and today we will use two science words: conduction and convection to describe how heat follows.
G1: My aunt say if you are slake and not cover the Kup Mauri the food burns. (students laugh)
B2: I was told that, why so mister?
P: What do you think?
G1: Aunt says wind make food burn.
P: What in the wind will make food burn?
B1: Aha! Oxygen mister, *Yupla* (you me fellows) that experiment, when you cover the fire stops and when you open you have fire.
P: How can we test this?

[Conversation interrupted by Dean of Students entering room to make a sports announcement]

This conversation can imply that the students had started to realise that their traditional and everyday knowledge systems had an abundance of opportunities to explore an authentic scientific inquiry, able to generate authentic scientific knowledge. An argument emerges that science curriculum and pedagogical frameworks that embrace a community's cultural practices can enrich year 9 science learning in the same way western ways of knowing have enriched dimensions of the community's culture.

Science learning using a traditional drum and didgeridoo

When investigating vibrations (kinetic energy) using the traditional drum, students were keen to try different beats on the drum and analyse the waveforms produced on the oscilloscope. Students used their community knowledge and languages to investigate tightening the skin of the drum, loosening the skin (using the sun and hot plate as heat sources, causing expansion of the skin). Students investigated how sound is produced (vibrating skin) and air pressure at the end of drum using a barometer (compressions and rarefactions). Using a microphone (to pick the sound wave produced) and connected to an oscilloscope (to display the sound wave), students explored the loudness and pitch of the sound waves.

Students were fascinated with the relation between the amplitudes and frequencies of the waveforms to the loudness and pitch. Student B3 commented: "I always knew there was something special about the skin on the traditional drums, the way my *man popa* (grandfather) makes them, I think we should investigate that next week, should I phone him mister" (from research journal, April 2008). The investigations were repeated using the didgeridoo. Students were eager to take turns in producing these waveforms and measuring the amplitudes and frequencies. Extensions activities involved how we pick sound (vibrating ear drums, vibrating loud speakers) and sound production from string instruments.

Science learning using the marbles game

The marbles game is a very popular and enjoyable game with Indigenous students. To play the marbles game, you put the first marble on the ground and from a distance; you flick the second marble with your fore finger aiming for the first marble on the ground. If you hit the marble on the ground, you earn a point and the marble. The marbles game was used to introduce the experiment to investigate gravitational potential energy and how it is converted into kinetic energy. In this experiment, a marble is rolled down a ramp at different heights and the horizontal distance it travels is measured. Students were eager to estimate the horizontal distance the marble travelled before measuring the distance. Extension activities involved investigating projectile motion and gravitational acceleration.

The students did not want to have a science lesson on gravitational potential energy and kinetic energy. The students were asked to move the furniture next to the wall to create room, so they could play the marbles game. As students were warming to the game the Deputy Principal (DP) walked into the room and an extract of dialogue with Philemon in May 2007, as follows:

DP: You should stop playing marbles with students.

P: We will play for less than five minutes.

DP: I mean you are wasting students' time, they come here to learn.

P: I am using the game to introduce the lesson.

DP: That is not the way to manage Indigenous students. You need to have a firm grip; otherwise you will fail to manage the class.

P: Trust me, it will be all right.

DP: I need to talk to you about behaviour management skills. (And walked away looking very worried)

The students played the 'marbles' game for a few more minutes, moved the furniture back and started working on the science experiment. Thirty minutes into the lesson, the students were busy performing the experiment and measuring the variables, they did not realise the DP was back standing at the door and checking on the class. He just shook his head and walked away, and he never talked to Philemon about behaviour management skills, as the class was fully engaged in their science learning.

Science learning in the sports field
The students were more willing to actively participate to show their skills kicking balls, running and recording distances and times. Most students voluntarily demonstrated how Indigenous sports personalities like Jonathan Thurston, and Mathew Bowen of North Queensland Cowboys (National Rugby League) kick the ball. All students were familiar with the 45° long range kick, the 90° vertical kick 'the bomb' and the short near horizontal kick 'placing the ball'. Students increased the angle of kick (from the horizontal kick) to the 90° vertical kick (the bomb), and measured the range (the horizontal distance the ball travels). Students devised how to measure the angle of kick using a ramp, and levelling the kick against the ramp. Students initially argued they could put the same effort in the kicks (Impulse of force: $Ft=mv$), and kick at an accurate angle against the rump. After debates about accurate measurement of the angle of kick and controlling the impulse of force, they realised using human senses was too subjective, and agreed on the need to use a measuring scale for reliability and accuracy. Most students were able to illustrate the forces acting on an air borne football, gravitational pull and frictional drag acting on a football.

Students measured average speed in terms of time to run 100 metres and to cycle 100 metres and calculated and compared the average speeds (distance travelled divided by time taken). Extension activities investigated the need to put more effort (force) to increase speed and relating that to acceleration (rate of change of speed). Here is an extract of dialogue Philemon had with two students (B16 & B9) on the sports field exploring the concepts of speed and acceleration in May 2008:

> B16: So you mean if I run 100 metres in 15 seconds, and Bill here does 100 metres in 15 seconds on his push-bike, and you Mister drive your car 100 metres in 15 seconds, Is that the speed we were talking about in class?
> P: Yes, that is how we measure speed.
> B9: Aha will that be the same speed; no one will win that race.

Students expressed disbelief that what they were doing in the outdoor activities was the science they had found difficult to comprehend in the classroom situation. The students displayed improved level of interaction with the concepts in that they understood in order to run faster, you need to put in more effort (force) and they relate that to acceleration, as rate of change of speed, an attempt at conceptualising Newton's second law of motion ($F=ma$).

What we can learn
Employing learning strategies that recognise and celebrate Torres Strait Islander ways encouraged Torres Strait Islander students, generating enthusiasm, engagement and the all-important 'shining eyes, smiling faces' outcome (Whitehouse, 2007). These students used Torres Strait Creole to discuss physical science concepts in class. With careful and creative thought, it is quite possible to position these Indigenous students as knowledge creators capable of controlling their own learning. These Indigenous students are effectively 'denied' the opportunity to mobilise and marshal their cultural resources to enhance their learning of science in a curriculum formulated, taught and assessed using only SAE concept descriptors. These students' "cultural capital" (Bourdieu, 1986) in terms of what they can do and know, can not be captured in a situation where they are to be wholly taught and assessed in SAE. To quote Malcolm (2002, p. 131):

> The school context may confront Aboriginal and Torres Strait Islander students not only with modes of expression and interaction which are unfamiliar to them, but also, at least by implication, with messages that deny their own identity. The standard English which is used without question ... is not neutral to people to whom it has always been the language of the "outsider" ...The exclusion of Aboriginal and Torres Strait Islander languages and Aboriginal English from classroom communication is a symbolic exclusion of the identity and perspectives of those who speak them ... It forces a choice upon

Aboriginal and Torres Strait Islander students either to suspend or deny their identity, or to accept the status of "outsiders" to the education system.

What does it mean for a middle school Indigenous adolescent who may know how to identify problems, plan, research, analyse, evaluate and explain patterns but can not communicate their scientific ideas in the required language? It is conceivable and practical for school science to accommodate the multiple language dimensions of Indigenous peoples. But existing systemic constraints continue to sideline Indigenous languages, knowledge, skills and experiences in the science classroom. Indigenous students are asked to demonstrate scientific understandings in a language not their own, conveyed in a non traditional form (in writing), and they must negotiate knowledge(s) that are inimical to their well established cultural ways of being in the world.

The students' everyday languages and experiences were adopted in the science class and participation was observed to improve significantly. If school science continues to be taught and assessed using only SAE benchmarks and similar habits to mainstream Australia, it fails to recognise Indigenous students' cultural resources, especially those from remote communities. Science curricula and pedagogies that use only SAE benchmarks and similar habits to mainstream Australia are designed to facilitate the student's negotiations from SAE into science. They do not adequately facilitate the Indigenous students' negotiations from their vernacular language and cultural ways of knowing into science (Chigeza, 2008). As science educators, we need to address this deficit model by developing capacity building pedagogies that affirm these Indigenous students' lived languages, experiences and knowledge in their learning.

Currently, SAE is the language in which these students are expected to produce or reproduce scientific understanding and demonstrate their control of relevant genres, which may partially explain the standardised testing results discussed earlier. Indigenous students may develop quite good understandings of science concepts as discussed with each other and expressed in Creole language. The study has evidence of seven students with facility in English using Creole language substitute words and direct action (gestures) to 'translate' the science instruction words for the benefit of students with limited to severe difficulty communicating in English. But unless these same adolescents are highly able to translate both language and concepts accurately into Creole, they are likely to be judged as attaining only "low" levels of academic achievement. By contrast to these Indigenous adolescents, students from urban areas who speak and think in English as a first language are distinctly advantaged by current standardized science assessment practices. All students from remote areas whose first language is not English face similar challenges in terms of demonstrating what they do know about the world in the taken for granted culture of mass assessment.

CONCLUSION

The quality of science educational experience afforded these Australian Indigenous students who have English as a second or third language is not equal with their counterparts who have English as a first language, and similar habits to mainstream Australia as their cultural resources. If Indigenous students' cultural resources continue to be sidelined by educators, curriculum writers and policy makers in science learning, it can become problematic for these students to participate on an equal basis with their counterparts, whose cultural resources are part of the science curriculum. We need to rethink how we can acknowledge and accommodate culturally different styles of communicating and representing the knowledge of Indigenous students in our classrooms.

We need to rethink science literacy and classroom discourse. We can not continue to restrict science literacy, classroom discourse and assessment regimes in science to print-based forms of reading and writing in SAE, and deny Indigenous students' socio-cultural, oral, gestural and spatial language dimensions. Such assessment regimes and curricula marginalise these Indigenous students because they do not acknowledge and value their cultural resources.

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