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Bridging the Literacy Gap: Teaching the Skills of Reading and Writing as They Apply in School Science

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Whereas science teachers in the last century were trained to place empirical activities at the heart of school science (Yore, Bisanz & Hand, 2003) and give relatively less attention to language issues, fundamental literacy (as defined by Norris & Phillips, 2003) is now recognised as having a crucial role in learning science. However, there have been few research reports detailing just how experienced secondary science teachers go about teaching the language and literacies necessary for school science, especially for students who have low literacy skills. This paper explores the literacy-teaching practices of a teacher of "learning support" students during a double-period Earth science class. While the focus was on the science content, many reading and writing skills were taught either as part of the lesson plan or incidentally, thus ensuring that all students could participate more fully. Implications for science teaching and teacher professional development are discussed.

Keywords: Literacy, Pedagogy, Reading, Writing, Science Literacy

INTRODUCTION

The language and literacy aspects of science have attracted significant attention in recent years, with everyday literacy now recognised as an important tool for learning in science. For example, Norris and Phillips (2003, p. 224) argued that "literacy in its fundamental sense is central to scientific literacy" and Wellington and Osborne (2001) showed that the learning of many science students was impeded by their misunderstanding of everyday terms such as logical connectives.

Norris and Phillips (2003) made an important distinction between scientific literacy in the "fundamental" sense and scientific literacy in the "derived" sense. Hand, Alvermann, Gee, Guzzetti, Norris, Phillips, *et al.* (2003) explained it thus:

> *The international science education reforms enunciate the fundamental sense of [science literacy] as peoples' abilities, thinking, and emotional dispositions to make sense of nature and the communications to inform and persuade other people about these ideas, and the derived sense of science literacy as the understanding of the nature of science, scientific inquiry, relations among science, technology, mathematics, and society, and unifying concepts of science. (pp. 608-609)*

One could argue that the teaching of the language skills of reading, writing and speaking can and should be left to language arts teachers. Research in literacy education, however, suggests that language arts need to be taught across the curriculum, that, in fact, literacy is specific to each discipline (Yore, Bisanz & Hand, 2003); further, Lemke (2004) has argued that there can be "multiple literacies" in a discipline (Lemke, 2004), and that these can best be taught in context.

Moreover, bodies such as the National Science Foundation (NSF) in the USA believe that science should profit from recent research in language education research and this led to the setting-up of international conferences to bring together researchers in literacy instruction and in science education (e.g., Hand *et al.* 2003; Saul, 2004). The latter have argued that much is to be gained by teaching the literacy (or

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literacies) of science at the same time as the content, and that in fact, it is not possible to become science literate as it is understood in the 21st century without the development of student skills in reading, writing and argument.

Yore *et al.* (2003), writing about research on "the literacy component of science literacy" addressed the research on reading and the research on writing in school science separately. With regard to research on reading instruction, they reported that there has been increasing recognition among teachers that reading is an active feat of meaning-making rather than the simple, transparent task that it was seen as previously. They argued, however, that success in reading should not be seen simply as the aggregation of skills, but as an interpretation process requiring both metacognitive awareness and control. The process, according to van Dijk and Kintch (1983, cited in Yore *et al.,* 2003), involved interpreting the print text, remembering prior knowledge of the topic, and recognising the limits of the sociocultural context. Thus comprehending a science text required a reader to access the cues in both the textual and sociocultural contexts, and to activate both the content and literacy areas of memory and to integrate these to achieve the most meaningful reading possible. Yet science teachers may argue that instruction in reading is not properly part of the science teacher's role and should be left to language arts teachers.

In countering the latter argument Kamil and Bernhardt (2004) report that the skill of reading an informational text, crucial for science as a "critical mediating factor in the storage, transmission, and retrieval of scientific information" (p. 138), is not well taught elsewhere, since it demands reading skills specific to the area of science. They argue that "[c]urrent reading instruction deals primarily with the generalisable reading skills, not with those specific to genres" (p. 130), leaving students unprepared for difficult texts which they then find boring. They implied that what is needed is discipline-specific knowledge about how the various factors involved in reading comprehension interact in content-specific texts, and the explicit teaching of such content-specific comprehension strategies. This is because a different combination of genres is used in different content area texts, depending on how inquiry happens in that discipline. They wrote, "Combined with the notion of understanding the structure of domain knowledge, genre knowledge is a key to comprehension. Becoming familiar with the way in which texts are structured is one more parallel to understanding the discourse of science inquiry" (p. 127). In a similar vein, Lemke (1990) emphasised the significance of knowledge of the specific genres found in science for reasoning in science.

These days, however, reading in science needs to be expanded to take in the multiple modes of communication. Hand *et al.* (2003) comment that language arts have now been expanded to include representing, and viewing as well as speaking, listening, reading and writing in science classrooms. However, rather than seeing these as separate skills, it is more likely that they will be used in combination and hence the teaching of reading needs to take this into account. Lemke (2004) reported that one aspect of reading that differentiates science from other disciplines is the multimodal nature of most science texts. It follows that literacy-related science instruction must go beyond traditional reading, writing, and talking tasks to include instruction about "reading" the significant portion of science communication that is multi-modal (cf. Saul, 2004).

With regard to writing, Yore *et al.* (2003) found that, in parallel with an improved understanding of the complexity of reading, there has recently been an increasing understanding of the power of writing-to-learn (Tynjala, Mason & Lonka, 2001). The knowledge-transforming model of writing described by Yore *et al.* (2003) includes a more explicit focus on the tools of language and on developing metacognitive awareness and control by the students of the writing process and writing strategies. This did not mean that science content became any less important since such work was centred on authentic science inquiry. Yore *et al.* further argued that an increased focus on literacy would not diminish scientific literacy in the traditional sense. They stressed the importance of convincing teachers that these aspects of science literacy can empower future citizens to be scientifically literate in a more authentic way.

According to Bernstein (1990), children of middle class families were likely to be pre-socialised into "official pedagogic communication and the inner structure generated by its pacing rules" (p. 78), whilst children from "disadvantaged classes and groups" (p. 78) were doubly disadvantaged, as not only were they not equally socialised into the discourse of schooling but they were also affected by the sequencing and pacing rules of schooling, which meant they quickly got behind and missed out on accessing deeper levels of meaning.

Because Gee (2004) believed that the majority of students may have significant problems with specialist academic discourses such as (school) science and history, he introduced the need for lessons on "expanded texts". He saw the problem as a matter of different "social languages" that needed to be learnt for use in different social contexts, each with its code, that is, its own "grammatical patterns and styles of language (and their associated identities and activities)" (p. 14). He argued that until students are exposed to the "expanded language" of the written code, they will not be able to argue clearly and unambiguously and make real progress in understanding the finer distinctions

involved in what they are learning. He then went on to point out the pedagogical implications of this claim in terms of the need for explicit teaching as part of "reading lessons" on "expanded texts", highlighting the genre conventions of discipline-specific written texts. For Gee, success in argument depends on knowing the formal code of a discipline and thus is enhanced by expert teaching of how to read science texts.

Roth (2004) added another element when he argued that gestures which accompany talk in school science were important for students grappling to communicate their understanding of scientific concepts and hence that iconic student- generated diagrams were a stepping stone between these and formal written communication in science. He advised that "[s]cience and literacy educators ought not to overlook the complexity of the change from spoken to written language" and should make use of this intermediate stage of student sketches. As with reading, oral argument and writing in science also need to be seen as necessarily multimodal.

In spite of these more sophisticated understandings of the importance of fundamental literacy skills in the learning of science, Yore *et al.*'s (2003) review shows that this is not yet mainstream in the science education research literature. National and international Reading Associations produce monographs on such topics from time to time (e.g., Santa & Alvermann, 1991). In these there are excellent examples based in science classrooms of how to teach reading for comprehension (e.g., Aulls, 1991) or conceptual change (Roth, 1991), and using writing for learning science (e.g., Santa & Havens, 1991). Programs are now readily available for integrating the teaching of science with the teaching of literacy (see Thier and Daviss's (2004) text for "using language skills to help students learn science" in the USA and AAS's (2007) "Primary Connections: Linking Science with Literacy" in Australia), with activities and/or lesson plans and modules provided. These may be readily accessed by primary teachers who are generally teachers of language arts at the same time as being teachers of science, and who may even prefer this way of teaching science. However, as long as middle years and secondary science teachers see rivalry between language and inquiry with respect to the central focus of classroom science, as Osborne (2002) suggests, they are likely to see literacy teaching as being the domain of language arts teachers.

However, as has been suggested above, literacy in science is different from literacy in language arts. For example, Kamil and Bernhardt (2004) cite research that shows that informational texts, which are often central to work in science classrooms, have a very minor place in the language arts curriculum and hence students do not have much practice in reading or writing them. In primary school classrooms, where the science teacher is often the language arts teacher, students may receive the help they need to comprehend these dense, complex texts, and write notes and reports, but in secondary schools, teachers who have had no specific training in teaching reading and writing, are often at a loss, or, rather, mistakenly take for granted that students will have the necessary skills to comprehend science texts and write notes and reports and read and answer questions in written examinations. What is needed is a range of examples at the secondary school level of approaches to integrating the teaching of science with the teaching of the related literacy skills. That is where this article fits, as supplying one example. It is a detailed example, showing, in the minute-by-minute dialogue of a lesson, how science learning is enhanced when the teacher helps students develop the literacy skills they need to handle the reading and writing tasks that are part of a lesson on weathering.

METHOD

In this article I document the literacy-teaching practices of a teacher of students deemed to need "learning support". The teacher, Mrs Donna Savige[1] (DS in the transcript excerpts), was recruited as part of the larger "Exploring Motivation in Science" (EMS) project, reported in more detail elsewhere (Hanrahan, 2006a). Teachers in this project were selected because they—or their colleagues—were reasonably confident that practically all their students in at least one class were positively engaging in learning science. Because I was interested in access and equity issues, I was looking for classes that included students from a range of sociocultural backgrounds, levels of educational advantage/disadvantage, and likely fit with school science.

Mrs Savige had been recommended to me by an administrator in a school in a lower socio-economic status (SES) area, because he was impressed by the inclusive and skilled nature of her teaching. I visited a class to observe the teacher in action and interviewed her in depth after the class to get information about the local, institutional, and social context back-grounding the lesson observed. Both the lesson and the (1½ hour) interview were audio taped and later transcribed, after which they were checked by the teacher for content accuracy, but no changes were requested. I used N-Vivo software to help me categorise the teacher's practices and identify any literacy teaching episodes. The latter were interpreted in the light of both the literature on literacy in science and my prior experience as an adult literacy teacher. Then, as I analysed the discourse within these episodes more closely, I identified further literacy teaching practices addressing finer points of science literacy.

The lesson I observed was designed to have as much in common with regular science classes as possible so,

Table 1. Stages in DS Lesson Year 10 Sci004 Unit on Geology

1.	Pre-lesson as students arrive: settling students down as they gather outside the classroom
2.	Greeting the students and bringing them into the classroom
3.	Transition into the lesson
4.	Beginning the lesson on Earth science
5.	Looking at the heading structure
6.	Building interest by relating to everyday life
7.	Reading the introduction and introducing the idea of weathering
8.	Making notes on a worksheet
9.	Reading about frost action
10.	Highlighting a process
11.	More writing of notes on the worksheet
12.	Answering text-book questions in the notebook
13.	Representing new learning on a concept map
14.	Updating the vocabulary list
15.	Checking progress on a flow chart
16.	Concluding the lesson and distributing awards for appropriate behaviour

based on advance advice from the students about what they valued most, it was taken by a regular science teacher using the regular science textbook and in a science laboratory, not in a "learning support unit" classroom. On the other hand it was designed to be manageable by special needs students (e.g., having a "resource" teacher as well as a science teacher, and addressing only half of each unit (module of work) in the time normally allocated to a mainstream class).

Hence the context was not that of a typical secondary science class, since both the teacher I observed and the students were atypical, and other features of the class, including the curriculum and the way the teacher communicated, had been adapted. The class observed was co-taught by the two teachers, with the teacher I interviewed, a part-time teacher called Mrs Donna Savige being the main teacher for the two days a week that she met with them. She had previously been a science teacher but had more recently taken a Diploma in Resource Teaching and become part of the "Learning Support" (LS) team at the school, thus allowing the school to offer LS Science as well as LS English and Mathematics in what was a large high school in a lower SES area in the state capital. The second teacher unobtrusively supported students individually during the lesson as they needed it, with part of her role being described by Mrs Savige as "putting out bushfires" as they spotted and before they had a chance to flare up and seriously disrupt the lesson. The students were in the class not so much because they were slow learners but because they were at risk of failing in regular classes for other reasons, such as behavioural or literacy problems. The students were in Years 9 and 10, and about half the class (of whom nine were present on the day of my school visit, eight boys and one girl out of a possible 11) were English as a second (or further) language (ESFL) speakers, including two Aboriginal boys and two Samoan boys.

This was the last of four modular units offered to such students in Years 8 to 10. Students were not given homework and left both the textbooks and their notebooks (both of which were provided by the school) with the teacher between classes. The lesson, a double period theory lesson, addressed the "Earth and Beyond" content strand and, more specifically, the concept of weathering. Mrs Savige stated her goals as being "to get the nitty-gritty about the kinds of weathering that we were looking at but also to relate it to their own experience as Australians" [DS interview, lines 30-31]. She also mentioned a conscious goal of drawing their attention to the structure of the text.

FINDINGS

I will first summarise the stages in the lesson, paying particular attention to language-related episodes, and giving examples of how Mrs Savige helped the students with reading comprehension and writing skills. Then I will summarise the types of literacy-related skills that she addressed during this lesson.

The first three stages of the lesson consisted generally of conversational exchanges with individual students about administrative/procedural matters. Then the lesson began with an update of where the class were up to and what they did in the previous lesson. The teacher maintained a conversational tone throughout the lesson engaging in real dialogue with the students who frequently initiated questions. (See Hanrahan, 2006b, for an analysis of the teacher's style in terms of equity and access.) Reminders and corrections were interspersed with instructions and exchanges whenever students' attention wandered or they behaved inappropriately.

Skimming for an overview of the structure of the chapter

The first literacy teaching strategy used was a reading one, as the class prepared to read a text-book chapter as a whole-class activity. Mrs Savige drew the students' attention to the headings as they leafed through the chapter as a whole class activity, in order to help them get an overview of the structure of the chapter (and hence the unit). Then she read out the headings with some assistance from students who called out. This is an

important reading skill since any new scientific terms to be introduced to the students will have their discipline-specific meaning within the larger structure of the science topic of Earth science. Hence this is a way of beginning to build up what Lemke (1990) called the "thematic pattern" of a topic. If students can distinguish between major headings and minor headings, they will also begin to be aware of a hierarchy within the geological classification of weathering. When Mrs Savige was drawing attention to the four major headings, she commented on the way they were formatted and the sub-headings that appeared under each. My experience with adult literacy students tells me that without this activity, students with a low literacy level would have been more likely to see the whole chapter as undifferentiated new content, just hundreds of new facts, one following the other, and, as such, overwhelming. The episode proceeded as follows[2]:

DS Okay, page one-fifty. We're going to have a look at the structure [.] *of the chapter: major headings, minor headings and get some idea as to where we're heading.* [1] . . . *Now, |if we have a look, page one-fifty, it starts off with*
S |[indistinct]
DS "Wearing away Rocks"↑ That's a major heading. It's done in [.] *a block capitals.* [1] *When we go through one-fifty-one,* [1]*there's a minor heading "Cracks in Rocks". Over the page, one-fifty-two, "Chemicals and Rocks": one-fifty-three: "Limestone Caves". . . . "Rocks and Plants". one-fifty-four . . . "Weathering" at the top of one-fifty-four. Then we have another* ***major*** *heading. . . .*

*So, we, that section finishes "Wearing away Rocks" and then we start the heading "Erosion". . . . Right, and we've got some minor headings under Erosion: "Transportation↑"—some big words here—"****Dep****osition"* [1] *deposition—sounds interesting.* [2] *Over the page, another big heading: "Sediments". . . . "Layers of Sediment." Over the page, page one-fifty-eight: "Ayers Rock." . . . . Uluru. ...Okay, we've got "Layers of Rocks" and we've got "Layers of Rocks* ***Bending****". . . . Page one-fifty-nine at the top . . . . We've got "Joints and Faults", a major heading↑, and we've got "Rocks Bending and Breaking". And then, over the page, there's the activity that we will be doing at the end of this. And then a heading on page one-sixty-one: "Cycling* [.] *Sedimentary Rocks", looking at the cycles.* [Lines 194-241]

Mrs Savige does not leave it there, however, with the students as passive recipients of this structuring, but challenges the students to find the four major headings for themselves, so that they can see where the work to be covered in this double period fits. Connections have also been made to recent work on different types of rocks:

DS Where have we heard the word "sediments" before?
S Yeah, I know where.
DS Sedimentary rocks?
S Yeah, I have.
DS Okay. And have a look, we've got [.] *in the pictures there you can see rocks in all sorts of layers. We're used to seeing that when we we're talking about sediments.* [.] *So some of this* [.] *we will already* ***know*** [.] *something about it. "Layers of sediment".* [Lines 218-224]

New terms have been heard, even repeatedly (e.g., weathering, erosion, deposition, sediments, joints and faults), and enunciated clearly with emphasis so they will be more familiar when the reading of the chapter takes place, but without pressure at this stage to remember the actual terms. As well, hints have been given about what is to come, ("And then, over the page, there's the activity that we will be doing at the end of this" (p. 234)), and Mrs Savige possibly hoped that interest has been raised about some of what the students have heard and read and that students may be thinking such things as "Why would there be `cracks in rocks"'? "Can rocks actually bend?" "What's it like inside a limestone cave?" Students have also had their attention drawn to text formatting ("block capitals"), an important cue for the finer points of reading comprehension, such as noticing different levels of headings. Finally, for students who want to experience a real science class, scientific terms are being introduced, such as "chemicals", which should reassure them that they are in a science rather than a "learning support" class.

Vocabulary-building

Some hints of vocabulary building are evident within this reading episode (even though others have been omitted for the sake of brevity), for example, the introduction of new scientific terms such as weathering, erosion, deposition and abrasion, the differences between which will be explored later in the lesson., as also will be the difference between "abrasion" and "abrasives". During the lesson it is notable that any new words introduced are elaborated on: students are not expected to acquire new vocabulary without multiple connections being made between each new word and their prior experience.

Another feature of this class was that students felt able to challenge the use of words. A challenged the use of "trapped" for water caught in cracks. Interestingly, Mrs Savige's response was unusual in comparison with science teachers who may treat the scientific meaning as the only valid one. She did not insist that she was "right" and hence imply that the student was "wrong", but rather treated the situation as a case of usage, thus implying that it was a convention in science rather than a case of right or wrong. In this way, she avoided one of the common ways of alienating students: assuming that the scientific meaning of a word is the only "right" meaning.

DS [1] *So* [.] *we have a process. First thing that happens is "Water is trapped" . . . .*

S [Indistinct: not really trapped, it's not]
DS Well, when it can't get away, we use the word trapped.
[Lines 849-862]

Connecting to intertextual meanings

An important skill in reading is relating the content of a text to prior knowledge so that its full significance can be recognised. According to the interactive-constructive model of reading referred to above (e.g., Yore et al, 2003), words do not have meaning in themselves but have to be interpreted in relation to the text in which they occur, to prior episodic and semantic memory, and to knowledge about the immediate sociocultural context. Mrs Savige commented in the interview that some of the students have few prior experiences relevant to the science content and hence need additional help in relating new learning to old. One of the ways she created significance for the students, was by telling them stories they could relate to, in one case, about her recent trip to Uluru, a geological feature in Central Australia managed by Indigenous people. Several of her students were Indigenous and this would have had special significance for them, and indirectly for the non-Indigenous students because of their Indigenous class-mates.

DS And today [.] we're going to focus on the first one [2], but before we do [.] um, [.] one of the reasons why I find this section of work really interesting is because Australia, our country..
S |[Indistinct]
DS is considered |to be [.] I was born here too, David. [.] Okay?
S [Indistinct]
DS It's considered to be [1] the oldest [.] continent, the oldest country on the planet, and for that reason, sh, for that reason, [.] weathering has been happening here longer than it has almost anywhere else. So when we're talking about rocks weathering [.] right [.] we're talking about what's been happening to Australia for a very, very, long time. Now, as I said to you just recently, I was out at Uluru.
S Uluru
DS And I brought back some books.
S Can we have a look?
DS Yes, we're going to have a quick look through these because [1], all right, Uluru holds a fascination for most Australians and it's there because of weathering, and weathering is one of the things we're going to [.] to study.
[Lines 259-275]

Along with the books, at this point in the lesson, Mrs Savige showed the students satellite maps of both Central Australia and their local area, pointing out features of the landscape that show weathering, such as the remaining core and rim of a nearby ancient volcano that the students have studied previously. She also gives other examples in the Northern Territory and New South Wales interspersed with travel stories and/or descriptions that include many of the key words in the text being read.

This relationship between a text and related texts has been called intertextuality. Defined broadly, it refers to all the other texts that a given text depends on for reader understanding, which Fairclough (2003) describes as "the dialogicality of a text, the dialogue between the voice of the author of a text and other voices" (p. 29). For example meaning in a textbook chapter might depend on the reader having read earlier chapters, having conducted an investigation in an accompanying practical workbook, or being aware of the periodic table of elements. When I refer to inter-texts, I mean all the other texts referred to explicitly or implied in a given text.

Another intertextual allusion Mrs Savige makes (and I know of its pertinence for this class because during the interview she referred to the fact that most of the students are currently taking woodwork as a subject) is to sandpaper, to further connect them to the idea of weathering, the main topic, and to the sub-topic of abrasion.

DS Thanks, David, you can keep reading. That last paragraph
S [Sound of reading, indistinct] is called abrasion [Indistinct, but sounds like another two or three sentences]
*DS Good. . . . . There's the "wearing away by substances rubbing together is called a**brasi**on".* [.] *Okay, so that is any kind of wearing away when things rub together. So any sort of sandpaper effect,* [1] *ok, where you have those small particles* [.] *bumping into and grinding at* [indistinct] *is called abrasion.*
S And what's this one, miss?
*DS And **abrasives*** [.] *are the substances that **do*** [.] *the abrasions*
S [Indistinct]
DS Mm, it has friction between the two. [Lines 575-587]

Another example comes soon after, during a note-taking exercise:

DS [Much expression and emphasis is used during the following monologue.] *Now, one thing it didn't talk about* [.] *was glaciers,* [1] *okay? And glaciers occur* [.] *in* [.] *shallow-bottomed valleys, where they have a lot of snow on the mountains and the snow packs down* [1] *and the snow packed down into ice and gradually moves down the valley. As it moves down the valley, it picks up rocks, and stones, and grit, and sand,* [.] *and because it's moving down the valley very slowly, those rocks and **boulders**, on some occasions they actually **grind** into the bottom of the valley. And if you've been—if you ever get the chance to go to a valley where there **used** to be a, um, glacier, you can actually **see*** [.] *the lines of, of where the rocks have been **dragged** across the surface of the bottom of the valley. And that's very similar to sandpaper. You know if you get a really coarse sand-paper?* [.] *and drag it*

across a smooth surface, you have all of those [.] *lines that you've dug into it. Well, that's what a glacier can do, because it's very heavy, it's got very, you know, it's really thick ice,* [.] *um sometimes hundreds of metres thick↑, bearing down↑ and it has, a, these big rocks and boulders in the bottom of it, being dragged along. [Lines 708-721]*

Similarly when reading about "wave action", she compares it to their probable experience with surfing and feeling the force of a wave against their bodies, but noting that that's just an ordinary wave without the force of some of the waves full of sand and grit that pound against some cliff faces, especially during storms. The reading of the chapter is continually interrupted for similar graphic explanations of key concepts.

Later in the lesson, during the reading relating to frost action, Mrs Savige arouses the students' attention by explaining that they will not be doing the activity in the text-box because is it now considered too dangerous. In making such allusions, even though they do not have the hands-on experience, Mrs Savige has provided some intertextual context that will make the next section more meaningful for the students. Not only that, she makes this explicit for the students ("in this section, `Cracks in rocks,' it assumes that you might have done that experiment" [lines 86-87]), thus helping them understand something of how texts work, with one section being dependent on another if it is to be understood as the writer intended.

Reading the introduction as an introduction to the idea of weathering

After noting the overall structure, reading the detail follows. In line with her goal of helping students not only read for meaning, but also read to notice how the genre of a textbook chapter is written, Mrs Savige instructs the students to look for something that sounds like an introduction to the idea of weathering:

DS . . . . This first section is the introduction to the idea of weathering↑ . . . .
DS Ian, would you like to start reading for us?
S Where [indistinct] Miss?
DS Wearing away rocks. Okay. Page one-fifty. And we're looking for the sort of information that we would find in the introduction.
S "The photograph below shows rocks that have been worn away. This wearing away proceeds [indistinct] a long period of time. [indistinct] What do you think has happened to wear away [indistinct] rock?"
[Lines 443-458]

This is a signal for Mrs Savige to draw students' attention to the photograph and to teach some visual literacy, or in fact, multimodal literacy since the text and picture must be read together (see Lemke, 2004, above). Some teachers would expect students to take in what they need to from the photograph without further comment but this LS teacher knows that this is a literacy skill that her students will not necessarily have. She gets the students to look at the photograph in detail by asking a series of questions about what is in the photograph, why the cliff face is there in the landscape, what may have happened to it previously over a long period, and even whether the students would sit on the rock ledge in question themselves (why or why not?). As Lemke (2004) pointed out, recognising the importance of "visual representations of many sorts" in written communication in science is an important literacy of science and one that needs to be taught explicitly. Mrs Savige appears to appreciate this fact, both during reading and when getting students to make diagrams to accompany their own notes (see below).

Later, she explains to the students why they will not be viewing a film strip she had planned for the class and comments that this is disappointing because it was a great film strip and now they will have to get the information from the text instead. This should suggest to the students that visual information is a valuable way of learning and that the text is to some extent a substitute and perhaps a less satisfactory way of obtaining the same information, thus reinforcing the point she continually makes that it is their understanding of the science that is important, not rote learning a particular arrangement of words. This does not mean that she does not emphasise scientific terminology. On the contrary, she finds every opportunity to revise each of the key geological terms and their relationship to each other, including in anecdotes she recounts, in dialogue with the students (e.g., as they look at photographs in the illustrated travel books she has brought to the class), and by having students read and write them several times in different contexts (in the text, on the worksheet, in their notebooks in questions to questions, on the concept map, and in additions to their "vocab list"). The term "weathering", for example, appears 33 times in the audible part of the transcript. What she probably does not want is to have students think they will know something simply by reading the text-book at a superficial level.

The next move is significant for two reasons. Firstly, Mrs Savige is promoting the idea that a text is interactive—this one explicitly so—and that readers have to play their role and put questions to themselves about what they are reading. Secondly, during reading she scaffolds the students through the process of connecting the photograph to the concept of weathering:

DS Okay, let's stop there and answer that question. What do you think might have happened? [.] to form that rock ledge in that photo? [Quickening her pace] First of all, do you think it was always like that?
S No.

S Can I read again, miss?
DS In a minute, you've got to answer the question. What do you think has happened to make that rock formation? It's up in the mountains. [.] Does it look like a place that might be cold in the Winter?
S Yes.
S Yes.
DS Possibly↑ Or would they get—what sort of weather would they have? Would they have lots of rain?
S Yes.
DS In a [Indistinct] of wind?
S Yeah.
DS So what would happen. What has made those rocks look like that?
Ss [Silence]
DS The wind? The wind blowing what?
S Eroding the earth and the dirt.
S Blowing the dirt
DS Do you think that those rocks that are sticking out? Are they [.] harder or softer [.] than the rocks that are gone?
S Harder.
S Softer.
DS They would be harder. The rocks that are underneath that have worn away would be the softer rocks. You're right. Would you be keen to be that person sitting out there on the edge?
S Yes.
DS Yeah? I wouldn't. I'd I'd be much, rather be back at the top of the photo there where that other person is standing, on the [Indistinct]. Do you think at some stage in the future that might just topple into the valley?
S Yep.
DS Probably. [.] Things like that have happened.
[Lines 459-491]

After a student has read a little further on, Mrs Savige again stops the reading to make sure the students understand that the text refers back to the same picture. More significantly she does some "talk-aloud" to demonstrate her thinking process when she reads something which does not seem to make sense, a comprehension repair skill that poor readers are likely to lack:

*DS Just a minute, David. Just stop there. It says, it says. "**the** cliff face was worn away by the action of waves and sand particles in the wind." **Which** cliff face are they talking about?*
Ss The one in the picture.
DS Do you really think that there were waves anywhere near?
Ss [Various answers] Yep. Nope. [Indistinct] *Ice Age.*
DS Probably, yeah, yeah, maybe that's. Yeah, cos I looked at that and I thought that's not a cliff at the beach.
[1] *But yeah, maybe, end of –*
S [Indistinct]
*DS That's right. So **may**be that one was formed by **wave** action, but not in **our** lifetime.* [Lines 557-566]

Similarly with text, Mrs Savige helps students make the necessary connections, and at the same time understand that this is how such a text works. She has explained that this section is an introduction designed to get across the idea of weathering and now she is helping the students understand that, as well as using photos, the writer is reminding them of experiences that can help them connect to the idea being introduced:

S "Have you ever been on the beach and had sand blown in your eyes" [Several more sentences are read, all indistinct]
S Eyes.
DS And why would they be telling us about sand and dirt and grit damaging our eyes? when they're talking about wearing away rocks? [Lines 500-504]

As is recommended in the literature on reading, Mrs Savige is helping the students understand reading as an interpretation or problem-solving activity, one in which they need to work out what the writer is trying to communicate, based on clues in the text, such as that this in part of the introduction to the chapter, and other information they may have, such as prior experience of what it felt like to have the wind blow sand into their eyes. In this case, the text explicitly asks questions to help in this process, but, even when it does not, Mrs Savige, is teaching her students about the interactive nature of reading, especially for illustrated, informational science texts.

Note-taking: Writing about abrasion

The note-taking referred to previously happens as the students write on a prepared worksheet with Mrs Savige supporting those who get left behind. She first gives students ample time to write their own notes before writing on an overhead transparency (OHT) on the overhead projector. Rather than have students copy notes directly from the board or an OHT, Mrs Savige works with them to help them understand that the reading, note-taking and talking are all inter-related and that when they write notes, it is to help them remember what they have been reading and discussing:

However, with this class, much individual attention is needed before all students understand where the note is to be written. For these students, co-ordinating the reading, discussion and note-taking around an unfamiliar topic in which new abstract words are introduced is a difficult task. It would have been simpler to make each a separate task, but then the inter-relationship between the three tasks would have been less clear, and the point of note-taking as an active way of assisting in remembering what one has read would have been lost. Mrs Savige makes this reading

comprehension-note-taking process explicit and scaffolds it step by step.

Several notes are made during the reading but as they stand they are not complete without one further step. Another of the literacies of science is illustrating the phenomena being written about. Mrs Savige encourages the students to draw little sketches that will represent visually what is in their notes. Even if the resulting diagrams are not clear to anybody else, the very act of attempting to transform the verbal information into a visual form will help fix the imagery and the facts in each student's mind in association with the notes on abrasion.

DS Now, what I'd like you to do over here, is just draw a simple little diagram or two that will help you remember [.] *what those notes mean. So for instance, with the, um,* ***wind***↑*, you might, sort of , you know, draw a bit of windy looking stuff with sand and grit being blown along.* [1]

S [Indistinct] *miss? We draw that, miss?*

DS If you want to↑*. The ocean waves, you could draw um,* [.] *a cliff* [.]*with um,* [.] *ocean waves coming up and pounding on to it. Like this - and draw some grit* [.] *in the waves.* [.] *Just to remind yourselves* [.] *what it looks like. If you want to have a go at the glacier, you could draw some* [.][.] *chunky rocks and boulders* [.] *that are imbedded* [.]. *Right?* [.] *and being dragged along.*

S [Indistinct]

DS I'm not very good at drawing diagrams. You might like to improve upon [.] *Okay, just draw yourself a couple of little diagrams there to help you remember.*

[Lines 724-737].

The activity also models for the students that, just as writing full sentences from the text-book is not required, neither is artistic ability necessary, since the point of the activity is that the notes are for their own understanding and to help them remember what they are learning.

Reading about frost action

The reading and note-taking are alternated. After this episode of note-taking, the next part of the reading dealing with cracking of the rocks is read as a whole-class activity, with continuing elaboration and repetition of new vocabulary (e.g., "shattered") and concepts ("e.g., frost action"), and attention being drawn to how the text is structured (see above in the section on intertextuality).

Highlighting a common genre in science: A "process"

Reading comprehension of informational texts is facilitated when students become aware of top level processes that can be found within paragraphs (Bartlett, 2003). As the students read further about weathering, Mrs Savige draws their attention to a genre that is common in informational writing in science and one (which I later learn in the interview) that they have met before: a process, in this case the process of frost action, which Mrs Savige then helps them review step-by-step:

DS Okay, Rose, can you read that last paragraph [indistinct] *weathering, please?*↓

S [Indistinct, but there is much expression in the voice]

*DS Good. And there's a process—shh, that's enough thanks, Rose, there's a ...****process*** *in that paragraph*↑*. Steps in a process. See if you can identify them. It says*↑

S [Indistinct]

DS Sometimes, yep, water gets trapped inside a crack in the rocks. That's step ***1****. Very cold days, it can freeze: step* ***2****. What happens when it freezes?*

S It expands

DS It ***expands****: step 3*↑*. And expansion can?*

S [Indistinct] *shatter.*

DS Shatter it—force the rock apart. And the rock may even be ***shattered*** *by the force of expanding ice!*

[Lines 810-824]

The process is reinforced a short time later when the students make notes on it on their worksheet. Further consolidation happens when Mrs Savige encourages the students to draw a diagram to illustrate the process, reminding them again of the purpose of the drawing being to help them understand what they have just read:

Answering text-book questions in notebook

Ostensibly "as a break from our note-taking now", but probably as a way of having each student revise and consolidate some of the knowledge gained through the reading and discussion, not to mention as a rough check on how much the students have understood, Mrs Savige has the students answer two questions from the text book in their own notebooks, questions which require understanding of what they have been reading. The first is a question about the photograph at the start of the section: "What do you think has shaped the cliff face?" During this process, she incidentally revises another school literacy: how to use the stem of a question to begin to write an answer. Just as importantly in terms of the literacies of science, she is also making students a little more aware of an aspect of science writing that is unlikely to be very familiar to them, viz, the passive voice:

DS Okay, let's take a break from our note-taking now and answer some questions. [2] [Indistinct] *You need to turn back to your notebooks where we put our* [1] ***heading***↑. [.] *We're going to answer Questions 1 and 2. Ian?* [5] [Lines 870-872]

DS [.] *Okay, just talking about that cliff face. What do* ***you*** *think has shaped the cliff face?*

Ss [Some low talk continues]

DS Shh. Have a look at your notes and come up with some answers. How would we start [.] *that question if we have to answer it. I won't* [.] *I won't get you to answer it in a full sentence but if we* ***did*** *have to answer it in a full sentence, what words from the question would we use? ...It says, "What do you think has shaped the cliff face?"*
*S [*Indistinct: *Do you mean?]*
S [Indistinct]
DS Good. That's a good start [.] *to the answer. "The cliff face was shaped* ***by****".* [Lines 900-910]

The passive voice (e.g., "was shaped by something" rather than "something shaped") is typical of traditional scientific report writing and is probably second nature to science teachers, so much so that they do not realise that this form of expression is not likely to be familiar to disadvantaged students in a low SES area. This is part of what Bernstein (1970) was referring to when he wrote about elaborated and restricted codes, which act to the detriment of children from lower SES backgrounds. Normally the elaborated code is expected and taken for granted, thus making it invisible. However, because Mrs Savige has altered the "pacing rules" in her class (halving the amount of content) she has the time to make visible the elaborated code and take her students further towards understanding the more abstract levels of knowledge. This has, of course, to be seen as operating within the limits of the further disadvantage of her "learning support" class.

Both during note-taking and here, Mrs Savige has stressed that the students are writing things for themselves, to help them remember what they are learning. Because of this they are usually given a choice about how to word what they write. During this question answering segment, she makes many efforts to get students to find their own answer before she provides one.

There are some occasions when she does consider it worthwhile to get the students to write a full sentence, such as when an explanation is required for an event. She has used the word "because" two dozen times since the beginning of the lesson and students have used it as well, but now she is helping them to write a formal sentence linking a cause and an effect, an important part of "talking science" (cf. Lemke, 1990). Given that Wellington and Osborne (2001) have reported that many senior science students have difficulty with a range of connective words, it makes sense that students at this level may need help with framing an answer that contains both the stem from the question and an explanation.

DS [.] *Question three.* [2] *I think it's worth writing a proper answer for something like this when it's asking us for a* ***reason****. How would we start our answer? Listen to the question again. "Rocks found in alpine areas have more cracks* [.] *than similar rocks found in coastal areas."*
S Okay, rocks in alpine areas will [1] *crack with um* [.] *crack* [.] *because of the weathering* |[indistinct] .
DS |*Because* [.] *right* [.] *bec****ause*** *is the word that we're after in our* [Indistinct]
S Because [Indistinct]
DS [Indistinct] *the difference about the weathering.*
S [Indistinct]
DS Okay. So let's write up on to the [.] *We'll start off with* [Indistinct] *"Rocks found in alpine areas have more cracks be****cause*** *[9]. Right, now "because" is the word that we* ***need*** *in that sentence because it's asking us for a* ***reas****on* [.] *and our reason needs to include something about* [.] ***ice*** [.] *melting and freezing and melting and freezing.* [1] *Okay?* [.] *See if you can finish that sentence.*
[Lines 1032-1048]

Another literacy of science that is addressed briefly during this question-answering phase in the lesson is the use of grammatical metaphor, more specifically, of nominalisation, that is, the use of an abstract noun to represent a previous action or process as an entity, a thing (cf. Gee, 2004). This is a particularity of science writing that makes for efficiency in explanations but is difficult for students to understand, especially when their written English is much weaker than their oral English. Nominalisation is used much more rarely in spoken English, especially in what Bernstein (1990) would call a "restricted code".

DS Okay, 2(d). "When water freezes it something?"
S [Indistinct]
DS What does it do?
S It expands.
DS What does it do? It expands [.] *all right* [.] *we'll find that word in our notes* [.] *"expand" –when the water freezes it expands. This* [.] *something* [.] *can cause rocks to split open.*
S The change in temperature.
*DS Yes, what does it say in your actual text? This ex****pan****sion-----*
S Expansion.
*DS They use the word "ex****pan****sion"*
S What [.] *expands?*
DS [Indistinct] *and expansion* [.] *the verb and the noun. Expansion.*
S So expands and expansion.
*DS Yes. When water forms ice it expands. [3 This ex****pansion*** [1] *can cause rocks to split open.*
[Lines 984-999].

"Expansion" is an example of an abstract word which sums up the previous sentence, the kind of discourse that helps a scientist make an argument clearly and succinctly through nominalisation of an earlier-mentioned process (cf. Martin, 1990, cited in Gee, 2004).

Table 2. Literacy teaching foci and strategies observed during the class

Domain	Lesson focus	Literacy teaching strategy	Inferred goals
Vocabulary building	Multiple meanings of a non-technical term	Distinguishing between two meanings of a word, each in its context	To build up awareness of words and the ways they can be used
	New technical terms	Repeating, discussing and making notes on new technical terms	To build students' familiarity with scientific terms
	Closely-related variants of Latinate words	Showing how a similar-sounding word can change its meaning as its ending changes	To help students distinguish between related, similar-sounding words
	Grammatical metaphor	Noting how a process can be represented by an abstract word	To help students understand and use abstractions in science texts
Reading	Reading for the gist using headings and the introduction	Getting students to find and notice each of the main headings and sub-headings and note the main topics	To help students get the gist of the chapter and become aware of how they did this
	Reading graphics	Scaffolding how to read a photograph in context and make connections to the text and other photographs	To promote student understanding of how graphics complement a text
	Interpreting the text	Making connections between concepts in the textbook chapter and everyday knowledge and experience	To facilitate reading comprehension by creating meaningful connections to a text
	Intertextuality	Making connections to texts outside the immediate text	To promote understanding of text interpretation intertextually
	Noting the genre-specific cues that signal meaning	Drawing attention to the functions of different sections of the chapter and how keywords are emphasised	To help students become aware of textual cues in an informational text of this kind
	Problem solving how to best interpret text	Using a think aloud to resolve an apparent anomaly in the text	To model comprehension repair when meaning breaks down
	Treating texts as interactive	Having the students answer both implied and explicit questions in the text as part of reading	To model how to interact with a text by asking oneself questions and answering its questions
	Noticing structural features of the genre	Helping students identify a process in the text	To help students become aware of textual top level structures
Writing	Note-taking	Using a prepared worksheet to capture key words and make notes	To promote understanding of writing to get down the gist
	Creating a visual representation	Creating drawings to illustrate notes made	To promote drawings as a useful way to represent concepts
	Writing an extended answer	Reorganising a question to frame an answer scientifically	To teach how to frame answers using the discourse of science
	Keeping track	Using graphic organisers and glossaries to summarise progress	To promote metacognitive awareness of the place of the parts in the whole
	Transforming information	Writing notes on a worksheet; answering questions in a student notebook; completing a concept map	To help students represent their understanding of concepts and relationships in a science unit

Representing new learning on a concept map

As part of helping students understand the gist of what they were learning in the context of the overall unit, we have seen how Mrs Savige got students to identify the main headings in the textbook chapter as a reading activity and then as a writing activity. Towards the end of the lesson, she also had students write on a concept map of the unit (a handout in the previous lesson), to identify where the material covered in this lesson fitted in the overall plan of the unit.

DS Okay. [.] *Can you turn* [.] *can you turn to your, um, concept maps? We're going to put some of these ideas into your concept maps before we go. . . . Okay. So "Wearing*

away of the land↑" is the heading at the top of your concept map. Okay? "Wearing away the land"↑ And we said that there are a number of different ways that we can wear away the land so we need to just write in the ones that we have done so far which is abrasion.
So I'm not going to write the whole heading up [.] *that says, "Wearing away the land." Can you draw a line over here and put "weathering". ...Okay and the first kind of weathering we looked at was* [2] ***abrasion*** [.] *and the second kind of weathering we looked at was* ***frost action*** *[5]* [These long pauses usually mean DS is writing on the OHT]. *We had* ***three*** [2] *three methods of abrasion.* [.] *Have a look in your notes and you will see we had ocean waves, wind and glaciers. So we'll just put "****waves*** [1] *wind* [2] *and glaciers* [.]*" and we have* [Indistinct] *frost action* [.] *we had the, um, "heat and cold and the ice* [.] *freezing.↓* [.] *Okay?* [3] *The main thing we were looking at today was "weathering:.* [2] *Two kinds of weathering* [.] *"abrasion" and "frost action". [Lines 1103-1124]*

This summary obviously serves the purpose of representing the day's learning in a graphical way in relation to the chapter heading, "Wearing away the Land", as well as consolidating learning during the lesson. It is another occasion on which key words are repeated in a meaningful context and written by the students.

Updating the vocabulary list

Another way of revising key concepts and creating awareness of the range of new vocabulary introduced during the lesson is the activity of updating the cumulative vocabulary list that the students keep in their notebooks. As is typical of this teacher, not only is the activity completed, but metacognitive awareness of the genre and its purposes are encouraged by explicit discussion. ("Vocab lists are mainly focusing on the new words that we should use, that we should know from [Indistinct]." [Lines 1083-1184]

Checking Progress on a Flow Chart

The final activity is another one that places new learning in relation to the overall goals of the unit, this time in terms of activities: checking progress on a flow chart of the unit. As it is a checklist, it is a way of helping students take some responsibility for keeping track of their own progress. It is also a chance for them to clarify anything they missed or are confused about, and, as happened in this lesson, ask their own questions about it. Having a visualisation of all the activities in the unit in front of them makes it possible for the students and the teacher to talk about what would otherwise be invisible.

This activity also serves another important purpose. In the interview, Mrs Savige talked about the importance of the flow chart for helping students have a sense of achievement each lesson as they see the progress they are making through a one-page summary of the unit activities. She tells her students, "We're halfway through the work-sheet, half-way through the questions (Line 1214)." For students who have missed classes, it allows them to see clearly what they have missed and need to catch up on. As well, the flow-chart also helps students pre-view what is yet to come and is a chance for the teacher to begin to acquaint them with new terms.

Lesson Closes and Students Choose Prizes

The final stage of the lesson is the time when students who have observed the basic rules of classroom behaviour over five periods get a small reward from the "prize box". This helps motivate them to behave appropriately in class and is a positive complement to the behaviour cards that add up to detentions and exclusion from class.

DISCUSSION

Even though Mrs Savige's primary goal in the double lesson I observed was to introduce her students to the science of weathering, in the process she used 17 different types of literacy teaching strategies, as detailed in the analysis above and summarised in table 2.

The low level of literacy of the students in this study means that the skills being developed were often those that can be taken for granted in a more literate, middle class community. However, there are also generic and specific science literacies being developed that would benefit students in a regular science class and make science more accessible and hence less alienating for them. Table 2 lists the types of literacy activities and some examples that were addressed with this class.

For each domain (of literacy) (column 1) I have listed the particular literacy foci addressed in this lesson (column 2). The third column in the table summarises the literacy teaching strategies used, and the fourth column shows what I inferred to be the literacy teaching goal behind the strategy.

I have divided the literacy domains into three: vocabulary-building, reading and writing. In fact vocabulary building was part of both the reading and writing instruction during this lesson and has only been abstracted because it was common to both, to save repetition or overlap. Kamil & Bernhardt (2004) cited vocabulary knowledge as one of the key factors in successful reading and it is no doubt included as a key component in Yore *et al.*'s (2003) model of an interactive-constructive view of reading, under the guise

of "prior knowledge of the topic". As such, vocabulary-building could be seen as a pre-reading skill; here it is obviously included as part of the process of interpreting the *current* text. Because these students have so little knowledge of the pre-requisite vocabulary, Mrs Savige attempts to catch them up during the reading.

This process continues during the writing activities because developing understanding of the full meaning of each new word is a gradual, on-going process of building rich connections as part of the development of the thematic pattern of the topic. Each use of a new technical term is a step along the way, from the teacher's first mention of the word, to hearing it being read by another student, to hearing it in the context of an anecdote or analogy, to learning to spell and write it during scaffolded note-taking and question-answering, to recognising it as an addition to one's vocabulary during the "vocab list" exercise, learning to distinguish it from closely-related words, especially for the Latinate words so common in science texts, seeing its place in representations of the overall unit, to finally making independent use of it in a future note-writing exercise, or even better, using it competently as a communication tool in a context outside the science classroom. This also applies to non-technical terms, where each new usage of a word in context will help refine a student's understanding and control of the word.

Unfamiliar multi-syllabic (often Latinate) words are likely to confuse students when they have variants (e.g., abrasion and abrasives) that look and sound very similar but have different endings and usages. Hence Mrs Savige took particular care to distinguish between them and model how each variant was used. Nominalisation (e.g., expansion) which is so common in science texts, is not likely to be used by the majority of students in everyday talk, so Mrs Savige provides support in helping her students use it in the context of answering a question.

Table 2 shows that the reading skills that Mrs Savige covered with her class fitted with the interactive-constructive view of learning described by Yore *et al.*, 2003). The strategies were related to activating both episodic memory and semantic memory, and to accessing available cues in both the textual and sociocultural contexts. However, rather than merely reminding students to access such memories and cues, Mrs Savige needed first to teach students about the typical features of the science textbook chapter genre, such as the way the introduction and the headings indicate what the chapter is to be about and what the main topics to be covered are, the way formatting cues differentiate between more and less important headings and terms, what to expect in different parts of the chapter, and how different parts, such as the text and graphics, depend on and reinforce each other.

Further, she needed to encourage students to take an active role in interacting with the text and in interpreting it, when connections needed to be made between different parts of the text, and to model how to undertake comprehension repair when the meaning was not clear or seemed anomalous. This meant teaching her students to ask and answer questions about the text and graphics, whether or not such questions were explicit in the text. Further, with regard to episodic memory, she had to scaffold her students to make connections between their own experience and the science content of the chapter. They needed to be helped to see the connections between the chapter section they were reading, other texts Mrs Savige had introduced into the lesson, a photograph in the text, a text-box within the chapter, and texts which they had studied in the past. These connections all added richness to the frequent summaries of the key concepts they were studying or would soon study.

The final section of Table 2 summarises the writing skills that Mrs Savige was apparently aiming to develop in her students during the observed lesson. These were note-taking skills, question-answering skills, and ways of representing a snapshot of their progress in relation to the unit. As well, she modelled how to integrate the various literacy tasks they were engaging in, so that the reading, talking and writing were clearly linked.

Rather than have students copy down already prepared notes, Mrs Savige tried to help the students create notes and diagrams on the spot as she summarised orally what they had just been reading and discussing. In fact some had such difficulty with writing and spelling that they depended on Mrs Savige to write first and then copied from the OHT. Nevertheless, she communicated that writing notes was about getting down the key features to help one remember what one has been reading and discussing. She helped students translate the knowledge into a new form in a way that encouraged them to think about the concepts, allowed for repetition of new technical terms, provided a further chance to connect to their experience (such as when she made references to surfing and using sandpaper), took advantage of an attentive audience for the introduction of new factual material (about glaciers), helped them consolidate knowledge about textual top level structures such as a process, and provided a safe environment for students with very limited writing skills to complete a meaningful writing task.

Helping students write answers for comprehension questions about the text allowed Mrs Savige to introduce her students to ways of thinking and writing that are typical of informational science texts but with which they may not be familiar. In the first instance Mrs Savige scaffolded the process of rearranging words from a question into the passive voice to create a stem to begin an answer to a question, and in the second she

scaffolded the construction of a complex sentence to create an explanation that would answer a "why" question. The final writing activities were designed to help students have an overview of where new terms fitted into the overall unit plan and included using graphic organisers (a concept map and a flow chart) and a glossary to note what had been covered in that particular lesson and what was still to come. In all cases of writing, the students were being asked to transform information from one format to another, which is in line with the knowledge-transforming model of writing that Yore *et al.* (2003) described. For example, they were being asked to spend more time thinking about the purpose of the writing (to help them remember new learning), specifying the audience (themselves), accessing and revising content knowledge, and, thinking and negotiating language use. Writing was not being used merely to transcribe predetermined knowledge or evaluate students' learning, although the writing activities may have involved elements of the former and the discussion around the writing would have provided feedback to Mrs Savige about the level of understanding of many of the students.

While some of the time was spent on reading and developing reading skills and some on writing and developing writing skills, it is notable that Mrs Savige integrated the various processes so that students could see how they were inter-dependent. She appreciated that this increased the complexity of the task from their point of view (cycling between reading the textbook section, talking about what they were reading, writing notes on a sheet about what they had just read, answering questions, and copying from an OHT) and prepared them to accept this complexity by making explicit the several processes in which they would be engaged. In this way science was presented as coherent and meaningful and not as a series of disjointed activities as it otherwise may have appeared to be for these students.

CONCLUSION

While the focus was on the science content, many reading and writing skills were taught, thus ensuring that the low-literacy students were given increased access to participation. However, this teaching did not happen subconsciously: Mrs Savige had explicit literacy-teaching goals even while focusing on teaching the science of weathering. She was not simply getting students to find information in the text and get a record of it, but wanted them to become independent readers who could find, interpret, and record such information for themselves. Like many high schools in Queensland at that time, particularly where the general literacy level was problematic, the school visited in relation to this exemplar was getting involved in the movement for whole school literacy development. When I asked Mrs Savige what this meant to her, she said she saw her role as a literacy teacher as being to make explicit processes that she herself was engaging in:

> *I think when I look at how much literacy do my students need to access science I look at my self talk [.] the literacy skills that I employ . . . to get that information. . . . I think literacy is more than just reading and writing. . . . when I'm looking for information I have an expectation as to what is going to . . . when you're working with the text whether it's a written text or visual text or whatever, I think it is important to, to point out to students quite explicitly where the information is and how it's organised . . . . And where they can expect to find it and what they can expect to find and whether they're going to find it in a picture or a table.*" [Lines 964-984].

This is a good example of what Gee (2004, p. 31) referred to as "reading lessons" on "expanded texts" in which people more expert than the students model how they read such texts, and engage the students in overt discussion about the language and genre conventions of such texts, "in the midst of practice". Of course, the fact that Mrs Savige trained as a resource teacher meant that she was much more aware of the breadth of literacy skills she was using than many science teachers would be and so had many more literacy skills about which she could be explicit. At another level, she was inexpert and needed to help both herself and her students understand a topic she had not studied formally herself. As someone who had not specialised in geology, she used travel to enrich her understanding of the topic and so provided her students with travel books and stories as texts to help them see the significance of the science they were studying during this lesson.

There are some obvious limitations to this study of literacy teaching strategies to help bridge the gap between students' current literacy skills and those needed for school science. In the first place, this was only one double science lesson during one module of one course unit for at a particular time of the year in a particular context.

It should also be noted that because this analysis was limited to one class, albeit a double period, this article has only covered a sample of all possible aspects of fundamental and science literacies that students will need. Mrs Savige herself may have addressed other aspects of literacies or more generic or more scientific ones in other lessons and other teachers will no doubt cover other generic and science-specific literacies.

Another limitation was the fact that these students had reduced content to cover when compared with a regular class. However, this is a good example of the benefits of reducing the pace at which new content is introduced for students who can be deemed to have a restricted language code in Bernstein's (1990) sense of the phrase. The students appeared to learn more and in

greater depth and with better engagement when given time to make rich connections in a range of directions. I was amazed at how they generally maintained their interest in the topic for the duration of a double period.

As well, these were low level literacy students who needed extensive work on a range of literacy practices. It may be that this exemplar has more to offer primary school teachers whose students may need extensive scaffolding in the literacies of science. Students in regular middle years or secondary classes may be assumed to need less detailed and repetitive work but it is likely all the same that for at least some of these literacy practices they will benefit from having them made explicit. In aspects such as the use of nominalisation and the use of logical connectives, it may be a useful model not just for secondary science but in other academic subjects where abstract discussion is required. While this paper is perhaps an extreme case of the need for integrating literacy teaching with science teaching, it nevertheless demonstrates how reading comprehension and transformative writing can enhance learning in science.

One implication of this study relates to teacher training. If science teachers are to feel comfortable teaching the literacies of science they may need to have what is transparent for them made opaque again. What is needed may be a module focusing on discourse analysis preferably during teacher training, or later, when they are noticing early signs of deficiencies in the language skills of their science students.

The alternative, that language arts teachers should be responsible for developing such skills has been found not to be a solution, since both the literature and this study demonstrate the importance of a discipline-specific teacher in helping students work with both the specific content and the specific genres and literacies of school science. It is true that Mrs Savige had learnt literacy teaching skills as part of her LS role in the school, but it was her discipline-specific knowledge of science that enabled her to facilitate the processes of reading a science textbook and the processes of writing that are consistent with the discourse of school science. Both are necessary and another solution may be to team science teachers with literacy teachers.

Another implication of this study is that it is clear that literacy can be taught as part of science without wasting precious time for science content. On the contrary, such teaching enriches the learning of science, by enriching reading comprehension and the transformation of knowledge in ways that enable a deeper understanding of science concepts and processes.

In conclusion, while the class has been firmly focused on the Earth science topic of weathering, I have demonstrated that this teacher has also been able to teach the fundamental and scientific literacies required to understand the topic. The literacy skills she has been teaching are essential for learning the science being taught.

Throughout, learning is seen as an interactive process and this is not only good for learning, but it is also likely to be good for students' motivation and engagement. Just as the writing heuristic (SWH) has been found to lead to benefits in learning through the transformation of knowledge, having more metacognitive control over both reading and other writing processes is also likely to be beneficial.

Finally, with regard to equity and access, because she changed the pacing rules to allow time for "smelling the roses along the way" (DS interview, line 1085), Mrs Savige's curriculum made it more likely that students with a disadvantaged background and a restricted language code could progress beyond the initial concrete stages of learning to deeper, more abstract levels of meaning. She allowed time for her students to fill some of the gaps in literacy skills and background knowledge which meant that they could actively participate in learning science in spite of such disadvantages.

Notes:

[1] *I have permission from the teacher to use her actual name. I made sure this was part of the research arrangement because I think teachers such as this one should be recognised and acknowledged for their expertise and for what they have to contribute to research.*

[2] *The following conventions have been used for this transcription:*

- *Even though the teacher's real name has been used (for the reason given above), students have been given pseudonyms;*
- *"S" stands for an un-named student, and "Ss" for more than one student;*
- *Words in curved brackets are an acknowledgement that a word or several words was indistinguishable or, alternatively, they may represent the best guess at what the word(s) sounds like;*
- *Words in italics in square brackets are a comment by the transcriber to convey non-verbal aspects of the situation;*
- *Up and down directional arrows are used to indicate abrupt changes in pitch;*
- *A "|" has been used to align simultaneous talk by two parties when the talk overlaps;*
- *Other than by the use of a full stop at the end of a sentence, additional pauses are indicated within square brackets by a full stop for a momentary pause, or by a whole number for seconds of duration;*
- *Emphasized syllables appear in bold type;*
- *"..." or "...." represent phrases or sentences respectively that have been omitted from the transcript excerpt for the sake of brevity; with the constant (often indistinct) interruptions from students, teacher corrections of minor inappropriate behaviour and such like, excepts would have been inordinately long without contributing much to the point being made. Line numbers give an idea of how many lines have been omitted.*

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