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A professional learning model that cultivates primary science classrooms' representational profiles

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ABSTRACT

The aim of the study was to explore representational profiles of seven primary science classrooms prior to and following professional learning around representational practices. Teachers' self-efficacy to teach year six geology with representations and their competencies to interpret, explain and choose geology-based representations significantly improved. Teachers with very different years of teaching experience chose the same types of representations to teach the same concepts. Despite variation between classes and students, there was a significant and substantial improvement in student competencies to interpret, understand and create representations to explain geological concepts and this improvement occurred across all classes. The findings suggest the professional learning promoted conceptual and representational competencies in all classes despite the differences across the teachers and their classrooms.

1. Introduction

The communication of science requires a specialised language that is inextricably linked to several other modes of representation (diagrams, images, graphs, mathematical symbols) and the meaningful way they are used to construct knowledge or argument (Lemke, 2004) through inquiry. Often, modes of representation like graphs and diagrams are complex. Members of the scientific research community consistently work with, conduct scientific inquiry through, and communicate their discoveries by using relevant modes of representation. In other words, they are fully fluent with representational modes and capable of interpreting, explaining creating and relating the meaning of and across representations. However, teachers do not always have these skills and may not be able to explain representations to students or guide students to the key features of representations that convey conceptual meaning. Furthermore, students are often unable to interpret information from or work with representations in order to construct an understanding in science (Jaipal, 2010). While some students possess the skills of reading particular or several representations in science and constructing meaning from them, many students require these skills to be modeled for them (Prain & Waldrip, 2006).

To facilitate the teaching and learning of science concepts, teachers need to be explicitly trained to choose, sequence, and explain multiple content-appropriate and accepted representations of science including text, drawings, diagrams, graphs, tables, pictures and sound in animations to promote students' interpretation, understanding, explanation of, and even creation of representations. Prain and Waldrip (2006) emphasize the need for teachers to "focus not only on the concepts,

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but on the signifying codes within different representations and their interrelationship" (p. 1864). Teachers' inquiry-based instructional approaches in the science classroom must be structured around the introduction, discussion, and conceptual meaning of a range of representational modes; the explicit discussion of key representational features and related meaning between the accepted representations of the scientific community.

1.1. Instructional competencies around representations

Developing students' conceptual and representational competencies in science is an important instructional goal (diSessa, 2004) and one which requires skills in evaluating and understanding the semiotic and material affordances of accepted representations of science (Kozma & Russell, 2005). To be able to explain the features of a representation that convey meaning requires agency over representations (Kockelman, 2007). Previous research suggests that teachers and students must be trained to develop this agency (Nichols, Gillies, & Hedberg, 2015a; Nichols, Stevenson, Hedberg, & Gillies, 2015b). Agency with accepted representations of science is only a foundational skill upon which other important skills emerge. Once agency is attained, and this becomes an automatic tendency to evaluate accepted representations of science in terms of what they relay about a concept or do not relay, then careful choice, sequencing and conceptually connecting meaning across multiple representations is possible. In other words, agency precedes fluency with representations or the ability to translate meaning across representations to build a picture or knowledge of a science concept, idea or phenomenon.

Several studies have shown the critical importance of instructional modeling of the language conventions around multiple representations and the concepts they convey for promoting students' meaning making and conceptual understanding of science through representations (Airey & Linder, 2009; Hilton & Nichols, 2011; Nichols, Hanan, & Ranasinghe, 2013a; Nichols, Ranasinghe, & Hanan, 2013b). However, there is a paucity of research around professional development or learning models that promote teachers' representational agency and the consequent impact on teachers' and students' use of and competency to work with representations. Can professional learning help build these representational profiles of teachers and students? If so, what model of professional learning will support the development of classroom representational practices and profiles?

Some more recent studies suggest that this may be possible. A study (Gillies, Nichols, & Khan, 2015) investigating the impact of professional learning of teachers around representational practices on year 6 students' social and scientific language skills around geological concepts showed that students exhibited higher levels of social and scientific language than their untrained peers. A subsequent study (Nichols et al., 2015a) exploring how argumentation-promoting inquiry practices focused on representations impacted on year 6 students' representational competencies and knowledge-building discourse around geological concepts showed that compared to their untrained peers, these students exhibited significantly higher conceptual understanding and collaborative knowledge construction discourse. Moreover, these students were better able to work with accepted representations to inquire about and construct an understanding of geological concepts. These skills, taken together, provided a measure of students' representational fluency.

1.2. Professional learning for inquiry instruction

It has been suggested (Crawford, 2012) that many professional learning models are not effective in supporting teachers' understanding of the nature of scientific inquiry nor do they sufficiently prepare teachers to implement inquiry learning into their science classrooms, due to the focus on curriculum rather than pedagogical approaches. This claim suggests the need to consider what teachers require from professional learning experiences in order to design more effective models (Grigg, Kelly, Gamoran, & Borman, 2012).

Several studies have researched what teachers perceive to be useful aspects of professional learning for improving their implementation of inquiry science. A study conducted by Tseng, Tuan, and Chin (2012) discussed interview responses from 15 experienced junior high school teachers to reveal their perspectives of and recommendations for professional learning around inquiry teaching. A seminal study by Supovitz and Turner (2000) described a meta-analysis of published research that identified widely accepted characteristics of quality professional learning. These studies assert that an immersion approach to professional learning is considered most effective. Such a professional learning model immerses teachers in inquiry learning themselves, demonstrates how learning links to specific curriculum standards, involves material and practical resources, demonstrations, and strategies that can be connected to other areas of learning, and provides sustained support from research teams. Supovitz and Turner (2000) analysed data collected through self-reported teacher surveys and found that increased engagement in professional learning which embodied these elements was associated with both increased use of inquiry-based teaching practices and higher levels of uptake of the professional learning. Lee, Hart, Cuevas, and Enders (2004) implemented a professional learning intervention that embraced many of these elements in its design and found teachers identified positive changes to their practices in alignment with an inquiry approach to teaching and learning. The suggestion here is that a professional learning model that captures these successful elements around inquiry teaching with a focus on representational practices could be an effective model for improving representational and conceptual competencies in science.