STEM and Indigenous students

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Elizabeth McKinley is currently Professor Indigenous Education in the Melbourne Graduate School of Education at the University of Melbourne. Her role is to establish, build and provide leadership to the school's Indigenous Education Research Centre. Professor McKinley brings extensive experience in leading research, and research and development (R&D), projects with Indigenous students, and collaborating with – and drawing on the expertise of – other R&D teams. During her time in Auckland, she was a Professor in Māori (Indigenous) Education at the University of Auckland, and the director for The Starpath Project for Tertiary Participation and Success, which is a Partnership for Excellence between the University of Auckland and the government of New Zealand. This 10-year externally funded project has focused on students from schools that serve our low socio-economic communities, particularly Māori (indigenous) and Pacific Island students. Professor McKinley also co-led a major R&D project to increase the achievement of Māori students in English-medium schools. She brings extensive experience in research relating to school-wide change for Māori and Pacific students, and in higher education. She has also had extensive experience at research higher degree supervision and postgraduate teaching.

Abstract

Achievement disparities between Indigenous students and their non-Indigenous peers in education continue to be documented across the globe. Over the past three decades, there has been a significant amount of writing on Indigenous methodologies, epistemology and, to a lesser extent, pedagogies. All are crucial in the lifelong process of teaching and learning – the nature of knowledge, how it is gained, and the transmission of it. However, much of this work is contested or seen as inappropriate or irrelevant in STEM education. Indigenous students do not perceive STEM subjects as being welcoming. As STEM educators, we need to take a broader perspective that encompasses the complex interaction of family, social, cultural, educational, economic and political contexts, and to take into account the nature of knowledge and the importance of cultural identity to Indigenous communities. PISA data shows that Indigenous students have an interest in science that is equal to that of their non-Indigenous peers. So the questions we need to ask are: Why have STEM educators and schools not been able to capitalise on this interest? What makes for effective STEM teaching for Indigenous students? What makes for quality STEM teaching for Indigenous students? What makes for successful learning for Indigenous students in STEM subjects? This presentation will debate current approaches and ask what more needs to be done

Introduction

Recent educational policies in Australia explicitly aim to provide high-quality education and learning opportunities for *all* students, while at the same time promoting high performance outcomes and the development of specialist, knowledge-based skills (MCEECDYA, n.d.). Increasing the numbers of students pursuing science, technology, engineering and mathematics (STEM) education has been identified as the means to achieve this outcome (see Freeman et al., 2015). Australia consistently performs well on international assessments like the Programme for International Student Assessment (PISA) (Knighton, Brochu & Gluszynski, 2010), yet Indigenous peoples continue to have significant disparities in educational attainment relative to non-Indigenous peoples (Woods-McConney & McConney, 2014). Other research shows the achievement gap between Australian Indigenous and non-Indigenous students is far larger than that found in New Zealand (Song et al., 2014). These disparities are well documented. This paper will briefly review what we know about the achievement of Indigenous education in STEM, and discuss how we might move forward.

Research literature

Research in the Indigenous STEM field has examined the engagement and achievement of students in science and mathematics, and focused on issues of teaching and learning, foregrounding Indigenous languages, ontologies, and epistemologies. This work includes Indigenous knowledge in the curriculum, place-based curriculum, pedagogical theories on cultural border crossing, culturally responsive pedagogy, and language of instruction (see McKinley & Gan, 2014; McKinley & Stewart, 2009; Meaney, Trinick & Fairhall, 2011). There have been fierce debates, particularly concerning the nature of science and whether Indigenous knowledge of the landscape can be and should be considered as knowledge to be included in school science. But such debates, while important, leave the teachers and the practice of STEM education with little guidance. Such debates, in a variety of settings, provide a broader context for all teachers of Indigenous students.

Achievement

One of the latest PISA reports on Australian Indigenous students (Dreise & Thomson, 2014) states (emphasis mine):

> The latest international assessment of students' mathematical, scientific and reading literacy – the Programme for International Student Assessment (PISA) – shows that the gap between Indigenous and non-Indigenous students *has remained the same for the last decade*. In short, Indigenous 15 year olds remain approximately two-and-a-half years behind their non-Indigenous peers in schooling.

While such results are dire, it would be wrong to think that by giving Indigenous students more of the same, and by saying it with more emphasis, their STEM achievement will be raised.

A recent Australian report suggests the reason Australian Indigenous students don't participate and achieve in STEM is because of their low proficiency levels in STEM literacy; there is a suggestion that there is a need to look to other countries (for example, Canada, NZ, the US) for 'solutions' (Marginson et al., 2013). These 'solutions' include different approaches to curriculum and pedagogy to engage Indigenous students in STEM; programs and activities to facilitate Indigenous student engagement; and professional development for teachers in cultural literacy (for example, respect, recognition, culturally responsive pedagogy). Using these approaches, researchers – in conjunction with STEM teachers – have attempted to resolve the questions on Indigenous students' engagement and achievement in science and mathematics education through specific contexts, with consideration given to the local sociocultural and sociopolitical backgrounds. But while important, possibly too much emphasis has been placed on cultural difference and low literacy as explanations.

It has been suggested that more attention should be given to the potential of large international datasets, such as PISA, beyond the country reports. Work carried out by McConney et al. (2011) has demonstrated that Indigenous students' interest in science (PISA works with literacy in science and maths) is greater than that of non-Indigenous students. In a subsequent analysis, Woods-McConney et al. (2013) demonstrated that engagement in science was most strongly associated with the extent to which students participated in science-related activities outside of school. These indicators provide some thought as to how interest might be constructed with Indigenous students in science, and how science educators may be able to engage Indigenous students more.

Culturally responsive pedagogy

Recent research has been carried out in Australia on effective teaching practices for Indigenous students, as reported by Aboriginal parents, students, and teachers in a group of schools in Queensland (Lewthwaite, Lloyd & Boon, 2015). Of note in this work is the difference in views between teachers and parents in relation to knowledge of Indigenous histories, and how this manifests itself in schools, and especially teacher–parent and teacher–student interactions. Parents, teachers and students recognised the need for assistance on 'code-switching', but teachers tended to take a narrower view, in that they recognised that assistance was required linguistically, but were not necessarily able to respond to the incommensurability and discontinuity between home culture and school culture and academic success. Another factor identified by the participants was the need for positive relationships in the classroom, where individuals are respected and seen as important, and priority is placed on 'caring'. Students and parents thought there was a limited awareness shown by teachers of the linguistic, social and behavioural capital that is necessary for success in classrooms; and limited awareness of the assistance students identified as necessary for negotiating the demands of the classroom. The researchers reported that teachers also showed a limited awareness of the importance students and parents place on cultural inclusion and affirmation, especially in regards to promoting an educational experience that validates cultural identity. Rozek et al. (2015) argue that there have been very few projects looking at the influence on parents to motivate their children in STEM classes. In their study, they found that mothers have an effect on their high-achieving daughters' STEM achievement behaviours, but no further general conclusions could be drawn.

Boon and Lewthwaite (2015) have extended their work into developing measures of culturally responsive pedagogy. A tool is being tested with teachers; early piloting and analyses indicate that there is considerable variability found among the measures related to whether teachers were teaching in primary or secondary contexts. Analyses of variance showed significant difference between primary and secondary teachers in their overall scores in culturally responsive pedagogy, in their Indigenous cultural value, behaviour support, literacy teaching, and pedagogical expertise. Secondary school teachers:

- found communication with parents and community difficult
- found incorporating literacy teaching into subjects difficult
- scored lower on developing self-regulated behaviours in students for learning.

However, they reported confidence at incorporating Aboriginal and Torres Strait Islander perspectives into their subject areas.

While this work is still being developed and tested, it shows promise. At the moment, it is able to provide practicing teachers with an overall picture of their teaching against the characteristics that Indigenous parents and teachers believe are the most supportive of learning for Indigenous students. Potentially it gives the opportunity to a teacher to reflect on areas that could be moderated to accommodate the needs of Indigenous students or to focus on an area that could improve. The instrument could be modified to be used by students to appraise their teachers, and for principals to identify and arrange for professional development for staff. The behaviours measured are about quality teaching and effective teaching for Indigenous learners.

These findings are consistent with research with other Indigenous groups in Western countries (see Bishop et al., 2012; Webber et al., 2016). The Te Kotahitanga project carried out in New Zealand has shown a sustained increase in achievement scores of Māori students in the participating schools (see Bishop et al., 2012). Focusing on the nature of the interpersonal relationships between Māori students and their teachers, Bishop created an effective teaching profile and implemented a professional development program. The success of this program indicates that a pedagogy that improves Māori student experiences at school can affect achievement outcomes regardless of students' literacy levels.

Conceptions of culture in science education research

While most researchers recognise that culture plays an important role in the teaching and learning of the sciences in schools (Aikenhead, 1996; Gutierrez & Rogoff, 2003), there is less consensus on the conceptualisation of 'culture' in school sciences instruction and how it is understood and applied by educators in classroom practices. One line of research that draws on developmental psychology and anthropology conceptualises a cultural view of teaching and learning as a dichotomy of two idealised developmental pathways: *individualistic* – focusing on individual identity, independence, self-fulfilment, and standing out; and *collectivistic* or *socio-centric* – focusing on group identity, interdependence, social responsibility, and fitting in (Greenfield et al., 2003). The two cultural pathways are often viewed as in conflict when there is a mismatch between what is valued in the classroom and what is valued at home or in the community where the student comes from. Greenfield et al. (2000) argue that the two divergent cultural priorities placed upon the student mean that teachers need to understand and mediate the learning process, not only in relation to cognitive demands, but cultural demands as well. Bridging between home and school culture thus provides an underlying cultural approach for teachers to support learners who come from different cultural backgrounds.

Attempts to engage non-Western students into the subculture of STEM are challenging for STEM teachers. Students who are capable of negotiating the transitions between their everyday worlds and the subculture of STEM without having to assimilate or acculturate STEM's cultural baggage are seen as more successful learners, particularly by some Indigenous communities. Those who struggle to negotiate the cultural borders will require explicit instructional support in order to traverse from the subcultures of their peers and family into the subcultures of STEM and school STEM. This is aptly captured by the metaphor 'border-crossing' (Giroux, 1992), which suggests that there are domains of knowledge specific to various cultural contexts and that excursions from one way of knowing to another can occur in science learning. Aikenhead (2006) proposed that teachers make border crossings explicit for students; facilitate these border crossings; promote discourse so that students, not just the teacher, are talking science; substantiate and build on the legitimacy of students' personally and culturally constructed ways of knowing; and teach the knowledge, skills, and values of Western science in the context of its societal roles (for example, social, political, economic, and so on).

Some tentative concluding thoughts

This short paper has shown there has been a surge in research on culturally responsive STEM pedagogies. The increase in interest in culturally responsive pedagogy implies that there are a number of research avenues to investigate. First, research is needed to identify ways to support teachers and students to better leverage on the funds of knowledge that each bring to the STEM classroom. An important area of research involves how teachers and students from diverse backgrounds make use of their linguistic and cultural experiences as intellectual resources in learning STEM subjects, and how they attempt to overcome the tensions and challenges that may arise when these resources are found to be discontinuous with the way STEM subjects are defined and taught in the classroom. Recent research from the US suggests teachers who position themselves as learners with – and build strong relationships with – their Indigenous students are more likely to have stronger culturally responsive practices in their classrooms (Nam et al., 2013).

A number of questions that could be pursued in future work include: Does culturally relevant pedagogy support Indigenous students to learn STEM subjects? If so, how? And what can be done to help teachers become more skilled in practicing culturally relevant STEM teaching? Little work exists on finding out what students bring to STEM classrooms.

Secondly, developing teachers' culturally responsive pedagogies must arise from the actions of an entire school system rather than from classroom teachers alone. The school system should actively support teachers to build a cultural perspective on teaching STEM and involving the community in helping to create a collaborative learning environment, which will not only enrich the school content but promote a cultural shift of school STEM that facilitate more responsive science teaching (Bang et al., 2010).

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