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# Teaching the distinctive language of science: An integrated and scaffolded approach for pre-service teachers

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## HIGHLIGHTS

- Science knowledge and the language of science.
- Integrating science education with literacies education in initial teacher education.
- Using genre-based literacy pedagogy to teach science writing in the middle years.

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## ABSTRACT

To learn science and demonstrate science learning, school students must bridge the gap between everyday use of language and image and the specialised use of language and image needed to achieve science curriculum outcomes. Pre-service teachers studying at a regional Australian university were shown how to help their future students bridge this gap. A transdisciplinary model was used to demonstrate the teaching of specialised science literacies integrated with the teaching of science in the middle school years, resulting in high levels of engagement, more effective use of learning time, and valuable opportunities for teacher educator professional learning.



## 1. Introduction

The language of science has "evolved to meet the needs of scientific method, and of scientific argument and theory" (Halliday, 2004, p. 178). Learning science is, thus, inextricably entwined with learning the language of science (Halliday & Martin, 1993; Halliday, 2004; Lemke, 2004; Martin & Veel, 1998; Osborne, 2002; Pearson, Moje, & Greenleaf, 2010; Shanahan, Shanahan, & Misischia, 2011; Unsworth, 2004, 2005; Wellington & Osborne, 2001). Teachers need to help their students bridge the considerable gap between the use of spoken language in everyday life and the reading and writing of scientific texts, which feature distinctive schematic structures, and specialised vocabulary, grammar and visual representation (Halliday & Martin, 1993; Halliday, 2004). This is especially true for those teaching in the middle years of schooling, from Year 4 to Year 9, the years students transition from learning initial and generalisable reading and writing skills towards mastering the specialised reading, writing and use of images needed to learn and display the distinctive knowledge of each curriculum area, including science (Fang, 2012; Freebody, Chan, & Barton, 2013; Shanahan & Shanahan, 2008, 2014).

The barrier to students' successful learning of science represented by the failure to acknowledge the central role of the literacies of science in the teaching of science is increasingly recognised in the science education literature (e.g., Fang, 2013; Gee, 2004; Hand & Prain, 2006, 2012; Hynd-Shanahan, 2013; Wellington & Osborne, 2001). Pre-service teachers (henceforth PSTs), both primary and secondary, have been shown to lack awareness of the distinctive features of the specialised literacies of science, and tend to be uncertain of their role in teaching these literacies (Hynd-Shanahan, 2013; Shanahan & Shanahan, 2014), because, as Lemke (2001, p. v) has argued: "few [teachers] have been taught specific techniques for supporting students' use of scientific language". If teachers have not studied science beyond the middle years of secondary school, they may lack science-specific literacies themselves, further limiting their capacity to teach these literacies effectively. Furthermore, generalist teachers in the primary school

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implementing a curriculum they often experience as crowded (APPA, 2014), may lack strategies needed to purposefully connect learning areas, such as English and science (Naylor, 2014), especially if these strategies are not modelled during initial teacher education programs.

Nothing less than the "restoration of language and literacy" to a "central position" in science teaching practice is required, following Osborne (2002, p. 215), to improve "the quality of science education, both in terms of the experience it offers to its students and its cognitive and affective outcomes". Nevertheless, Yore, Bisanz, and Hand (2003, p. 717) suggest that science teachers need to be "convinced" that multimodal literacy practices will enhance their students' learning of science, and argue that "the science education community must incorporate these approaches into their teacher education programs and help practicing teachers infuse these approaches into science inquiry teaching".

While science teacher educators are encouraged to incorporate into teacher education programs strategies for teaching science literacies, this can prove difficult in practice. To interweave teaching about science-specific use of language and image into the teaching of science successfully, teacher educators need explicit knowledge about the language and images used to represent science, and how to teach it, a knowledge base potentially strengthened when science and literacies educators collaborate. However, in traditional teacher education programs, science education and literacies education are typically taught separately, an institutionalised disciplinary boundary that hampers the sharing of ideas between science educators and literacies specialists (Yore et al., 2003). In fact, as pointed out by Pearson et al. (2010, p. 462), "the structure of teacher education virtually guarantees isolation between literacy and science preparation". Hence, despite the demonstrated need to attend to the literacy practices of science in initial teacher education (Yore et al., 2003, pp. 716–717), models of how this might be achieved in practice are rare in the literature. It was for this reason that the study described below was initiated.

## 2. Research aim

The study was initiated when science and English teacher educators, working collaboratively, combined and co-taught a module spanning third year science and English education units of study usually taught separately. The aim was to design and test an initial teacher education pedagogy in which PSTs experience how an inquiry approach to science education in the middle years might be augmented with a sequence of discipline-specific literacy activities for scaffolding the writing of scientific texts to report and explain inquiry findings. Specifically, the teacher educators were interested in exploring, first, how disciplinary boundaries isolating science education from literacy education in a traditional PST education programme could be overcome, and, second, how the design of teaching sequences integrating science education and disciplinary literacies might be modelled for PSTs. The teaching sequence was designed as a model PSTs could apply to teaching both science and literacy, so their future students learn how to talk about, recall, record, read and display scientific knowledge in texts that are recognisable as science.

## 3. Literature review

The design of the study reported here encompasses related but distinct concepts including *disciplinary knowledge* and *disciplinary literacies*, *cross-disciplinary teaching*, *scientific literacy*, *literacies of science* and *everyday literacies*. These concepts are interpreted in multiple and sometimes ambiguous ways in the context of scientific inquiry and meaning-making in science education, underlining the challenge faced by teachers of science in the middle years when applying these concepts to their practice. Below we review these concepts and interpret what they mean for science teaching program design and practice, and for science teacher education.

### 3.1. Disciplinary knowledge and disciplinary literacies

Many school curricula, including the *Australian Curriculum,* are organised into distinct learning areas in ways that reflect traditional academic disciplines. This organisation is a response to growing awareness of the value of apprenticing school students into *disciplinary knowledge* in systematic and explicit ways (Freebody, Maton, & Martin, 2008). As students build knowledge in each discipline, they also gain access to a community of scholars who, over time, have jointly constructed this system of knowledge. Members of each discipline community use this knowledge as a foundation for asking questions, building and communicating new understandings, designing methods for observing and inquiring, making judgements and new discoveries, agreeing and disagreeing, and for engaging in dialogue with other disciplines (Christie & Maton, 2011). Disciplines, in the words of Freebody and Muspratt (2007, p. 46) are "resources for gearing young people into an "explicable" world beyond the touchstones of the tribe, commonsense and *dogma*". Mastering disciplinary distinctions is necessary if students are to succeed academically across the curriculum in the middle and senior years (Christie & Derewianka, 2008; Fang, 2012; Fang & Coatoam, 2013; Polias, 2016; Rose & Martin, 2012; Shanahan & Shanahan, 2008, 2014).

Closely related to "a disciplinarity-based understanding of knowledge" is an understanding of "the relation between curriculum knowledge and the language of that curriculum knowledge" (Freebody et al., 2008, p. 188). This relation is foregrounded in the *Australian Curriculum* with the inclusion of literacy as a general capability in all learning areas:

> Success in any learning area depends on being able to use the significant, identifiable and distinctive literacy that is important for learning and representative of the content of that learning area (ACARA, 2016a).

Disciplinary knowledge is learnt through the language and image, or *disciplinary literacies*, used to represent that knowledge. As students move through the school years, they are increasingly required to display curriculum knowledge using the literacies specific to each discipline. For this reason, a key task of teacher educators preparing PSTs to teach curriculum content organised into distinct discipline-aligned learning areas is to model "how to intertwine the teaching of language with the teaching of curriculum knowledge" (Freebody et al., 2008, p. 188).

### 3.2. Cross-disciplinary teaching

Many generalist primary school teachers, and even some junior secondary school teachers, take a thematic approach to programming not only to reduce the impact of the crowded curriculum, but also because teaching literacy without content is impossible. They select and organise content from across a range of curriculum areas related to a theme they believe will engage their students and make learning meaningful and relevant, while at the same time facilitating the achievement of learning outcomes from multiple curriculum areas. As shown by Smith, Loughran, Berry, and Dimitrakopoulos (2012), connecting science to content areas where primary teachers feel more comfortable can enhance their confidence in teaching science, while combining this approach with professional conversations about scientific literacy can have