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The Senses of Scientific Literacies in a Middle Years Multiliteracies Project

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This article focuses attention on conversations with one teacher, Olivia Augustakis, and her description of a science inspired multi-literacies project (New London Group, 2000; Kalantzis & Cope, 2005). The 'Land Environments Board Games' project, undertaken by Year Five at St Thomas More School, Sunshine Beach, Queensland, was part of a collection of literacy projects awarded a National Literacy and Numeracy Week Celebration Grant in 2006 for effectiveness in engaging students with the complex demands of curriculum literacies. Definitions of curriculum literacies (Wyatt-Smith &Cumming, 2003) draw attention to each field's sets of knowing (content knowledge) and ways of representing knowing (literacies). Norris and Phillips (2003) contend that written forms of representing scientific knowing are too often left implicit, thereby hindering the development of students' derived senses of scientific literacies. A multiliteracies pedagogies (New London Group, 2000; Kalantzis & Cope, 2005) framework is employed to analyse Olivia's talk and to render opaque her understanding of the interdependence of science as content and its specialised representation. This single case analysis is important also for its showcase of the four interrelated phases of a multiliteracies project: student practice, overt instruction, critical framing and transformed practice (New London Group, 2000; Kalantzis & Cope, 2005).

Scientific Literacies & Mutlliliteracies Projects: Tensions in Theory and Practice

New understandings emphasise that each field of knowledge has its own sets of knowing (content knowledge) and ways of representing knowing (literacies). Wyatt-Smith and Cumming (2003) refer to subject specific ways of representing knowing as curriculum literacies*.* Their thesis is there is no single literacy that can be spread homogenously across all curricula. Wyatt-Smith and Cumming's (2003) two year study of the literacy demands of school science highlight the need for explicit instruction to progress students' scientific literacies. Wellington and Osborne (2001) contend that the greatest barrier to learning school science lies with learning how to engage with and produce its complex representations. Likewise, Lemke (2000) purports that learning in the subject of science includes learning to use and express its specialised language in meaningful and multi-modal ways. Without these multiple modes there can be no science; science cannot be separated from its integrated modes of representation (Hand & Prain, 2006).

In an attempt to make science more accessible, some teachers employ an inquiry-based hands-on curriculum where students focus on experiments and observation. The problematic is that scientific thinking and doing are jettisoned to the foreground as if these tasks have little to do with language (Gee, 2004). Another move has seen publication houses market print-based or digital 'information narratives'. Both approaches have some merit 'in that they have the potential to motivate learners, stimulate their engagement, and scaffold their learning of science' (Fang, 2006, p. 515); however, on their own they are insufficient to ensure the development of scientific literacies. Although students are able to develop, critique and refine their scientific thoughts through speech and action, and exposure to terms and concepts in information narratives, the text emanating from these discourses neither provides the tools nor the forms of expression to become scientifically literate. Students must become expert users of the authentic scientific language to communicate their understandings of the natural world. Lemke's (2000) research confirms that most of the conceptual information of science is in the form of written text.

A corollary of the above mentioned views is that making-meaning from and producing written representations of scientific knowledge should be a major emphasis in the science classroom. At one level, it would seem that undertakings of this ilk are being prioritised in school systems throughout the

Western world. However, the recent uptake of multiliteracies projects (New London Group, 2000; Kalantzis & Cope, 2005) in various classrooms has seen, at times, its philosophies (mis)represented as progressivist approaches that only adopt constructivist pedagogy. In actuality, multiliteracies projects are founded on a transformative approach, where overt instruction of the designs of meaning are included, alongside phases of student practice, critical framing and transformed practice. Significantly, overt instruction necessitates the introduction and scaffolding of explicit metalanguages, which describe and interpret the design elements of different modes of meaning, including audio, spatial, gestural, visual and linguistic design (New London Group, 2000: Kalantzis & Cope, 2005).

In addition to these attempts to reform curricula and pedagogy, major national projects focusing on the development of scientific literacies are currently underway in the United Kingdom, the United States and Australia. The United Kingdom's project, *Twenty First Century Science*, involves a national pilot of 12 000 students (Millar, 2006, p. 1500). The *Science for all Americans* program states that 'schools do not need to teach more and more content', rather 'focus on what is essential to scientific literacy and to teach it more effectively' (Millar, 2006, p. 1500). In Australia, a research report commissioned for the Department of Education, Training and Youth Affairs (Goodrum, Hackling, & Rennie, 2001) lists five recommendations, the first being that 'the purpose of science education is to develop scientific literacy'. The import of scientific literacies is also underscored by the Organisation for Economic Cooperation and Development's (OECD, 2006) Programme for International Student Assessment (PISA) where students' scientific literacies are assessed rather than their school science content knowledge. However, the extension of the aforementioned principled positions on the dialectic of science content and its written representations is at best only implicit within the OECD's (2006, p. 12) revised definition of scientific literacies, published in the third and most recent PISA (Program for International Student Assessment) report:

An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.

It would seem that Norris and Phillips' (2003) caution on the over-emphasis of the development of the derived sense of literacies (being knowledgeable, learned and educated in relation to science), at the expense of the fundamental sense of literacies (reading and writing science-specific texts), is still warranted. The point is that scientific literacy in its general sense is diminished by not having acquired scientific literacy in its fundamental sense. Empirical evidence supports their argument that 'reading and writing are inextricably linked to the very nature and fabric of science, and, by extension, to learning science' (Norris and Phillips, 2003, p. 226). The OECD definition, and many like it, fails to sufficiently explicate the fundamental sense of literacy to reveal its significance.

This research paper thus examines what is happening in the name of science in a middle years classroom. A focus on the constitution of scientific literacies in middle schooling is timely. Lemke (2001) notes that middle school students are often characterised as apathetic readers who feel alienated from academic subjects like science. Citing a range of empirical studies, Kamil and Bernhardt (2004, p. 128-129) maintain that feelings of alienation could result from students' lack of familiarity with information texts, augmented by an over-emphasis of literacy texts in the elementary grades, and these non-literary texts being much less like the conversational language of their life worlds. Recent research into the so-called 'middle years slump' has highlighted students' continuing difficulties with literacy (Carrington, 2002) and the sometimes ad hoc approach to literacy instruction (Luke et al, 2002).

The next section introduces and examines one teacher's talk about a science-based multiliteracies project. The teacher, *Olivia Augustakis,* was selected for interview as the project she and her teaching colleagues, Jim Mc Kendry and Chris Campbell, were facilitating was part of a cluster of projects from St Thomas More School, Sunshine Beach, Queensland, that was awarded a National Literacy and Numeracy Week celebration grant in 2006.

The Multiliteracies Project: *Land Environments Board Games*

The multiliteracies project was borne out of Olivia, Chris and Jim's desire to make their students' learning fun but also purposeful. Olivia described her students as *very intelligent and if we're doing something they perceive as boring, it takes a lot to get them back. We have to engage them straight away.* The project was scaffolded by the Catholic Education's *Learning Framework*, which centres learners as 'knowledgeable', in 'various stages of development' and able to 'develop deep understanding when given time to engage, explore, reflect, revise and apply their learning' (Catholic Education Office, 2006). The *Learning Framework* also designates 'recognition of difference', 'a quality learning environment', tasks of 'significance', and demands for 'intellectual quality' as indicators of effective pedagogical practice (Catholic Education, 2006). Included within the dimension of intellectual quality are two statements that reference how effective teachers use language: 'examine with students how language is used to construct texts and knowledge' and 'engage students in substantiative conservations in a variety of modes to clarify and refine understanding' (Catholic Education, 2006). The *Learning Framework* thus explicitly links content knowledge and language. The culminating task for the multiliteracies project required students to work in groups as well as undertake some aspects independently to produce a three dimensional board game for their middle years counterparts and their families to promote both entertainment and deep knowledge about the scientific elements of land environments, in particular, coastal, wetlands, woodlands and arid interiors. To achieve this, students had to master a range of technology objectives and understand and express scientific understandings through various forms of linguistic and 2D and 3D visual design.

Project – Phase One

The commencement of the project was framed by students' own experiences with and critiques of board games and technology resources. In multiliteracies terms (New London Group, 2000; Kalantzis & Cope, 2005), this activity showcases student practice and critical framing in action. Olivia clarifies:

Extract One (Student Practice & Critical Framing)

Olivia: *To start off with we had a day where the students played board games, looked at what made a good board game, the colours, the layout, was it easy to read, simple or complex. They looked at 'Trivial Pursuit' and found it was too hard for them and that made it boring. I asked them, 'Why didn't you enjoy it?'. They also found the little kids' games were too easy. We looked at visual components and the technology used in their construction, which materials might be most suitable, etcetera.*

The students' everyday knowledge of the scientific content of land environments was supplemented by a local area excursion. This out-of-school activity in their own environs allowed Olivia to determine their presenting knowledge and specific areas of interests. It allowed the students to share a common experience and provide Olivia with an opportunity to identify and clarify students' (mis)conceptions of scientific content. Olivia explains:

Extract Two

Olivia: *We went to Teatree Bay to look at coastal forms and they had to identify certain forms in the national park. We went up to Mount Tinbeerwah where we could see three of the four land environments: coastal, wetlands and woodlands. They could see the relevance of the activity and a lot of the kids said, 'We've been to Teatree so many times and I never noticed the little crabs running around the rocks'.*

Project – Phase Two (Student Practice & Overt Instruction)

In Phase Two, Olivia provided overt instruction in linguistic design of written text. Success in the culminating task, the production of a board game, required students to read and construct a range of written text. In Extract Three, below, Olivia recounts the project's evolution and her pedagogies for drawing on the students' practice as well as focusing the students on the linguistic design of written text production.

Extract Three

Olivia: When we got back to school, the students drew on their own experience plus their observations from the excursion and their research from brochures, books and the internet to formulate multiple choice questions for their board game. I got them to write a question straight away rather than teaching them the structure explicitly. We then looked at the structure of the questions they wrote and we wanted deeper questions that challenged and informed [game players]. We looked at what's not a good question, the need to have limited open questions, and how to inform people who are not familiar with the topic. We looked at using technical and non-technical language. We also looked at forming a definition within a question. This required students to explain technical language. For example, if the students were forming a question about crustaceans, some players may not know what a crustacean is, so we looked at forming a definition within the question. My strategy for this was getting the students to work individually to write a definition, then forming groups of two to refine it, and then join with another pair and refine it again. The kids found it more relevant because they were dealing with a topic and an activity they were interested in. We had a glossary of terms and a word bank and in the initial phase where they were writing their own definitions, a lot of those key words came out. Well the technical terms, for example, a woodland, and we can also call it a forest and a rainforest. Words we might associate with woodland might be undergrowth and what sort of animals and plants we'd find there.

In multiliteracies terms, the project moved into a productive phase of overt instruction, framed firstly by students' own practice *(I got them to write a question straight away),* and then the development of a shared metalanguage for text production *(definition, question, technical and non-technical language).* Of significance is the way students generated their knowledge from their points of inquiry. The pedagogical strategy that Olivia used showed her faith in the students as knowledgeable and as recognising their various stages of development. She did not launch into explicit modelling as is common place with more constructivist models of teaching and learning. Rather she gave time over to the students to develop deep understanding of the complex language of written science text and their variations across contexts of use.

The students were actively engaged in their learning as they negotiated the processes for making meaning, sought authorisation from various informational texts, including brochures, books and the internet, and drew on their own experiences. Informational books are crucial to science learning because they provide students with opportunities to experience the language that scientists read, write and talk. Importantly, this project allowed students to engage with the essential properties of professional science discourse, such as informational density, technicality, abstraction, and authoritativeness. These texts adopt a wide range of linguistic features that are seldom used in everyday informal spoken interaction and that students often find peculiar and alienating. For example, technical terms are often multi-morphemic and stem from Latin or Greek origins, and common everyday words have particular meanings in science (Fang, 2006). Science texts often use abstract nouns, extended noun groups and a passive voice, which makes it difficult for students to recognise actors and their actions (Fang, 2006). In addition to these more traditional texts, the students' informal personal experiences were also sourced and valued, thereby aiding the connection of out-of-school science with school science instruction.

Like real scientists who have to write to different audiences (for example presenting a media grab to the general public), these students were being required to frame their content knowledge in different ways, yet still adhere to the scientific habits of mind required by the discipline. The many acts of writing required a fundamental sense of literacy whilst also offering opportunities for reflection on the derived sense of literacy. The students were orientated to making meaning from an assortment of texts showcasing a range of scientific content as well as constructing texts that made meaning for a specific audience for specialised purposes.

Project – Phase Three (Overt Instruction & Critical Framing)

The next phase of the project orientated the students to overt instruction of linguistic, spatial and visual design of the technology component. Olivia continues:

Extract Four

Olivia: We looked at words like challenges and player pieces. The students had to devise rules, so we looked at the rules as a procedural text and we looked at examples and identified the key linguistic features. They then had to consider elements like the player pieces and challenges in each land environment. So they had to make it entertaining and identify a relevant challenge, like you couldn't get stuck in water in the arid interior. They even enjoyed the computer aspect. They had to type up the cards. We used powerpoint and printed out 9 slides per page and they enjoyed exploring the symbols they used on the back of the cards.

Project – Phase Four (Transformed Practice & Critical Framing)

Importantly, in the spirit of the collaborative principle underlying the *Learning Framework,* and because students benefit from explicitly understanding assessment criteria (Wyatt-Smith & Cumming, 2003), assessment criteria was co-negotiated with the students at the beginning of the project, and its contents were reviewed throughout the project. Also embedded within phase four was a critical framing component. Olivia exemplifies:

Extract Five

Olivia: I gave them the criteria sheet before we began. This was formulated by the students where the students looked at the appearance and the questions and the challenges and I added things like spelling in a real life situation and editing skills. They were given the rubric I was going to be assessing by, so we talked about it. So to achieve an 'excel' this is what I expect. So they went and assessed their peers. We had a day to play their board games, we had popcorn and it was a very noisy day. And they all received a criteria sheet where they had to assess two board games. We thought as a class if they had to create a board game for an audience of their peers why not let their peers assess it? The students loved it, and I think it was because it was hands-on. They enjoyed the construction of it as well. They became more interested and involved because they had to recreate and they could see the practical side of things. They had so much fun playing it. The parents were saying that the kids were playing at home.

Implications for the teaching of science in the middle years

In conclusion, this analysis adds to the contention that effective teachers of science recognise and provide carefully scaffolded instruction in a range of scientific literacies (Wyatt-Smith & Cumming, 2003; Hand & Prain, 2006), defined by Norris and Phillips (2003) as a derived sense and a fundamental sense. As Olivia exemplified, this is not so much a matter of adding a whole new strand to the curriculum as it is of foregrounding the literacy demands already within the curriculum. As evidenced, students need help to see more clearly what is expected of them for success. The point borne out of this analysis is that the fundamental sense of literacy, that is reading and writing, is a large part of what is considered 'doing science'. Thus, the relationship between reading and writing and 'doing science' is so intimate that great care is needed to maintain a distinction between scientific literacy in its fundamental and derived senses so that neither is supreme but both effectively co-exist in teaching and learning.

Another important finding of this analysis relates to Olivia's commitment to the four phases of multiliteracies pedagogy: student practice, overt instruction, critical framing and transformed practice. Phase One of the project, where the students played and critiqued board games and undertook an excursion showed Olivia's subscription to the power of student practice and critical framing where talk and experience are viewed as important mediums for sharing, clarifying and distributing knowledge amongst peers. The second phase foregrounded overt instruction for reading and writing science texts as an important discursive tool for organising and consolidating rudimentary ideas into scientific knowledge that is coherent, well-structured and achieves its social purpose. The third phase refocused the students on the teaching and learning for the technology objectives whilst the final phase allowed the students to showcase what it is they could now do and actively participate in its evaluation. This research adds to the growing storehouse of literature that confirms the route to scientific knowledgeability is through the development of students' skills with written text. Scientific literacy that attends to its fundamental as well as its derived senses addresses the anomalous and short-sighted view that scientific knowledgeability is acquired through isolated bits and pieces of scientific information.

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