LANGUAGE NEGOTIATIONS INDIGENOUS STUDENTS NAVIGATE *when* LEARNING SCIENCE

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Abstract

This paper reports on implications of a research study with a group of 44 Indigenous middle school students learning the science concepts of energy and force. We found the concepts of energy and force need to be taught in English as we failed to find common comparable abstract concepts in the students' diverse Indigenous languages. Three categories of describing the concepts were identified: nine students who used scientific genre to explain and demonstrate the concepts (20%); 15 students who used limited scientific genre to explain and demonstrate the concepts in terms of direct action (35%); and 20 students who did not use scientific genre to either describe or display by direct action their knowledge of the concepts (45%).

Indigenous students learning school science navigate language negotiations before negotiating the language challenges in science learning. School science achievement is measured using Standard Australian English concept descriptors. These assessment instruments are designed to measure the student's negotiations from Standard Australian English into science. It is possible that these instruments do not adequately measure the Indigenous student's negotiations from their vernacular language into science. Developing a Creole science could empower Indigenous students learning school science to develop the capacity to successfully negotiate the language systems.

Introduction

The Organisation for Economic Co-operation and Development (OECD) Program for International Students Assessment (2006) results in scientific literacy show that 40% of Indigenous students performed below the OECD "baseline" and were judged to be at risk of not being able to participate adequately in the 21st century workforce or to contribute as productive future citizens. The 2003 National Year 6 Science Assessment Report acknowledges only 54.9% of Queensland was at or above proficient standard, compared to 58.2% nationally. It highlights that proficiency of non-Indigenous students is significantly higher than Indigenous students and students whose home language is not English. The students classified as living in remote locations are reported to perform significantly worse than students from any other location. The assessment instruments were administered in Standard Australian English (SAE) and assumed competence in SAE, and might not have taken into account the role of Indigenous languages in Indigenous students' development of science understandings.

Science education in schools can highlight the understanding that science is a way of thinking, shaped by language and can be done anywhere: on a farm, in the bush or in a playground, and by anyone who uses a scientific process of inquiry (Chigeza, 2007; Graziano & Raulin, 2004). The teaching of science in schools should be inclusive of all students, irrespective of their language or cultural backgrounds.

Background to the study

A study conducted by the Catholic Education Office, Diocese of Townsville (2003) in 16 North Queensland boarding schools reports that very few Indigenous students were identified as speaking SAE as their first language. A socio-linguistic analysis of the 2003 student intake at one of these schools found that none of the students from remote communities spoke SAE as a first language. The study identifies four types of Aboriginal and Torres Strait Islander speakers as follows:

1. SAE as foreign language: first language is a traditional language or dialect, the second language is Aboriginal English (AE) or Torres Strait Creole (TSC).
2. SAE is a second or third language: the first language is either AE or TSC.
3. SAE is a second dialect: AE is the first dialect.
4. SAE is a first language.

Research conducted for the Queensland Indigenous Education Consultative Body (2002) also identified that very few Indigenous students from remote communities spoke SAE as a first language.

The Queensland Studies Authority supports and implements strategies to embed Indigenous perspectives into its products and services. In April 2008 the organisation launched a statement acknowledging the importance of understanding, maintaining and promoting the diverse Australian Indigenous languages spoken in Queensland and across Australia. The focus is to support curriculum initiatives assisting schools and communities to work in partnership and to recognise and value local Indigenous languages.

The *Primary Connections* project, an initiative of the Australian Academy of Science (2005), links science-specific and generic literacies such as reading text and writing required by children to effectively engage with science phenomena, to construct scientific understanding and develop science processes, and to represent and communicate ideas and information about science (Hackling, 2006). Indigenous perspectives on the *Primary Connections* project calls for attention to Indigenous cultural diversity, students' worldviews, and culturally inclusive resources and pedagogy.

The study

The action research study was undertaken in a part boarding, wholly Indigenous school, Djarragun College, in North Queensland during the period including second semester 2006 to first semester 2008. The students board in the school and come from communities in the Cape York region. The school is one of the 16 boarding schools in the Catholic Education Office, Diocese of Townsville 2003 survey. The study aimed to: gain insight into ways a group of 44 Indigenous middle school students describe the science concepts of energy and force, develop more effective strategies to teach the concepts of energy and force, and enhance educational outcomes. The study was guided by Level 5 outcomes of the Queensland Studies Authority, Science Syllabus Years 1 to 10.

The study attempted to implement a constructivist and context-based learning model to develop students' descriptions of the science concepts of energy and force. Constructivism concerns the knowledge, experiences and skills a student brings into a lesson and then focuses on individual students as they inquire into and explore phenomena and, in the process, construct their own meanings and understandings (Bennett, 2003; Fleer & Hardy, 2001). The context-based approach to science learning calls for the daily activities to be integrated with other content, founded in constructivist pedagogy, and rich in interactive dialogue with fellow students and the teacher about local issues in both the home language and English (Hampton et al., 2005). Science concepts should not only be meaningful and cater for Indigenous students' interests, but should also strive to improve Indigenous students' science literacy.

Each participating student attempted or completed a sequence of learning strategies on the science concepts of energy and force. These learning strategies consisted of: individual "pre-inquiry" concept mapping, group brainstorming on students' everyday ways of knowing, group guided comprehensive hands-on/minds-on inquiry on scientific ways of knowing, group construction of Venn Diagrams to compare and contrast the two ways of knowing, group "post-inquiry" concept mapping on the new ways of knowing, application to their real life experiences at every stage of learning and individual student reflection on the whole process. Students were encouraged to draw diagrams, pictures, cartoons, to reflect on their thoughts, feelings and/or ideas during and after the learning activities and data collection sessions.

Results of the study

The results of this study were presented at the 39th Australasian Science Education Research Association (ASERA) conference in July 2008 (Chigeza & Whitehouse, 2008). In trying to understand Indigenous students' conceptual perspectives, we consulted five Indigenous teachers and assistant teachers and local word banks to investigate how concepts of energy and force translate from common Indigenous languages into SAE. We found the meta-concepts of energy and force need to be taught in SAE as we failed to find common comparable abstract concepts in the students' diverse Indigenous languages. However, the large majority of students in the study (n=37) had difficulty communicating in SAE, they struggled to understand the SAE terms used in the science classroom; only 16% (n=7) of the students spoke SAE. Mellor and Corrigan (2004) suggest a distinction exists between two groups within Indigenous communities. The first group is those from traditional and remote communities, where the vernacular is the common daily language, and SAE exists only in schools. The second group is those communities where SAE or a dialect of Indigenous English is the community and school language.

Three categories of describing the concepts of energy and force by the group of students were identified: Category A: 9 students who could use scientific genre to explain and demonstrate the concepts of energy and force through speaking, writing, drawing and direct actions (20%); Category B: 15 students who could use limited scientific genre to explain and demonstrate the concepts of energy and force in terms of direct action (35%); Category C: 20 students who did not use scientific genre to either describe in SAE or display by direct action their knowledge of energy and force (45%), which meant the teacher could not appropriately assess levels of scientific understanding.

Category A

The students were able to:

- Use scientific genre in speaking and writing to explain and demonstrate the concepts of energy and force.
- Use scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.
- Use scientific genre to demonstrate by direct action the concepts of energy and force.
- Show evidence of phonic awareness and textual interaction (making meaning) with scientific words and concepts (see Table 1)

All seven students who were identified as competent speakers of SAE were among the nine students in Category A, who used scientific genre to explain and demonstrate the concepts of energy and force through speaking, writing, drawing and direct actions.

Category B

The students were able to:

- Use limited scientific genre in their speaking and writing to explain and demonstrate the concepts of energy and force.

Table 1: Main features of the categories of describing the concepts of energy and force.

Category	Referential features	Structural features	Number
A	Students who used scientific genre to explain and demonstrate the concepts of energy and force through speaking, writing, drawing and direct actions.	Used scientific genre in speaking and writing to explain and demonstrate the concepts of energy and force.	9 (20%)
		Used scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.	
		Used scientific genre to demonstrate by direct action the concepts of energy and force.	
		Evidence of phonic awareness and textual interaction (making meaning) of scientific words and concepts	
B	Students who used limited scientific genre to explain and demonstrate the concepts of energy and force in terms of direct action.	Used limited scientific genre in the speaking and writing to explain and demonstrate the concepts of energy and force.	15 (35%)
		Used limited scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.	
		Used limited scientific genre to demonstrate by direct action the concepts of energy and force.	
		Some evidence of phonic awareness and limited textual interaction (making meaning) of scientific words and concepts	
C	Students who did not use scientific genre to neither describe in English nor display by direct action their knowledge of energy and force.	Did not use scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.	20 (45%)
		Did not use scientific genre to demonstrate by direct action the concepts of energy and force.	
		Limited evidence of phonic awareness and no evidence of textual interaction (making meaning) of scientific words and concepts.	
Total			44

- Use limited scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.
- Use limited scientific genre to demonstrate by direct action the concepts of energy and force.
- Show evidence of phonic awareness and limited textual interaction (making meaning) with scientific words and concepts (see Table 1).

Category C:

The students in the group:

- Did not use scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force.
- Did not use scientific genre to demonstrate by direct action, the concepts of energy and force.
- Showed limited evidence of phonic awareness and no evidence of textual interaction (making meaning) with scientific words and concepts (see Table 1).

Language used in learning science in school

Language has been identified as one of the main barriers to learning science in school, even for students who speak SAE as their first language (Bennett, 2003). Research literature suggests specific language challenges in science are of two main types: vocabulary and grammatical challenges (Wellington & Osborne, 2001). The specific types of vocabulary difficulties are:

1. Technical terms that give new names to familiar objects (e.g., insulator)
2. Technical terms that give new names to unfamiliar objects, including those that are only encountered in laboratory settings (e.g., electric circuit board)
3. Technical terms for phenomena that can be demonstrated and observed (e.g., conduction)
4. Technical terms for phenomena that can not be directly observed (e.g., electromagnetic force)
5. Theoretical entities (e.g., conservation of energy)
6. Abstract idealisation (e.g., point mass, frictionless surface)
7. Mathematical words and symbols.

The grammatical features of science text that can cause reading and reasoning difficulties include:

1. Logical connectives (e.g., frequency, simultaneous, consequently, thus, conversely) that are vital components of the language of hypothesising, comparing, sequencing, attributing cause and other key features of scientific reasoning
2. Qualifying words (e.g., the majority of; in a few cases) can be a barrier between the reader and the information
3. Objectification/use of passive voice removes human agency in science
4. Lexical density, content or factual words are presented in much higher density at the expense of the narrative prose (e.g., the atom emits energy in quanta or discrete units)

Model 1: Language negotiation model of Indigenous students learning school science.

An Indigenous student's everyday ways of talking and knowing		**Scientific ways of talking and knowing**
An Indigenous student from a community where the vernacular is the commonly used language, and English is used only in schools. →	An Indigenous student from a community where English or dialects of Indigenous people's English is the community and school language →	An Indigenous student becoming competent in school science ways of talking, thinking and doing
Legend		
→ language negotiation		

Model 2: Language negotiation model of English as First Language (EFL) students.

English as First Language (EFL) students' everyday ways of talking and knowing		**Scientific ways of talking and knowing**
Students from low socio economic backgrounds →	Students from high socio economic backgrounds →	Students becoming competent in school science ways of talking, thinking and doing
Legend		
→ language negotiation		

5. Nominalisation, where nouns can be substituted for verbs (e.g., crystallisation, evaporation, acceleration) or nouns can be used as adjectives (e.g., glass crack growth rate).

Research has shown that students need explicit coaching in these language challenges to achieve in school science outcomes (Bennett, 2003). These language challenges can also further alienate Indigenous students or students who do not speak SAE as their first language, negatively affecting their science achievement.

Language is not merely an adjunct to science but a core constitution of science (Norris & Phillips, 2003). The development of SAE knowledge and skill in talking, writing and reading in the context of science lessons plays a central role. The language used in teaching and learning science involves describing, questioning, explaining, discussing and formulating argument. Science learning also uses other means of communication: images and symbols such as, graphs, diagrams, charts, mathematical symbols, chemical symbols, formulae and equations. Valentine (1996), researching students' understanding of logical connectives in science writing concluded that students with English as a first language had fewer difficulties than those with English as a second or third language. Students with English as a second or third language are marginalised from science learning if SAE becomes the only medium of communication when teaching and assessing. Assessment of Indigenous students' learning in science should not be dependent upon their learning and acquisition of SAE.

Indigenous knowledge systems

There are features in Indigenous people's lifestyles in the communities that enhance scientific understanding. For example, children watching and learning from experience as they go hunting, fishing and collecting bush food and medicines with their elders. The children learn to improve their listening and observational skills. The Australian Bureau of Meteorology *Indigenous Weather Knowledge* website (2007) is an example of Indigenous peoples' systematic observations over many years and how these observations have contributed to current scientific understanding. This knowledge and understanding of the world is contextual and relevant to the needs, concerns and personal experiences of traditional Indigenous communities. Science teachers should allow students to add their experiences and languages from their communities to facilitate a two-way exchange of language, knowledge and cultural understanding.

Some Indigenous people's knowledge systems have been identified as having scientific perspectives. Cultural anthropologists (e.g., Brindon, 1988) identified Aboriginal knowledge that resembles scientific ways of understanding, including: use of plant, animal and mineral material to treat or relieve ailments; removing poisons from bush foods; knowledge of vegetation management by fire to maximise food; knowledge of environment and animal migration patterns; knowledge of navigation and sea currents; and knowledge of local fauna and flora and use of Indigenous tools and weapons. The concepts of force, which is defined as a push or pull with magnitude and direction, and energy, which is the capacity to do work (Queensland

Model 3: Language negotiations in the mainstream school system.

English as Second Language (ESL) students' everyday ways of talking and knowing		English as First Language (EFL) students' everyday ways of talking and knowing		Scientific ways of talking, thinking and doing
Students from remote communities (where the vernacular is the commonly used language, and English is used mainly in the schools) →	Students from urban and semi-urban communities (where English, including dialects of Indigenous people's English is the community and school language) →	Students from low socio economic backgrounds →	Students from high socio economic backgrounds →	Students becoming competent in school science ways of talking, thinking and doing
Legend				
→ language negotiation				

Studies Authority Science Syllabus Years 1 to 10), are not new to Torres Strait Islander and Aboriginal groups in North Queensland. These groups have traditionally used the wind directions and force for sailing, wind directions to define their seasons, and sea currents to manage aspects of their lives (Sharp, 1993). Students in the descriptive Category C, did not use scientific genre in labelling their drawings to explain and demonstrate the concepts of energy and force, did not use scientific genre to demonstrate by direct action the concepts of energy and force, and showed limited evidence of phonic awareness and no evidence of textual interaction (making meaning) with scientific words and concepts. They did, however, show evidence of knowing how to apply the concepts both in the classroom setting and the field of play during sporting activities using direct action and their languages. Students in this category would fail to cope with an assessment instrument that is administered using SAE. They would be judged as performing below the OECD "baseline" and at risk of not being able to participate adequately in the 21st Century workforce, or to contribute as productive future citizens.

Language negotiations

Indigenous students can encounter two types of language negotiations when they are learning science in school. The first language negotiation involves moving students from their everyday use of vernacular to communicate to becoming competent in the use of SAE or dialects of Indigenous people's English. The second language negotiation involves moving students from their everyday ways of talking, thinking and doing to becoming competent in scientific ways of talking, thinking and doing.

A student from a community where SAE (including dialects of Indigenous people's English) is the community and school language will need to negotiate the language challenges in learning science: vocabulary and grammatical challenges (Wellington & Osborne, 2001). A student from a community where the vernacular is the commonly used language will need to negotiate into SAE or a dialect of Indigenous people's English first, before negotiating the vocabulary and grammatical challenges in learning science.

The model can be used to represent English as First Language (EFL) students learning school science. The Queensland Government Department of Education, Training and the Arts (2007) discussion paper highlights a large achievement gap between poorer and more affluent students, and between schools with large proportions of either poorer or more affluent students in Australia.

English as Second Language (ESL) students, especially students from remote communities where the vernacular is the commonly used languages, have a series of language negotiations before negotiating the language challenges in science learning, as compared to English as First Language (EFL) students, especially students from high socio economic backgrounds (see Models 1, 2 & 3). If science achievement is measured using SAE concept descriptors, it adds to other advantages English as First Language (EFL) students have, especially students from high socio economic backgrounds, over the other groups of students. The assessment instruments are designed to measure the student's negotiations from SAE into science. They do not adequately measure the Indigenous student's negotiations from their vernacular language into science.

The science teacher should not only be equipped with the different teaching strategies that target the different groups of students, but should be able to identify in which group the individual students operate from, as well as being able to transient smoothly within the groups. Teachers might need support to effectively teach the different groups of students.

A Creole science

A more informed approach would call for inclusion of Indigenous students' everyday ways of talking and knowing in science teaching and learning. The Queensland Studies Authority (QSA) Science Syllabus Years 1 to 10 calls for constructivist and context-based approaches to science learning. A constructivist approach to learning values Indigenous students' language and everyday ways of cultural understanding and build on that knowledge to enhance their learning in science. A context-based approach to learning links science to everyday life experience of the Indigenous students at every stage, and the learning is structured in situations the Indigenous students encounter in their world. Developing a Creole science can empower Indigenous students learning school science to develop the capacity to successfully negotiate the language systems. A bilingual English/Haitian Creole dictionary has been successfully implemented to provide teachers and students with Haitian Creole equivalents for English terms used in science. The dictionary contains over 3, 000 English terms used in science and science related disciplines with Haitian Creole equivalents. It provides clarifications of terminology and instructional materials for teachers.

A Creole science will not dilute or "dump down" the science curriculum, but encourage Indigenous students to talk about science in both their Creole languages and SAE. Constructivism and context-based approaches to learning focus on the students' everyday oral and written languages, and how they construct new meaning and understanding. Two groups of words used in talking and writing about science play a significant role: science words and instructional words in science. Science words include: technical terms (e.g., conductor), theoretical entities (e.g., conservation of energy), abstract idealisation (e.g., frictionless surface) and mathematical words and symbols (Wellington & Osborne, 2001). The study failed to identify common comparable Creole language equivalents for most of the science words and concluded that they need to be taught in SAE. Introducing few science words per lesson, using concrete materials and representations proved helpful to Indigenous students. Instructional words in science learning include: observe, describe, compare, classify, analyse, discuss, hypothesise, theorise, question, challenge, argue, design experiments, follow procedures, judge, evaluate, decide, conclude, generalise and report (Lemke, 1990). The meaning of these words is not a packaged product ready to be delivered to Indigenous students. The meanings and implications of these words are negotiated. Indigenous students construct meanings and understandings of these words from their everyday languages and experiences. The study shows evidence of students in all the three categories talking about science in their Creole languages. Creole language equivalents can be used to aid instructional words in science, not only to construct new meaning and understanding for Indigenous students, but to assess them.

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