Disciplinary Literacy: Its Value and Implication to Pre- and In-service Science Teacher Education

By *Jennifer Yeo*

AS A PHYSICS teacher, I would hear my students commenting that "there is a physics graph, a chemistry graph and a math graph" or about how values are written differently in math and physics. These comments suggest that students perceived the same modes of representation in math and science to be different. I used to wonder why this was so. Isn't a graph a graph, regardless of whether it is used in physics, chemistry, biology or mathematics? And isn't a number a number, regardless of the discipline in which it is used? Seah Lay Hoon's (2016) presentation on Disciplinary Literacy can perhaps shed some light into these comments.

Lay Hoon's presentation puts the spotlight on the distinctive features of language specific to different disciplines. Expanding on the traditional notion of (scientific) literacy as encompassing reading, writing and talking (science), the added component of *scrutinizing scientific language* in her framework of disciplinary literacy highlights an often neglected or taken-for-granted component of science learning—learning *about* the language used in science (e.g., words, drawings, graphs, tables). This neglect could perhaps be explained by common perspectives in science education on what counts as learning science.

Science learning has traditionally been perceived as conceptual change (Posner, Strike, Hewson, & Gerztog, 1982), and more recently as participation in the social activities of science. The conceptual change perspective views science learning as a

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change in one's mental model, and language as an externalization of that mental model. The latter views science learning as an enculturation into the practices of science, which includes participating in inquiry practices of science (Roth, 1995), talking science (Lemke, 1990) and making meaning with the various modes of representations of science (Kress and van Leuwen, 2006). While language might feature in these various perspectives, it is regarded as a mere tool for giving insights into students' learning, rather than an object of science learning in itself.

The learning of scientific language is often taken for granted; it is assumed that students will "pick it up somehow". The anecdotal recount of comments made by students (as mentioned in the early part of the article) suggests that understanding the language of science is not automatic. Learning *about* the language of science needs to be made explicit. Drawing from Gooding's (2004) and Latour's (1999) analyses of representations in scientists' work, Prain and Tytler (2013) found that theory-building invariably happens through a series of transformations from one representation to another, representation refinement, and improvisation in a bid to develop a plausible explanation for an observed phenomenon. If learning science should involve authentic practices, then this should include understanding why and how discipline-specific and generic literacies are used to build and validate scientific knowledge; in other words, the epistemological and ontological purposes of the modes of representations with which knowledge is constructed should be included in the learning of science.

The representational approach developed by Tytler, Hubber, Prain, & Waldrip (2013) is one example of learning about the language of science. For example, the approach shows how it is not sufficient to just learn the conventions of using arrows to draw free-body diagrams to think about the forces acting on a body. Rather, authentic science learning should entail the exploration of different representations in modeling the phenomenon and consideration of the affordances and aptness of the pictorial representation of an arrow in conceptualizing an explanation for changes in motion.

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Implication to Pre-service and In-service Science Teacher Education

To help students learn the form and function of scientific language, teachers need to understand the epistemological and ontological purposes of the modes of representations with which knowledge is constructed (Prain & Tytler, 2013). This goes beyond merely knowing how to draw magnetic field patterns with arrows and its conventions; it should include understanding that the use of arrows to represent a magnetic field is derived from the pattern produced by iron filings when they are sprinkled around a magnet—a representation that has been found useful when thinking about the effects of magnetism. In this sense, signs/representations in the scientific system of language (e.g., the arrows used to represent magnetic fields) are not arbitrary; rather, they reflect one's reasoning expressed in a form thought to be most appropriate in communicating meaning for that particular context.

Studies by Tytler, Hubber, Prain, and Waldrip (2013) on representation-oriented pedagogies show that the biggest hurdle for teachers in working with students on representations is the epistemological shift in viewing science knowledge as consisting of resolved, declarative concepts to one which is contingent and expressed through representational use. Nevertheless, awareness of this can potentially help to address misconceptions such as the relation between concepts and representation. For example, conceptual change studies have shown that students often mistake the representation for the "reality" of a concept. By explaining how the language system of science is a product of a long historical tradition that informs present use of these various symbols, teachers can help students learn to use these representations of science more effectively.

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About the Discussant

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