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Representing Science Literacies: An Introduction

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Clarifying the relationship between science education and broader literacy learning has received increasing attention in recent years, with researchers claiming the need for closer mutually beneficial links between these two areas (Australian Academy of Science 2008; Saul 2004; Shanahan and Shanahan 2008; Yore et al. 2003). There is now growing recognition that learning science means learning a particular "disciplinary literacy" (Moje 2008, p. 1), and therefore learning how to integrate the multi-modal literacies of this subject. Rather than these literacies being viewed as peripheral to learning, or surface features of content acquisition, they are now understood by researchers in this area as crucial tools for meaning-making and knowledge production. Developing this understanding, especially with secondary science teachers, perhaps needs further work, where subject-specific literacy is often perceived as a matter of technical correctness, or addressing an expression deficit, rather than as the acquisition of critical tools for reasoning and thus learning in this subject.

This is not to argue that broader literacy learning is not crucial to developing this disciplinary literacy, as noted by Shanahan and Shanahan (2008). Generic literacies, such as knowing how to contribute effectively to group discussion, making a powerpoint, reading a newspaper, interpreting a photograph, noting a pattern in evidence, and writing a report, are seen as critical adjuncts to supporting the development of disciplinary literacy, which in turn enhances student motivation and performance in literacy more generally. Shanahan and Shanahan (2008) make the point that the role and relationship between generic and disciplinary literacies change as students progress in learning science, with the necessity of an increasing focus on discipline-specific literacies in secondary schooling.

Science education researchers now broadly agree that learning the particular literacies of science is crucial to developing science literacy. These literacies include all the signifying language practices of science discourse, including verbal, visual, and mathematical

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languages, as well as understanding the purposes and rationale for these literacies in representing scientific reasoning, practices and processes. Knowing how, why, and when to integrate the use of tables, graphs, diagrams and written text is crucial to representing scientific processes and claims. In this sense, every representation in science makes claims about the natural world, and learning science entails understanding the bases of these claims as a form of knowledge production. This capacity to construct and interpret science texts, what Norris and Phillips (2003) consider fundamental to demonstrating science literacy, therefore depends on students developing both procedural and conceptual knowledge entailed in scientific representation. Learning this disciplinary literacy, as noted by Moje (2008, p. 4) means learning not just subject knowledge but also the multiple ways of "knowing, doing, believing and communicating" in this subject.

In this issue of RISE, we present research on a range of tasks designed to support student acquisition and use of the literacies of science to develop science literacy at different year levels, with a specific focus on student-generated representations. The purpose of these representations can vary, depending on the students' level of attainment and whether the students are engaging with new ideas early in a topic, consolidating understanding, or attempting to make key claims at the end of a topic. We acknowledge that students must learn how to interpret science texts to achieve science literacy, and recognize a strong reciprocity between interpreting and constructing these representations. However, we consider that there are particular learning gains when students are expected, with teacher guidance, to make evidence-based claims through their own representational work. For Ford and Forman (2006), such work is consistent with the knowledge-production practices of the science community, in that these literacies are used to develop and contest scientific claims. In constructing and assessing these representations, students are judging their coherence and adequacy in representing their intentions and ideas, the extent to which their claims will make sense and convince others, as well as whether appropriate conventions have been used (Greeno and Hall 1997). This representational work also provides ongoing crucial feedback to teachers on students' emerging and diverse understandings.

We also acknowledge the developmental nature of this learning, by focusing on different challenges faced by younger and older students in the different research studies presented in this issue. Younger school students are expected to learn the form and function of representational conventions at the same time as they are using representational options to develop conceptual understanding. Older students are expected to know how and why to embed modes within modes to demonstrate scientific reasoning and explanation. We would also assert that students often need considerable practice in negotiating the construction of representational options, in order to understand in any depth the function and design of representational practices in science discourse, including their strengths, limitations, and selectiveness in addressing only some aspects of any given phenomena. Students need to understand the necessity of modal diversity in representations of science concepts and processes, be able to translate different modes into one another, as well as understand their co-ordinated use in representing scientific knowledge. There is increasing recognition that developing students' capacities to construct these complex science texts poses significant cognitive and pedagogical challenges.

The paper by Hubber, Tytler and Haslam identifies learning opportunities and enabling teacher strategies when junior secondary students produce their own representations as part of their engagement with the topic of force. Hand and Choi investigate tertiary students' use of embedded multimodal representations in laboratory reports, noting that some students needed explicit support to develop this literacy. The paper by Anthony, Tippett and Yore reports on challenges and successes in seeking to embed literacy instruction within a middle school science curriculum taught by generalist and specialist science teachers. Drawing on a range of theoretical perspectives and classroom-based research studies, Waldrip, Prain and Carolan present a framework to guide teachers' incorporation of student-generated representations into learning sequences in science topics. Each of these studies highlights the challenges teachers and students face in using student-generated representations as part of the learning process. The challenges can relate to teachers' own understandings of the complex relationship between key concepts in a topic and their co-ordinated representation, as well as pedagogical questions about task design, effective classroom interactions and sequences, and appropriate assessment methods. For students, the challenge is about learning how to build on their current representational resources to acquire the literacies of science as the tools for engaging in this subject. At the same time, these studies also indicate that a focus on student-generated representation can be meaningful and productive for both teachers and students.

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