2nd International Conference on Leadership in Pedagogies and Learning (4-5 August 2012)

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Title of presentation: Affirming learning capacity of Indigenous students in classrooms: One focus for pre-service teacher mathematics and science education research and practice.

Type of presentation: Paper

Abstract

For some Indigenous students, school mathematics and science can be a "fish out of water" experience. Our initial research asked the questions how can science and mathematics education become more meaningful for Indigenous students and how can Indigenous learners use the cognitive tools of their cultural community to engage with school mathematics and science? We then looked towards our own practice as teacher educators to investigate another question: how can pre-service teachers explore how Indigenous cultural knowledge can be used more productively in mathematics and science classrooms? In this paper we present an account of our present understanding of capacity building practises, which are those pedagogies that draw on Indigenous students' cultural resources: cultural disposition, community knowledge and cultural capital. A key purpose of the presentation is to emphasise the socially negotiated, cultural and embedded nature of meaning-making in mathematics and science education and how this can be made more apparent in pre-service teacher education.

Introduction

All students at school in Australia (and by inference their teachers) are now subject to extensive performance measures. One of the unfortunate outcomes of standardized measures is that groups of people who perform below a decided benchmark can be judged as deficit in terms of educational achievement. For Australian Aboriginal and Torres Strait Islander students their relative 'poor performance' on benchmarked mathematics and science assessment has been extensively reported. The OECD Program for International Students Assessment (PISA) 2009 data measured Australian Indigenous students' performance as below the OECD 'baseline'. Similarly, the Third International Mathematics and Science Studies (TIMSS) reported that Australian Indigenous students have significantly lower average scores than their non-Indigenous counterparts. According to the 2011 NAPLAN data, the academic performance of Indigenous students in regional and remote areas is amongst the lowest nationally. Such results are commonly explained through a deficit model of Indigenous learners. Essentially, any deficit model blames Indigenous students and their families for having poor educational motivation, low interest and low ability levels (Sara, 2007) without properly examining student experiences of formal learning environment or instructional practices. The problem is that deficit models can be persistent in all levels of

formal education. But how can this be changed? One leverage point is within pre-service teacher education.

Deficit models do not serve the social goal of improving educational attainment. Nor do they raise performance scores for historically marginalised groups of students. As teacher educators, we are highly critical of mathematics and science education practices that persistently reproduce deficit models of any student achievement (or attainment). Our research has shown that pedagogies that lead to deficit models and student 'blame' actually fail to acknowledge or legitimise or build upon the cultural resources Aboriginal and Torres Strait Island students bring to the classroom (Chigeza 2011). We have come to the conclusion that what is needed within science and mathematics education is an affirmation of Indigenous student learning capacity and a reversal of the easy dismissal of lower performing learners as deficit.

Our research first looked at Indigenous learners in school classrooms (Chigeza and Whitehouse 2010). It was from this work that we developed our understanding of Indigenous students as highly capable learners who bring a rich array of cultural resources to the classroom. It is possible to create a pedagogical approach to science and mathematics education that is strongly focussed on capacity building. In our view, a capacity building pedagogy in a science or mathematics classroom draws specifically on Indigenous students' cultural resources: their cultural dispositions, community knowledge and cultural capital. Drawing on cultural resources in classroom practice can strongly affect student agency to positively develop their mathematical and scientific learning dispositions. A capacity building pedagogy also recognises the socially negotiated and embedded nature of meaning making in mathematics and science education.

The next stage in our considerations was to examine what we do as teacher educators. How can we use our research findings within our own practice? How can we reshape pre-service teacher knowledge and understanding of culture and how it works to enable or disable learning in diverse classrooms? The question is discussed later in this paper.

Cultural resources are brought to the classroom

Bourdieu's (1986) cultural sociology was a starting point for our research into Aboriginal and Torres Strait Islander students learning in secondary mathematics and science. Bourdieu argues habitus and cultural capital inform agency, which is the idea that an individual is equipped with the ability to understand and control their own actions, regardless of the circumstances of their lives. Habitus refers to a set of dispositions, that is, patterns of thought, behaviour, and taste created and formulated as a result of internalization of culture. Culture refers to an individual's habit of mind; the development of a whole society; or the whole way of life of a group of people (Rojek, 2007). Cultural capital therefore is a set of culturally authorised attributes, skills and awards an individual acquires and includes forms of knowledge (including mathematical and scientific knowledge) and forms of language. Yosso (2005) conceptualised cultural capital for Indigenous groups of people as community cultural wealth - this includes the aspirational, navigational, social, linguistic, familial and resistant capital nurtured within communities.

In our research we reconciled Bourdieu's and Yosso's notions of capital as 'cultural resources' which, as cultural disposition, community knowledge and cultural capital, when brought to the classroom, influences the agency of a student. 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, not the least of which is classroom education. In science and mathematics classrooms, teachers work at all three levels simultaneously. Culture is recognised as an important element in developing personal and interpersonal learning proficiencies and therefore demands pedagogical attention in order for learning to be effective and meaningful. Sewell (1992), in analysing the relationship between resources, agency and power, suggested that learners are agentic when they transpose resources learned in one context to another. So, in terms of our idea of cultural resources, it is possible to conceive that the cultural resources students bring to the classroom can be highly leveraged into meaningful science and mathematic learning. Classroom contexts can be enabling when Indigenous students' cultural resources are valued, recognized and legitimized. Classroom contexts where students' cultural resources are marginalized, ignored or forbidden (as was the case in the not so distant past) are highly disabling. Therefore, to challenge the deficit model of Indigenous learners, and replace this with it an affirming capacity building understanding of Indigenous learners, we discovered that what is needed is pedagogies that explicitly acknowledge and value the cultural resources students bring with them to the classroom.

We know that whatever the classroom environment, Indigenous students bring their cultural resources to the classroom. Cultural resources are their cultural disposition, community knowledge and cultural capital in all their diverse forms. Cultural capital informs student agency when learning mathematics and science, and, also Indigenous students engage in acts of agency when they transpose their cultural resources from one context to another. Indigenous students use their cultural resources to interact with (westernized) mathematics and science organisational structures in a dialectical relationship, but this relationship doesn't have to be negative. If educators take an affirming view, then a capacity building pedagogy can recognise the varying dialectics for positive educational gain.

Why a capacity building approach can work

According to Sutherland (2003), capacity building in mathematics and science education links concepts learning with the everyday lives of the students and their community, and also cues teachers to identify the congruencies and (inevitable) incongruencies between school and home. Ideally, pedagogical practices should enable learning. Eade (1997) has argued that since students' experiences and knowledge play a central role in learning, that learning, self-esteem, and the capacity for political action are mutually reinforced. Marginalised students have the right and the capacity to challenge authority if learning environments are not enabling for them. In regional, rural and remote areas of Australia, pre-service teachers can expect to meet significant numbers of Indigenous students in their practicum classrooms, and in their professional classrooms upon graduation. It is therefore incumbent on us as pre-service educators, that we draw our pre-service teachers' attention to pedagogies that will encourage enabling classroom practice for Indigenous learners. After all, it is far more rewarding to work in classrooms where the learners are engaged and feel they are acknowledged and valued than to experience the opposite, especially in the high stakes disciplines of mathematics and science.

Any capacity building pedagogy needs to satisfy two conditions. The first is that the elements composing a student's cultural resources (their cultural disposition, their community knowledge and their cultural capital, which includes home languages and Creoles) are explicitly acknowledged and seen to be valued. The second condition is that educators use this array of cultural resources build a student's capacity to learn the formal disciplines

(Chigeza, 2011). This is important as Cobern (1996) advised that Indigenous students can close their minds to explanations that completely reject their own cultural beliefs. It is much better pedagogy to effective negotiate learning spaces between what can be quite different *categories* of knowledge for the same concepts. A student's cultural disposition informs which learning approaches are used in the classroom. Community cultural wealth is a context in which to situate learning experiences. For example, traditional cooking practices can be used to teach energy concepts. And cultural capital is used as currency to make meaning. For example, we found that drawing on a home language, such as Torres Strait Islander Creole, and drawing on non-verbal communication skills (gestures and the like) in a Year 9 school science classroom was particularly useful for negotiating and then developing conceptual meaning in the physical sciences.

A capacity building pedagogy goes further in that explicitly drawing students' cultural resources to teach mathematics and science has many benefits. Using students' cultural resources helps the student (whether working individually or in a group) to negotiate through their cultural disposition to take up themselves as better disposed towards learning mathematics and science. That is, to develop their mathematical or scientific disposition. Using community knowledge as contexts for experiencing mathematics and scientific contexts has a powerful effect of student disposition. And using acquired cultural capital to then acquire mathematical and scientific capital means that learners, rather than being disposed, become possessed of and positive about discipline knowledge. All this works because, as Jenkins (2002) points out, cultural sociology views agency and structure as dialectical – structure influences human action, and humans are capable of changing the social structures they inhabit.

Pre-service education and capacity building pedagogy

Pre-service teachers are people looking for meaningful careers as educators. The burning question is always 'how do I survive and thrive in a classroom?' In pre-serve teacher education, the value of exploring the cultural dimensions of pedagogy is in learning how culture influences how an individual or a group make sense of the World. We know that peoples of different cultures use different styles of communicating and of representing their knowledge. An individual or group culture strongly influences ways of talking, thinking and engagement with learning new experiences. The pre-service teacher facing a career in highly diverse classrooms can flourish when s/he possess a deeper knowledge about the interactions between knowing, learning and culture. To know that students' lived experiences are the foundations for their academic learning (Gee 2005) is powerful knowledge for a successful teaching career.

Pre-service teacher education can do a number of things to better prepare future teachers for successful classroom careers working with Aboriginal and Torres Strait Islander students. We can explicitly teach pre-service teachers to learn how to recognise, investigate, draw on and draw out the cultural resources in classroom contexts. And pre-service teachers can be much better prepared to develop strategies to make capacity building more apparent in their practice. Most Indigenous students from regional, rural and remote communities are multi-lingual and multi-cultural, who traverse intersecting knowledge and language systems on a daily basis (Nakata, 2002; Snively and Williams 2005). When Indigenous students' cultural resources are ignored in mathematics and science learning - as is unfortunately rather common - it becomes difficult for Indigenous students to participate in class on an equal basis with students who have English as a first language and/or are from backgrounds whose cultural resources are implicitly valued in the mathematics and science classroom. And any

disenfranchised student can quickly become a resistant learner (Snively and Williams 2008) To change this is not simply a matter of introducing Aboriginal and Torres Strait Islander knowledge into the science or mathematics class, desirable though this may be. Change is also about teachers explicitly recognising the cultural resources students bring with them to the classroom. And in pre-service teacher education, learning to have the confidence to say to Indigenous students, we will learn the powerful western knowledge expressed in science and mathematics curricula drawing on the cultural resources you already have. This includes having the confidence to engage with learning the disciplines through different languages and different modes of knowledge representation such as dance, drumming, yarning, storytelling, songs, rap; and teaching through well-liked activities such as community cooking and fishing.

According to Zevenbergen and colleagues (2008), Indigenous students engage more actively in developing conceptual understanding when they are able to 'code switch' between their home language and instructional language representations. We investigated how powerfully even a limited knowledge of Torres Strait Creole worked for enhancing learning physical science concepts in our research school. Developing strategies to encourage Year 9 students to talk about science in both Creole and English really did positively alter learning dispositions towards science. At Yarrabah State School, near Cairns, Education Queensland has documented the use of Yarrie Lingo, the Creole language spoken in the community of Yarrabah (which has its origins in up to forty original Aboriginal and Torres Strait Islander languages) to assist non-Indigenous teaching staff and visitors engage with students and their parents across the curriculum. As McTaggart and Curro (2009) suggest, such types of language and cultural interchanges can resonate right across the formal curriculum in schools and across teacher education programs.

Conclusion

We have argued that a specific and positive focus on capacity building practices within formal school education and within pre-service teacher education programs may significantly enhance the agency of the Indigenous students to learn the established disciplines of mathematics and science. A capacity building approach shifts the perspective where the cultural knowledge, skills and abilities of Indigenous students are recognised, acknowledged and drawn upon when the students engage with formal learning in mathematics or science. Teacher education is an important site for shifting old prejudices in science and mathematics education.

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Biography

Dr Philemon Chigeza lectures in mathematics education and in cultural studies in the School of Education, James Cook University in Cairns. He has long experience working in Aboriginal and Torres Strait Islander education in north Queensland.

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