MURDOCH RESEARCH REPOSITORY

This is the author's final version of the work, as accepted for publication following peer review but without the publisher's layout or pagination.
The definitive version is available at

http://dx.doi.org/10.1080/09500690601161783

Ritchie, S., Rigano, Donna and Duane, Ann (2008) Writing an ecological mystery in class: Merging genres and learning science. International Journal of Science Education, 30 (2). pp. 143-166.

http://researchrepository.murdoch.edu.au/21249/

Copyright: © 2008 Taylor and Francis
It is posted here for your personal use. No further distribution is permitted.

Manuscript accepted for publication in:

International Journal of Science Education

Writing an Ecological Mystery in Class: Merging Genres and Learning Science

Stephen M. Ritchie[1], Donna L. Rigano[2], & Ann Duane[3]

[1]Queensland University of Technology, [2]James Cook University, [3]Saint Josephs School on The Strand

Correspondence Address: Associate Professor Stephen M. Ritchie, School of Mathematics, Science & Technology Education, Queensland University of Technology, Victoria Park Road, Kelvin Grove, Q'ld, 4059, Australia. s.ritchie@qut.edu.au

Writing an Ecological Mystery in Class: Merging Genres and Learning Science

Abstract

Reading and writing stories with science-related themes make it possible for students to develop interest in and capacity for scientific thinking when specialist science and more popular genres converge. As well, feminist scholars have called for greater use of creative-writing activities in school science to counter students' disengagement in participating in science discourses. Yet few studies have been conducted into how students construct meaning as fictional and non-fictional science genres are merged in writing activities. The purpose of this interpretive study was to investigate what happens as a class of fourth-grade children co-creates a publishable eco-mystery – that integrates both fiction and non-fiction – with their teacher. Interpretations are organized around two themes; namely, when genres clash, and scaffolding science learning. The study asserts that: the children's engagement and interest in the writing tasks were sustained across genres; and the children demonstrated fluency in their use of canonically accurate knowledge of ecological/biological concepts embedded in the eco-mystery with scaffolding from their teacher. Additional evidence suggests that the children's fluency with scientific registers had more than a short-term effect.

Key Words: Writing science, Participation in science and literacy, Genre, Eco-mystery

Primary (or elementary) teachers across the world tend to lack confidence in teaching science and promoting science learning (Appleton, Gins, & Watters, 2000; Dillon, Osborne, Fairbrother, & Kurina, 2000; Goodrum, Hackling, & Rennie, 2001; Harlen, 1997; Jarvis & Pell, 2004; Yager & Weld, 1999). In contrast, primary teachers are quite adept at literacy instruction (Akerson, Flick, & Lederman, 2000; El-Hindi, 2003). Furthermore, El-Hindi (2003) has suggested primary teachers “may feel more comfortable supporting science instruction if they have concrete means for integrating science with everyday literacy instruction” (p. 536). Although little evidence about the student learning outcomes from such practices was available, Saul (2004) argued that “when a truly effective literacy science connection is created in the classroom, both the literacy and the science work undertaken by the students makes sense in terms of both disciplines” (p. 5). Likewise, Klentschy and Molina-De La Torre (2004) asserted: “By linking science and language literacy, science educators can demonstrate the role of science in strengthening students’ language skills, thus extending and strengthening the place of science in a basic curriculum” (p. 340).

Despite longstanding calls for much more science-classroom research to investigate more deeply the writing-learning connection (Rivard, 1994), few studies have been conducted into how students construct meaning as fictional or narrative writing is merged with non-fictional science information. More recently, Hand and Prain (2006) acknowledged that research remains thin on the issue of building students’ understandings and interest in science through their participation in programs that open up the ways in which language can be used in science classrooms. The purpose of our study was to begin to redress this gap in the literature by exploring what happens in a fourth-grade class of nine-year-old children as they co-author with their teacher a children's book that merges narrative storylines with relevant science information.

Storytelling in Science

Fensham (2001) reminded science educators that story could be a powerful form of education in science and that several curriculum development projects in the UK and Australia have humanized science learning through story. Previously, Roach and Wandersee (1995, p. 365) in the USA had exalted: "Stories are fun! Everyone loves a good story," before arguing that storytelling could effect conceptual change by providing connections between science concepts. Similarly moved by the potential of storytelling in science classes, Stannard (2001) asked: "why should we not use the art of storytelling to pass on our modern scientific wisdom" (p. 30)? Anecdotal reports of the impact of reading fictional books with storylines that centre on scientific phenomena have been positive (El-Hindi, 2003; Stannard, 2001). For example, Stannard claimed that developmental testing of his books (e.g., *Uncle Albert and the Quantum Quest*) "revealed that the children not only enjoyed the story format, but also learned a considerable amount of physics from them" (p. 32). Ford (2004) also argued that storytelling provides an invitation to children to think creatively about science and encourage their interest in science. But storytelling in science need not be limited to reading the work of others. There is also potential for teachers to scaffold children's writing of stories. For example, El-Hindi (2003) has identified eco-mysteries – fictional books whose mystery storylines revolve around an ecological problem – as having potential in supporting children's science instruction.

Reading and writing stories with science-related themes have attracted some attention in the academic literature. In his review of literature, Prain (2006; see also, Wallace, Hand, & Prain, 2004) argued that it was possible for students to develop interest in, and capacity for scientific thinking, as they learn to cross borders between specialist and more popular genres and readership.

Broadly, genres are purposive social processes like routines or templates employed by individuals and groups to interact meaningfully with particular audiences in particular contexts (Varelas, Becker, Luster, & Wenzel, 2002). In science classes multiple genres meet; they relate specifically to schooling, science disciplines and youth cultures. A major task for science teachers is to create “spaces where students’ propensity for social interactions and affective reactions are brought into play to foster their engagement with science and their construction of scientific understandings” (Varelas et al., 2002, p. 583). There are different approaches to achieving such spaces. In terms of writing genres specifically, Prain (2006) identified two contrasting perspectives or emphases for the use of genres in learning to write science in classrooms: an epistemic orientation that foregrounds the teaching of formal genres like laboratory and research reports; and a diversified writing approach that emphasizes expanding the purposes, writing types, and readership for writing in science beyond the formal science report genres.

The epistemic orientation to writing science, promoted by Halliday and Martin (1993), for example, assumes that students learn science best when they reproduce the exact scientific meanings of concepts and use the technical-writing genres that feature in the formal publications of professional scientists (Prain, 2006). The use of the diversified approach in science classrooms is more consistent with science educators like Varelas et al. (2002) and proponents for writing eco-mysteries (e.g., El-Hindi, 2003). While not diminishing the importance of using canonically accurate scientific discourse in formal writing contexts, from this perspective children are expected to “cross borders” from everyday language conventions to more formal genres with appropriate scaffolding or support from teachers (Prain, 2006; Saul, 2004). Furthermore, Prain (2006) argued that, “meaningful learning must entail building extensive conceptual links between everyday languages and their referents and those of science” (p. 196).

Feminist scholars, in particular (e.g., DeCoito & Nieswandt, 2002; Hildebrand, 1998, 2002), have called for greater use of creative-writing activities in school science to counter students’ disengagement in participating in science discourses. For example, after asserting that teaching scientific genres in a technical manner constrains students thinking and turns them off science, Hildebrand (2002) argued that hybrid scientific/imaginative writing genres such as anthropomorphic writing (i.e., in which human behaviour and/or characteristics are attributed to non-human objects) had the potential to “interrupt the pairing of science with hegemonic masculinity through redefining science and science learning” (p. 20). Similarly, from a pragmatic position, Wellington and Osborne (2001) reasoned:

> If the scientific genre is alienating and offputting, and, if we wish to engage children with ideas in science, we should at least offer activities that initiate writing in science in a manner which is enjoyable. Using a familiar genre at least begins the process of helping children to express their thoughts in written language through being personally engaged. (p. 76)

Calls for in-class writing activities to make connections between familiar student genres and more formal scientific discourses in such a way that might lead to children’s fuller participation in authentic science-writing tasks are consistent with the theoretical framework of situated learning (Chaiklin & Lave, 1993; Lave & Wenger, 1991; Roth, Hwang, Goulart, & Lee, 2005).

Writing as Situated Activity

A situated perspective of learning de-centres the cognitive processes of individuals by focusing on the participation of actors in the practices of particular communities (Engeström, 1999). For Lave and Wenger (1991), learning involves the movement of newcomers from the periphery toward the centre of a community of practice in the process known as *legitimate peripheral participation*. As well as referring to the development of knowledgeably skilled identities in practice, legitimate peripheral participation also involves the “reproduction and transformation of communities of practice” (p. 55). A class working together to create an artifact like an eco-mystery could be studied as a community of practice, with newcomers (i.e., children) becoming more skillful participants as they interact with their more experienced “old timers” (i.e., teachers and guest speakers) through the project. Within such a community, knowledge is continuously reproduced (e.g., writing genres and scientific facts) and produced (e.g., merging of scientific and narrative discourses).

Lave and Wenger (1991) identified two interesting aspects of knowledge in situated learning: “the importance of transparency of the artifacts, and the importance of stories as resources for problem solving” (Engeström, 1999, p. 252). As Lave and Wenger (1991) explained: “Knowledge within a community of practice and ways of perceiving and manipulating objects characteristic of communities of practice are encoded in artifacts in ways that can be more or less revealing" (p. 102). Old timers then can assist newcomers to become fuller participants within the community of practice by increasing the transparency of the artifacts and practices of the community. For example, teachers who use the Science Writing Heuristic (Hand & Keys, 1999) – a heuristic that requires students in laboratory investigations "to examine their understandings, the gaps in their knowledge and to translate the technical language into more everyday language" (Hand, Wallace, & Yang, 2004, p. 148) – open up possibilities for their students to learn scientific practices and related knowledge. More specifically, in a study of 93 seventh-grade students enrolled in biology classes over an eight-week period in the USA, one group of students used the heuristic that required them to summarize the outcome of laboratory activities by writing for their peers rather than their teacher (Hand et al., 2004). The results of the study showed that the treatment group improved their understanding of the concepts and outperformed a control group on post-tests about cellular concepts. Similarly, a study in the UK with fourth-grade, sixth-grade and seventh-grade children also showed that the use of a writing frame (or heuristic) that helps children focus attention on the "thinking behind the doing" in science investigations, improves the children's metacognition and understanding of science as expressed in group discussions (Warwick, Stephenson, Webster, & Bourne, 2003).

Becoming a legitimate participant in a community involves learning how to talk and write as full participants (Lave & Wenger, 1991). Telling stories by talking and writing *within* (as opposed to *about*) a practice helps newcomers to learn to talk and write as members of the community. As Jordan (1989,) noted, "these stories, then, are packages of situated knowledge…. To acquire a store of appropriate stories and, even more importantly, to know what are appropriate occasions for telling them, is then part of what it means to become [a member]" (p. 935).

The Writing-learning Connection in Science Programs

Supporting children as they write science within the context of co-creating an eco-mystery seems an appropriate learning curriculum for children in primary schools. Although there are too few empirical studies that would suggest how such a learning curriculum might be implemented, it is becoming more clear that there exists a link between the use of writing heuristics or frameworks in student investigations and their conceptual understanding of science. Recent studies in Australia and the USA have shown that children do learn science when writing activities are embedded in a science program (i.e., a diversified approach), and that these improvements are not restricted to middle-class children as feared by Martin and Veal (1998).

Working from a definition for scientific literacy that encompasses broad conceptual understandings of science; interpreting a range of reports about scientific issues; and including competencies in asking investigable questions, conducting investigations, collecting and interpreting data and making decisions, the Australian Council for Educational Research (see Ministerial Council on Education, Employment, Training and Youth Affairs, MCEETYA, 2005) validated a three-strand scientific literacy assessment domain (i.e., Strand A: planning and conducting investigations; Strand B: interpreting evidence; Strand C: using science understandings for describing and explaining natural phenomena) for sixth-grade children in Australian schools. This assessment domain was one of the tools used by Hackling and Prain (2005) to evaluate a trial implementation of a

Primary Connections' unit that integrates science and literacy activities. From a sample of 71 fifth-grade students, they found consistent improvements in science achievement of the students during the unit.

In two large-scale studies in the USA, improvements in both literacy and science achievement were reported. In three consecutive trials of implementing *Seeds-Roots'* units that integrate science and literacy activities, impressive gains in science content knowledge were reported from the study involving 118 second- and third-grade classrooms across 21 states in the USA (Barber, Catz, & Arya, 2006) where no professional development was provided for teachers. In an earlier study involving over 1500 third- and fourth-grade children from six elementary schools, Lee, Deaktor, Hart, Cuevas, and Enders (2005) reported that the intervention program (providing resources for both science and literacy instruction as well as comprehensive professional development activities) was successful in improving both literacy and science achievement. Of particular interest to the current study was that the literacy booklets used highlighted activities to foster reading and writing in the context of science instruction.

While these results are encouraging for systemic and uniform approaches to learning science and literacy, the resources used in each program embedded literacy activities within the science units. Significantly, writing an eco-mystery adopts the opposite approach; that is, it embeds the science information (and its acquisition, hopefully) within a creative-writing project. In a climate where teachers are much more comfortable in teaching reading and writing than teaching science (Hand & Prain, 2006), this shift in orientation could have a stronger impact on practicing teachers than a program that is centred on science-inquiry activities. Thus a program of research that explores how children participate in the co-creation of an eco-mystery, and the associated outcomes from this experience, is both worthwhile and unique.

To contextualize the study it is necessary first to overview the genesis of the writing tasks at the centre of the study.

Background

Our incentive to investigate how children co-create an eco-mystery with their teacher stemmed from the successful completion (and subsequent publication) of a colour-illustrated children's storybook by a sixth-grade Australian class, named: *The hidden secrets of Skull Island* (Zicus, 2004). This book was commissioned by Ritchie (i.e., first listed author) to address the need for innovative resources at the primary-school level to help with the development of children's understanding of marine environments in the South Pacific Region (Ritchie & Hopley, 1997). Biodiversity and sustainability issues of endangered and protected marine species, poaching and conservation, as well as marine-science concepts (e.g., ocean currents, wave action, tidal zones, interactions) were included in the book. There were two noteworthy features of this eco-mystery.

First, the book mixes writing genres – narrative with factual information. According to Smolkin and Donnovan's (2004a) typology for science texts, *The hidden secrets of Skull Island* was a dual-purpose book because it offers readers several choices of reading paths. "Those readers who wish to focus on the story alone may do so, and those who wish to focus on the pure science content will find paths that allow them to accomplish this end" (p. 195). From the few studies conducted into determining the efficacy of dual-purpose texts, there are mixed findings. Generally, children who were read aloud dual-purpose texts by their teachers recalled more information than students who were read information books, but the differences were less noticeable when students read the books for themselves (Smolkin & Donnovan, 2004b).

With input from a marine biologist and the editor, scientific information was integrated throughout the book in one of two forms: either embedded in the text in coloured font, or as separate "boxed" supplementary information pages that were tagged, *fact stops*. Sample sections of the book can be viewed online (http://www.maps.jcu.edu.au/develop/sean/hiddensecrets/).

The process of co-creating *The hidden secrets of Skull Island* appeared to be a rewarding experience for teachers and students. However, the project's lack of a research focus makes it impossible to justify claims about the learning outcomes, or the preferred pedagogy for integrating mixed-genre writing tasks.

Informed by experiences from the previous development project that produced *The hidden secrets of Skull Island* and inspired by the obvious gaps in the research literature, a research program was initiated alongside subsequent children's book-development projects that integrate scientific concepts and narrative genres. This first research study focuses on the co-creation of an eco-mystery (named, *Ocean action: an adventure in Beachtown*) – set in tropical North Queensland – by a fourth-grade class. After reading *Hidden secrets of Skull Island* in whole-class and small-group sessions, the class began their development project. The research questions that guided the design of the study were:

1 How did the children's engagement and interest in the planned activities vary across their use of genres?

2 What did the children “learn” through the writing project?

Research Design

The study was designed within the parameters of an interpretive (Erickson, 1998) or participatory (Lincoln & Guba, 2000) paradigm. As Tobin (2000) noted:

> The goals of interpretive research are to make sense of experience, build patterns of meaning and relationship that are linked to well-described situations, and communicate what has been learned in ways that are connected to context. By presenting what has been learned in a context of the evidence for and against assertions, detailed descriptions of illustrative vignettes, and examples of explanatory data, a text prepared for dissemination can enable a reader to decide how credible and authentic the research is and whether or not anything in the account of it is potentially applicable to the contexts in which he or she practices education. (p. 510)

The interpretive procedures employed included ethnographic techniques like classroom observations and interviews with contributors, as well as interpretation of artifacts (i.e., text and illustrative contributions) and interpretation of videotaped lesson segments.

Context

The study was conducted in Ann’s (third listed author) fourth-grade class in a North Queensland city. The class consisted of 13 males and 17 females of average age of 9 years. The other researchers had worked at the school previously, so they were familiar with the school’s ethos and structures as well as being known by its staff and students. In fact they had conducted a coteaching research project with almost the same cohort of students three years earlier over a school year (see Rigano, Ritchie, & Bell, 2005).

While Ann supervised the class for most lessons, specialist teachers were also scheduled to teach the class for one or two sessions each week. Of particular relevance to this study, Mrs Moon (all names other than the researchers are pseudonyms) taught the class once a week. These lessons focused on research skills, like report writing, in much the same way as advocates of the epistemic approach would recommend (cf. Halliday & Martin, 1993).

As with *The hidden secrets of Skull Island* book, the *Ocean action* writing project was an eco-mystery that was situated within a marine-science environment. Ann decided on the sorts of habitats (e.g., mangroves) and animals (e.g., turtles) that would feature in the book, and planned complementary lessons (e.g., guest speaker from the university – “the turtle man”) and access to reference books that might support their work, prior to commencement. Ann was motivated to undertake the project because she could see opportunities to integrate several of the overall curriculum’s Key Learning Areas (KLAs like English, Mathematics and Science) into the topic. She was personally interested in environmental issues and children’s literature, and had an expectation that the children would maintain a high level of interest throughout the project, supporting its potential for promoting learning in context. Finally, she was interested in becoming involved in a research project.

Ann was much more than a “facilitator” of learning in this project. She was a co-author, editor, teacher and learner. Ann set the boundaries for the project by selecting the theme, deciding on a chapter-book format for a juvenile audience (a departure from the previous book project), and insisted that the storylines needed to be realistic (i.e., fantasy storylines like somebody arriving from another planet were deemed unsuitable). As teacher-author-editor, Ann indicated the places where "science" needed to be included or augmented, deleted parts of text that didn't work, took parts of texts and combined them to form one passage, restructured other sentences, added text to join sentences, and wrote a hook for the end of chapter 1 to illustrate how chapters could be linked (i.e., According to Ann, the following hook encourages the reader to anticipate what might happen in subsequent chapters: "'Something big is happening,' thought Elisha, glancing at her dad as he gathered speed. 'Dad's always like this when he's onto something. I'm going to find out what it is. I'm sure **I** can help. This is going to be a **great** holiday.' Elisha loved excitement and adventure and catching the turtle killers was sure to be just that!").

Storylines and character development typically were decided by class vote where consensus could not be reached. In whole-class brainstorming sessions, Ann welcomed suggestions from students, making sure that every student had a chance to contribute. This usually took the form of collective writing where Ann would add text to the chalkboard progressively. Not all text was composed in whole-class or small-group settings. The children also were invited to contribute individually. Typically, preceding individual story-writing sessions, Ann would review the current state of the story with the whole class before asking them to imagine what might happen next. Individually, the children were encouraged to write a story that could follow on from the existing text as well as develop the plot further by incorporating a critical incident that had already been decided upon in the storyboard. These individual-writing sessions could take up to an hour and were always completed within the classroom. After these sessions, Ann collected each student's work and carefully reviewed its potential contribution to the story. The main criterion for selection of any passage was that it was consistent with or developing the original storyline. Further sub-criteria included good use of descriptive language, inclusion of scientific concepts, clever use of dialogue, and novel or quirky plot developments. The selected passages were then collated by Ann into a provisional-story format and read back to the class on the next day. Where two or more potential passages were applicable Ann asked students to vote for their preference. Ann then edited the evolving story; identifying areas that needed to be elaborated or holes that needed filling, and leaving gaps in the typed text that could be filled later.

Unlike the dual-purpose (Smolkin & Donnovan, 2004a) format of *The hidden secrets of Skull Island*, where scientific information mostly was separated from the narrative in the form of fact stops, Ann decided that the science information in *Ocean action: an adventure in Beachtown* should be embedded within the narrative mainly because she thought the process of flipping backwards and forwards between narrative and the *fact stops* was cumbersome for the children. There were two forms of embedded scientific information in the text. Information appeared as either factual information about particular scientific phenomena – usually spoken by an authoritative person like a marine biologist – or merged within the narrative as characters converse during particular activities where scientific information is relevant to the task (i.e., factional text – see Hildebrand, 2002). An example of a factual statement within the text is: “Australia has seven types of turtles in its waters. Some of these are endangered, and if they keep dying at the rate they are, they’ll become extinct.” In this example, the character “Dad” (a marine biologist), who was the father of one of the child characters (i.e., Elisha), begins to explain to a group of children why turtles should not be killed for recreational or commercial purposes. In the same chapter, the following excerpt provides an example of how science-related information is merged within the narrative: “This is only the second hawksbill I’ve seen. No doubt about it, it’s been stabbed to death. It’s had time to dig the body pit and the egg chamber but not time to lay any eggs. Let’s hope this wasn’t its first batch.”

A content analysis of the 10 chapters of *Ocean action* (a total of 15,700 words) revealed that 6.5% of the text (where line was the unit of analysis) was factual and 20.8% of the text was merged or factional text. Table 1 shows the relative percentages of factual, factional and fictional text for each chapter. Concepts and other scientific information also are identified in this summary table.

Data Collection and Interpretation

Most data for the study were collected during Semester 1 (i.e., January to June), 2005. Donna (the second author listed) visited the class for one or two days each week during the semester to observe lessons related to the development of the eco-mystery as well as associated science lessons that were scheduled to support the themes in the book. A total of 42 one-hour lessons were observed. Donna recorded her observations in a journal, often in the form of vignettes that could be shared with the other researchers.

After a brief familiarization period, Donna introduced a digital movie camera so that classroom segments featuring joint construction of text for inclusion in the book could be recorded on disks. These clips from 34 lessons were shared between the researchers for later review and discussion. As children worked in their teacher-assigned groups, Donna conducted interviews with individuals (60 in total) and small groups (15 in total) to check on their perceptions of their progress, interest and engagement in the tasks, and their understanding of the related science concepts. These interviews were audio taped and transcribed. Copies of the children's writing tasks and related illustrations were made. A summary of the data collection procedures and associated timeline for data interpretation and class activities is presented in Table 2.

While samples of work from all 30 children were copied for interpretation, 13 children from two large groups were selected for filming and interviewing. The decision to constrain interpretations of video and audiotapes to just two groups was made for reasons of economy and practicality. Wiring up the classroom with numerous video cameras during the project was not desirable for maintaining a naturalistic-classroom setting and it would not have been possible to interpret all data from so many cameras in a timely manner. Reporting findings from a smaller sample of the class also makes it easier for the reader to follow the development of assertions within our discussion of results. The two groups of children were selected randomly. They were mixed in terms of gender and achievement in science and literacy as judged by their teacher. In short, they represented the full range of backgrounds and characteristics of the classroom population. English was the first language for all children, none of whom identified with any ethnic or cultural minority group. Group 1 included: Sarah, Nicole, Nick, Aaron, Liam and Max while Group 2 included: Angus, Tommy, Monica, Kiara, Lucy, Jane and Samantha.

Classroom observations were discussed at research meetings conducted weekly by phone. The preliminary interpretations from these meetings guided subsequent observations where confirming and disconfirming evidence were sought. From the vignettes, interview transcripts and video-footage of lessons, the researchers developed the emerging research assertions about the writing processes. These assertions were refined progressively through several iterations.

Interpretations of Data for the Research Questions

Consistent with guidelines and criteria for reporting interpretive case studies (Erickson, 1998; Lincoln & Guba, 1990; Roth, 2005), we highlight vignettes or stories that illuminate an incident not only indicative of the experiences of the children observed, but also directly related to each of our research questions. Once particular vignettes were identified in the field we then widened our search purposefully for confirming and disconfirming evidence for each emerging assertion from other data sources, thus preserving the ecology of the project (see Erickson, 1998) and reporting in a manner consistent with the focus of the research – storytelling. The refined assertions are supported through the discussion of each vignette in this report. In our stories, we highlight both the children's and teacher's voices as they participate in the activities that led to the co-created text of *Ocean action: an adventure in Beachtown*. While we acknowledge how important it is to re-present the teacher's voice for our stories to be viewed as credible by researchers and teachers (e.g., Tobin, 2000), we have been careful not to romanticize the teacher's voice (Hargreaves, 1996).

Vignette 1 deals with an incident where it first appeared that the children resisted the introduction of a formal-reporting genre. The associated discussion addresses the first research question; namely, how did the children's engagement and interest in the planned activities vary across their use of genres? We assert that the children's engagement and interest in the writing tasks were sustained across genres. The second vignette addresses the important pedagogical issue of scaffolding students' understanding of the science involved. The related discussion addresses the second research question; namely, what did the children "learn" through the writing project? While the curriculum project involved children in a wide range of activities that contributed to the development of all three strands of scientific literacy (cf. MCEETYA, 2005) and various language literacy competencies, our focus in this part of the study was the children's demonstrated (functional) use of science concepts (and facts) through the artifacts produced and associated conversations. Our second assertion is: the children demonstrated fluency in their use of canonically accurate knowledge of ecological/biological concepts embedded in the eco-mystery with scaffolding from their teacher.

Vignette 1 – When Genres Clash.

"Do I have to do it again?" asked Nicole, as she looked pleadingly at Mrs Moon, the specialist research and computer skills teacher, who was leading the students through their science project on a self-selected marine animal. Mrs Moon carefully reviewed Nicole's work. "Yes, do it again, and follow the headings that I have written on the board."

The students were writing a report on a self-chosen marine animal. They had already filled out a planning sheet in note form using at least two reference books. They were asked to put this information into sentence form and most had almost completed this task when Mrs Moon gave them an outline for a formal science report. Students like Nicole who had already finished writing their draft were upset that they had to do it again. “Why didn’t she tell us from the start that we had to write it like that,” quietly muttered Nicole as she returned to her seat to start again.

It took Nicole another research lesson before she finished her report following the structure provided by Mrs Moon. She was quite pleased with her effort, nevertheless, admitting: “I’m sort of glad that I wrote it again because I understand it better. It made me think about it a bit more and now I know about how the seahorse babies are born.”

Assertion 1. The children’s engagement and interest in the writing tasks were sustained across narrative and formal reporting genres.

Before Nicole’s question in Vignette 1, she had made good progress in listing characteristics of a seahorse. While her sentences made sense they were not connected in the more formal report genre that Mrs Moon had just requested. At first we felt that this was one sure way to dampen young children’s enthusiasm for science; that is, to force them into writing in a foreign genre – a practice promoted by advocates of the epistemic approach (e.g., Halliday & Martin, 1993) – that differed so much from their previous and current enjoyable experiences of writing in narrative form. Could this be how science teachers in the junior years of high school contribute to students’ disengagement with science (cf. Braund, & Hames, 2005; Goodrum et al., 2001; Hildebrand, 2002)? To our surprise, Nicole seemed to be more annoyed with her apparent unawareness of expectations rather than the required genre. In fact, she even admitted to having learned more about the seahorse by rewriting her report. What did other children think?

Sarah (who selected dolphins to study) and Lucy (who selected crabs) were cranky because each “didn’t get it right.” When Donna asked Sarah what she needed to do to get it in the right order, Sarah replied: “In the introduction you had to do classification and appearance, in the body you had to do habitat and food and life cycle, and conclusion (as she reads from the board) other information.” Getting it right was also important for Angus (hammerhead shark topic selection) who was glad to have Mrs Moon tell him “how to do it correctly. I wouldn’t have liked it if it was wrong… I wanted it up to her standards at least,” he confessed. When probed further, Angus declared that he not only wanted good marks, but welcomed a genre that was able to reduce the messiness of his notes: “It’s (i.e., the report genre) not all messy and all over the place, a bit about food there, and then after it comes appearance there, then more food, appearance, other information.”

Unlike Nicole and Lucy who expressed a preference for writing reports over narratives, Angus and Sarah appreciated both. Given the diverse interests of the children, it was unsurprising to hear Aaron and Liam’s preference for writing narratives over formal reports. When Donna asked Liam about his preferred writing genre he unhesitatingly remarked that “writing the story is better” because “you don’t have to study so hard, you don’t have to look all the way through books for one tiny bit of information, you can make things up in the story, but you can’t fake things up in this [report].” This suggests that Liam was more fluent in writing in the narrative genre (see also assertion 2). His frustration for searching and retrieving information from several sources was expressed as follows: “if you’ve found the book you have to find the information, and not all the time the book has the information you want so you have to go find another book. And then maybe when you need the information from that book, you can’t find it and you have to go look for it again.”

Even though the children expressed different preferences for writing genres, Ann noted that, “in general, the notion of including science in the story was welcomed by the students because they thought it would be a good way for other students to learn about marine animals – to read their book.” The goal of publishing a book for others to read was a highly motivating challenge for the children. “They were fascinated by it. They were captivated by the fact that they are writing a chapter book,” Ann declared.

The children co-authors also acknowledged that the writing project sustained their interest in writing and learning science as they mixed genres in their eco-mystery, as the following two responses suggest:

> It makes it sound more scientific and interesting, that we’re using bigger words, it makes us learn more. (Jane)

> It’s interesting and you find out more things about the marine environment because this is practically a science book so other kids will know about the marine environment… Well I really like writing books because it’s more interesting than just writing any old story because it’s interesting when you name more animals and things like that in stories, like the Hawksbill turtle, and sometimes it can be interesting for other kids and they mostly get it if it’s a good mystery story so they will think it’s good. (Kiara)

Contrary to our initial expectations and the assertions by others in recent literature (e.g., Hildebrand, 2002), it may be that teaching technical genres per se does not disengage children, but rather children find the context in which they are to write these genres disengaging. For example, routinely writing a formal laboratory report following a cookbook lab each week might help children develop familiarity with and competence in writing this genre, but is less likely to inspire children to engage in authentic scientific inquiry or develop competence in other dimensions of scientific literacy (e.g., Goodrum et al., 2001). In fact, as we have argued elsewhere, an over-emphasis on writing formal laboratory reports in school science programs can even spawn fraudulent student practices (Rigano & Ritchie, 1995). The context of writing an eco-mystery in this class appears to have engaged children in writing a range of genres (i.e., a canonically accurate technical genre with Mrs Moon and merging technical information with informal narrative storylines with Ann – a diversified writing approach), that many of the students found rewarding and only a few expressed a preference for narrative genres alone.

Ann recognized the importance of sustaining the children's enthusiasm for writing by selecting carefully extracts from each student's work for inclusion in the book: "One of the things that I have to be careful of is to make sure that every kid has got something that they recognize in the book. I have to go back and check that everyone has a bit in there so they can say 'oh I wrote that.'" The scaffolding employed by Ann for the children's science learning is illustrated in the next vignette.

Vignette 2 – Scaffolding Science Learning.

Before asking the class to write individually a story that involved the book characters going crabbing in the mangroves for Chapter 7, Ann had scheduled a sequence of lessons involving a variety of strategies and scaffolded activities. These activities included reading extracts from reference books to the class about particular features of mangroves and specific adaptations of plant species (e.g., aerial and prop roots, and salt extraction), student construction of a mangroves food chain, a practical activity where students evaporated salt water, students' composition of acrostic poems, a mock debate, and a class visit from a professional fisher. Towards the end of the poetry lesson, Ann asked volunteer students to read out their poems to the whole class. Kiara was first to volunteer. She began:

> Mangroves have filters that divide salt water
>
> Are homes for bugs and lots more things
>
> Native around Australia
>
> Grow in muddy areas
>
> Reach their stalks to get more oxygen
>
> Our wild life and our responsibility
>
> Very special and can drop seeds, brake off and then grow again
>
> Erosion can happen if they are not there
>
> Some have flowers

Ann queried: "In the line where you said 'reach their stalks to get more oxygen,' can you explain that to me?" "Well they can't get enough oxygen when the tide goes up (indicates higher level with hand) so they reach their stalks up, their roots up to get oxygen and they can survive," Kiara replied. Ann probed other students' understanding of related science concepts as volunteers read aloud their poetry.

Assertion 2. The children demonstrated fluency in their use of canonically accurate knowledge of ecological/biological concepts embedded in the eco-mystery with scaffolding from their teacher.

The sequence of the lessons provided students with opportunities to develop understandings of scientific phenomena about mangroves that could be weaved into the storylines of the eco-mystery. The culminating activity required each student to write a story involving the book characters crabbing in the mangroves. In this activity students were instructed to "incorporate as much science about mangroves as possible." However, the activities alone could not ensure that the children constructed canonically acceptable concepts. The teacher's interactions with the children in whole-class and small-group settings became an essential component of the lessons. While some questions sought clarification, like the one with Kiara, others probed more deeply to fine-tune emerging understandings. For example, when Donna asked Angus what he meant by "Extracts salt" in his acrostic poem, he initially shrugged his shoulders before admitting, "I don't know." Following a simple prompting question: "Can you remember what it's all about?" he suddenly recalled: "Yes, it takes all of the salt into its roots and then when the roots, it has two ways. When the salt is in the leaves, the leaves fall down and when the roots are full of salt, salt comes out of them." Additional questions established that Angus had grasped the scientific principles underpinning adaptations that mangrove plant species require. Confirming evidence for this claim was found later in Angus's extended writing (i.e., a six-page document) for the culminating activity that shows, in his hand writing (Figure 1) of the text as a situated activity (cf. Lave & Wenger, 1991), that he expressed clearly that the leaves of mangroves drop when "full of salt."

In some other cases, it appeared that the children's developing literacy skills masked a reasonable understanding of the related concepts that would not have been revealed without close questioning. In Max's poem, he included the line: "Observes salt." Subsequent interactions demonstrated that he wrote "observe" when he actually meant "absorb," as the following response suggests: "Well the mangroves can *observe* salt up their roots which are in the water here and it goes up into their leaves and when the leaves get too much salt in them they turn yellow and fall off and that's how it allows the mangroves to live in salty water and it makes it a really good nursery [for fish] (another line in his acrostic poem)." This explanation also featured in Max's unedited hand-written individual story partially reproduced in Figure 2, and re-presented in its elaborated form in the following excerpt – suggesting that he indeed had understood how mangroves extract salt as well as demonstrating his understanding of the structural characteristics used to sex crabs.

> It was 6:00pm at night and Zac had caught fourteen crabs. Sunni had just said she saw a squid but no one would listen to her. Dad said "they were allowed to keep the male crab if it was over 15cm but the female crab had to be restricted from being eaten, so if you have one there Zac you will have to throw it back into the ocean so if I were you I would check them and throw them back."
>
> "How can you know if they're a Jenny," said Zac.
>
> "Easy," said Jim. "The Jenny is wider than the Jake."
>
> "Oh," said Zac.
>
> Elisha had just butted in and said, "why are the leaves yellow, dad?"
>
> "Because they have so much salt on them so it allows it to live in salt water. Mangroves are the only plant that can live in salt water."
>
> Zac had just lost the biggest crab. They had enough so then went home.

Here is another possible example where Max's developing literacy skills may have constrained him from expressing canonically accurate information about mangroves. Had he substituted trees for plant in the second last line, as seen in the final text (Appendix A), there would be no doubt that he appreciated that some other plants (e.g., sea grass) can survive in salt water.

This extract also exemplifies how the children attempted to weave different genres together in their stories. In particular, note the mix of narrative with factual information about crabs and the salt extraction adaptation for mangroves. This provides another example of factional text. Sample excerpts from the final draft of the book are included in Appendix A. Max's ideas, for example, and many of his actual words are easily identified in the text, as are Angus's from Figure 1. Additionally, brief explanations for Jake and Jenny (i.e., colloquial expressions for male and female crabs, respectively) are merged into the dialogue for the benefit of a reader unfamiliar with the colloquial (Appendix A).

Further evidence of the children's developing scientific fluency occurred during the school's *Beachathon* – its annual 10km fundraising walk along the beach. During the walk, the fourth-grade students' comments and observations were rich in scientific language. As well as demonstrating their scientific knowledge fluently through writing activities, the children also could engage in fluent conversations using correct scientific vocabulary in appropriate contexts. They were picking up *bivalves* and *univalves* (not simply *shells*); they were examining *molluscs* (not *animals*); and they were walking along the *intertidal zone* (not the *beach*). Their ability to translate what they had learned in the classroom-writing project to the field was remarked upon by several teachers and students from other classes. Ann also was impressed about how much the children had achieved:

> They have certainly learnt heaps of things about the environment that they live in, about all the different animals, about how they fit, about food cycles – everything they weren't suppose to do they've learnt, everything that was not required. They have achieved even higher than what would be expected at Year 6.

Evidence of the appropriation of scientific registers into everyday discourses, for these fourth-grade children, reinforces the fine-grained data from individual writing scripts and interview responses that leads to the claim that these children had demonstrated fluency in their use and understanding of related scientific phenomena through their legitimate participation in the project. This is consistent with the coarse-grained data from Lee et al. (2005) that established a link between activities that engaged children in integrated genres and improvements in science achievement. Moreover, these results demonstrate the tangible ways that this classroom community was transformed (cf. Lave & Wenger, 1991) – the content and fluency of the children's spoken and written discourse towards the end of the project surprised impartial observers as well as showing a quality rarely observed by teachers at this school.

Further Discussion and Implications

The children sampled in the current study collectively were engaged throughout the project, maintained their interest and motivation to produce a quality publication, demonstrated written and spoken fluency with and understanding of scientific phenomena encountered, as well as developed literacy skills using both narrative and factual genres. Metaphorically, the project enabled participants to build a bridge together that helped children merge narrative and formal science factual genres (cf. Hand & Prain, 2006; Prain, 2006). The evidence for the children's conceptual development in marine science reported here (e.g., in the written artifacts) supports previous claims in the literature that activities involving the integration of science and literacy instruction (i.e., a diversified writing approach; Prain, 2006) promotes achievement in both disciplines (Saul, 2004;

Lee et al., 2005), and justifies the recommended practice of co-creating eco-mysteries in primary school classrooms (El-Hindi, 2003). Moreover, in the context of writing their eco-mystery, and despite mixed results relating to students' preferences for writing genres, the children recognized the usefulness of writing formally in more technical genres and they were motivated to participate actively in science-related discourses (cf. Hildebrand, 2002). While this account might provide teachers and researchers alike with the concrete means to engage children meaningfully by storytelling in science (i.e., writing tasks that integrate science with literacy instruction or a diversified approach to writing science), these results cannot be used to dissuade classroom use of the epistemic writing approach by teachers who find its justification compelling.

Drawing on the out-of-school experiences of the children was important in moving the project forward. Many of the children had a familiarity with boating, fishing and camping that enriched whole-class discussions about particular storylines. Reading reference materials and sharing this information with classmates also contributed to a quality product. As the benefits of sharing ideas and experiences between children as well as writing together became more apparent to Ann, she organized more writing sessions in pairs because "they were more productive writing the story in pairs" (Ann), despite knowing that half of the students preferred individual writing (i.e., expressed preferences: 15 individual; 8 pairs; 7 whole class). Teachers in subsequent projects should consider structures that favour pair writing over individual and small-group work if they value productivity ahead of student preference.

As we acknowledged earlier, Ann was a talented teacher with expertise in children's literature and an interest in environmental issues. While our description of the pedagogical approach used by Ann in merging writing genres might be helpful for some teachers with a similar background and context, teachers with less access to desirable resources may not be able to coordinate such a large-scale curriculum innovation in their classrooms with the same outcomes. It might still be possible to achieve similar outcomes within a compressed period, however, by introducing the task of writing short stories that are based on ecological issues. Furthermore, more-sharply focused studies in a compressed timeframe might help to unpack the compounding effect of supplementary activities experienced by the children over the extended period in the current project (see Table 2). In follow-up research projects we are planning, we have begun to explore how it might be possible to encourage a diverse range of teachers to implement mixed-genre writing activities with their students. In particular, we are implementing short-story templates in science with online access to relevant resources that might achieve enhanced scientific literacy for children. In this way, it might also be useful to investigate whether these teachers develop greater confidence in teaching science through the integration of science with everyday literacy instruction (cf. El-Hindi, 2003).

Even though we have focused on those aspects of scientific literacy most closely related to writing an ecological mystery, we acknowledge that other important dimensions of scientific literacy need to be emphasized in other parts of the science curriculum (e.g., graphical literacy). Writing stories should be just one of many strategies used by teachers in science teaching. While some topics might be better taught using student-designed investigations (e.g., density), other topics could lend themselves better to storytelling. For example, factional writing about incursions of diseases such as Foot and Mouth disease would be a responsible approach to biosecurity education.

Furthermore, subsequent studies could explore how books like *Ocean action: an adventure at Beachtown* can be used as a stimulus for curricular innovations that emphasize the development of all three strands of scientific literacy (cf. MCEETYA, 2005). We also plan to focus on investigating children's multimodal learning of science through their created texts and associated illustrations in follow-up studies. The procedures for data analysis used by other researchers (e.g., Hackling & Prain, 2005) might prove to be helpful in further scrutinizing the claims we have made here. Other possible studies could explore any differential gender effect in such writing projects (cf. Hildebrand, 2002).

Coda

Two and one half months after the first draft of *Ocean action: an adventure in Beachtown* had been completed Ann invited the class to do some fine-tuning of the text. Before they began that process Ann asked the whole class to recall what they knew about sea anemones, for example. The children contributed the following responses energetically: "they live in symbiosis with clown fish;" "clown fish are covered in mucous to protect them from the stings;" "they eat using their tentacles that attract passing algae;" "clown fish lay their eggs there;" and "their tentacles perform a cleaning function." Intrigued by how well they remembered earlier work, Donna later asked the children individually how they accounted for the ease with which they recalled accurate information about sea anemones, specifically, and aspects of the intertidal zone, generally. The responses included: from other lessons with Mrs D and from reading books; speaking with an adult friend after mentioning that the class was writing a book;

from her science report with Mrs Moon; class worksheet from *Skull Island* book (which was read seven months earlier); and from reading *Skull Island*, as well as looking at the fact stop about the intertidal zone. Collectively, these responses reinforce other evidence that the children did learn science through the reading and writing tasks associated with the co-creation of *Ocean action: an adventure in Beachtown*, and suggest that this learning had more than a short-term effect.

Appendix A: Samples of Text from the Pre-published Version of Book

Chapter 7 Mangrove Madness

Sample 1. On Monday morning Dad took Elisah, Jim, Sunni and Zac to the mangroves to go fishing and crabbing. He was always out and about looking for clues and Elisha thought that the trip to the mangroves wasn't only to take the kids fishing on the holidays but to do some investigating of the latest turtle deaths.

"I can't wait to get there," said Sunni. "We learnt at school how important mangroves are to the environment. They keep the ground secure and stop erosion as well as being feeding spots for marine and land animals. They are also nurseries for many different marine species. What do **you** know about mangroves, Elisha?" asked Sunni smugly, thinking Elisha didn't know anything.

"There are many different types of mangroves. They are trees with flowers so they are angiosperms. That's how they reproduce," answered Elisha who also had studied mangroves at school. "Bet you didn't know that," she smiled. "And, mangroves shed their leaves when they are full of salt. The leaves fall into the water and rot and become detritus, which is food for the fish and crabs. Mangroves have different kinds of roots, peg roots and knob roots. The peg roots get oxygen for the plant when the tide is in."

"Cool," said Jim, not playing his game boy for a change." "What else do you know?"…

Sample 2. "Now, everyone," said Dad, as they arrived at the mangroves. "Remember we can catch only ten male mud crabs, and they must be at least fifteen centimeters across. To tell if it's a male or female you flip it over and look at its belly markings. If it has a narrow marking it's a male, a jack. If it's a female, a jenny, you throw it back in. That way the female can produce more crabs and they'll always be here for the future. Of course we have to protect the males too. That's why we can have only ten males of a certain size," explained Dad. "Hopefully we'll catch some crabs in these crab pots."

References

Akerson, V. L., Flick, L. B., & Lederman, N. G. (2000). The influence of young children's ideas in science on teaching practice. Journal of Research in Science Teaching, 37(4), 363-385.

Appleton, K., Gins, I. S., & Watters, J. J. (2000). The development of preservice elementary science teacher education in Australia. In S. K. Abell (Ed.), Science teacher education. An international perspective (pp. 9-29). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Barber, J., Catz, K. N., & Arya, D. (2006, April). Improving science content acquisition through a combined science/literacy approach: A quasi-experimental study. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Braund, M., & Hames, V. (2005). Improving progression and continuity from primary to secondary science: Pupil's reactions to bridging work. International Journal of Science Education, 7(3), 781-801.

Chaiklin, S., & Lave, J. (Eds.). (1993). Understanding practice. Perspectives on activity and context. Cambridge, UK: Cambridge University Press.

DeCoito, I., & Nieswandt, M. (2002, September). Exploring gender differences in student writing in science. Paper presented at the International Conference. Ontological, Epistemological, Linguistic and Pedagogical Considerations of Language and Science literacy: Empowering Research and Informing Instruction. University of Victoria, Canada.

Dillon, J., Osborne, J., Fairbrother, R., & Kurina, L. (2000). A study into the professional views of science teachers in primary and secondary schools in England. London: Council for Science and Technology.

El-Hindi, A. E. (2003). Integrating literacy and science in the classroom: From ecomysteries to readers theatre. Reading Teacher, 56(6), 536-538.

Engeström, Y. (1999). Situated learning at the threshold of the new millennium. In J. Bliss, R. Säljö, & P. Light (Eds.), Learning sites. Social and technological resources for learning (pp. 249-257). Amsterdam: Pergamon.

Erickson, F. (1998). Qualitative research methods for science education. In B. J. Fraser & K. G. Tobin (Eds.), International handbook of science education (pp. 1155-1173). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fensham, P. (2001). Science as story: Science education by story. Asia-Pacific Forum on Science Learning and Teaching, 2(1), 1-5.

Ford, D. J. (2004). Highly recommended trade books: Can they be used in inquiry science? In E. W. Saul (Ed.), Crossing borders in literacy and science instruction: Perspectives on theory and practice (pp. 277-290). Newark, DE: International Reading Association, Inc.

Goodrum, D., Hackling, M., & Rennie, L. (2001). The status and quality of teaching and learning of science in Australian schools. Canberra: Department of Education, Science and Training.

Hackling, M. W., & Prain, V. (2005). Primary Connections. Stage 2 trial: Research report. Canberra: Australian Government, Department of Education, Science and Training.

Halliday, M., & Martin, J. (1993). Writing science: Literacy and discursive power. London: Falmer Press.

Hand, B., & Keys, C. W. (1999). Inquiry investigation: A new approach to laboratory reports. The Science Teacher, 66(4), 27-29.

Hand, B., & Prain, V. (2006). Moving from border crossing to convergence of perspectives in language and science literacy research and practice. International Journal of Science Education, 28(2-3), 101-107.

Hand, B., Wallace, C. W., & Yang, E-M. (2004). Using a Science Writing Heuristic to enhance learning outcomes from laboratory activities in seventh-grade science: Quantitative and qualitative aspects. International Journal of Science Education, 26(2), 131-149.

Hargreaves, A. (1996). Revisiting voice. Educational Researcher, 25(1), 12-19.

Harlen, W. (1997). Primary teachers' understanding in science and its impact in the classroom. Research in Science Education, 27(3), 323-337.

Hildebrand, G. (1998). Disrupting hegemonic writing practices in school science: Contesting the right way to write. Journal of Research in Science Teaching, 35(4), 345-362.

Hildebrand, G. (2002, September). It's electrophilic; it's hydrophobic… that's anthropomorphic language! Paper presented at the International Conference. Ontological, Epistemological, Linguistic and Pedagogical Considerations of Language and Science literacy: Empowering Research and Informing Instruction. University of Victoria, Canada.

Jarvis, T., & Pell, A. (2004). Primary teachers' changing attitudes and cognition during a two-year science in-service programme and their effect on pupils. Research report. International Journal of Science Education, 26(14), 1787-1811.

Jordan, B. (1989). Cosmopolitan obstetrics: Some insights from the training of traditional midwives. Social Science and Medicine, 28(9), 925-944.

Klentschy, M. P., & Molina-De La Torre, E. (2004). Students' science notebooks and the inquiry process. In E. W. Saul (Ed.), Crossing borders in literacy and science instruction: Perspectives on theory and practice (pp. 340-354). Newark, DE: International Reading Association, Inc.

Lave, J., & Wenger, E. (1991). Situated learning. Legitimate peripheral participation. Cambridge, UK: Cambridge University Press.

Lee, O., Deaktor, R. A., Hart, J. E., Cuevas, P., & Enders, C. (2005). An instructional intervention's impact on the science and literacy achievement of culturally and linguistically diverse elementary students. Journal of Research in Science Teaching, 42(8), 857-887.

Lincoln, Y. S., & Guba, E. G. (1990). Judging the quality of case study reports. Qualitative Studies in Education, 3(1), 53-59.

Maritn, J., & Veel, R. (1998). Reading science: Critical and functional perspectives on discourses of science. London: Routledge.

Ministerial Council on Education, Employment, Training and Youth Affairs (2005). MCEETYA national assessment program, science, year 6 2003: Technical report. Sydney: Australian Council for Educational Research.

Prain, V. (2006). Learning from writing in secondary science: Some theoretical and practical implications. International Journal of Science Education, 28(2-3), 179-201.

Rigano, D.L., & Ritchie, S.M. (1995). Student disclosures of fraudulent practice in school laboratories. *Research in Science Education*, *25*(4), 353-363.

Rigano, D. L., Ritchie, S. M., & Bell, T. (2005). Developing wisdom-in-practice through coteaching: A narrative account. In W-M. Roth & K. Tobin (Eds.), Teaching together, learning together (pp. 169-185). New York: Peter Lang.

Ritchie, S. M., & Hopley, D. (1997). Reflections on the development of tropical marine studies for South Pacific schools. In N. Saxena (Ed.), Recent advances in marine science and technology (pp. 421-428). Honolulu: PACON International.

Rivard, L. P. (1994). A review of writing to learn science: Implications for practice and research. Journal of Research in Science Teaching, 31(9), 969-983.

Roach, L. E., & Wandersee, J. H. (1995). Putting people back into science: Using historical vignettes. School Science and Mathematics, 95(7), 365-370.

Roth, W-M. (2005). Doing qualitative research. Praxis of method. Rotterdam, The Netherlands: Sense Publishers.

Roth, W-M., Hwang, S., Goulart, M. I. M., & Lee, Y. J. (2005). Participation, learning, and identity. Dialectical perspectives. Berlin: Lehmanns Media – LOB.de.

Saul, E. W. (Ed.). (2004). Crossing borders in literacy and science instruction: Perspectives on theory and practice. Newark, DE: International Reading Association, Inc.

Smolkin, L. B., & Donovan, C. A. (2004a). Improving science instruction with information books: Understanding multimodal presentations. In E. W. Saul (Ed.), Crossing borders in literacy and science instruction: Perspectives on theory and practice (pp. 190-208). Newark, DE: International Reading Association, Inc.

Smolkin, L. B., & Donovan, C. A. (2004b). How not to get lost on The magic school bus: What makes high school science content read-alouds. In E. W. Saul (Ed.), Crossing borders in literacy and science instruction: Perspectives on theory and practice (pp. 291-313). Newark, DE: International Reading Association, Inc.

Stannard, R. (2001). Communicating physics through story. Physics Education, 36(1), 30-34.

Tobin, K. (2000). Interpretive research in science education. In A. E. Kelly & R. A. Lesh (Eds.), Handbook of research design in mathematics and science education (pp.487-512). Mahwah, NJ: Lawrence Erlbaum Associates.

Varelas, M., Becker, J., Luster, B., & Wenzel, S. (2002). When genres meet: Inquiry into a sixth-grade urban science class. Journal of Research in Science Teaching, 39(7), 579-605.

Wallace, C. S., Hand, B., & Prain, V. (2004). Writing and learning in the science classroom. Dordrecht: Kluwer Academic Publishers.

Warwick, P., Stephenson, P., Webster, J., & Bourne, J. (2003). Developing pupils' written expression of procedural understanding through the use of writing frames in science: Findings from a case study approach. International Journal of Science Education, 25(2), 173-192.

Wellington, J., & Osborne, J. (2001). Language and literacy in science education. Buckingham: Open University Press.

Yager, R. E., & Weld, J. D. (1999). Scope, sequence and coordination: The Iowa Project, a national reform effort in the USA. International Journal of Science Education, 21(2), 169-194.

Zicus, S. (Ed.) (2004). The hidden secrets of Skull Island. Townsville, Queensland: James Cook University.

Table 1

Summary content analysis of "Ocean action: an adventure at Beachtown"

Chapter	Concepts	Other Science Content	Percentage of text by genre/form		
			Factual	Factional (Merged)	Fictional (Narrative)
1. Meet the Turners		Turtles, eggs, marine biologist	1.5	2.0	96.5
2. Death at Chownsy Bay	Sustainability	Work practices of marine biologist, turtle species	6.7	23	70.3
3. The new boy	Classification	Cephalopods, mollusk, seahorse, stone fish, hermit crab, octopus	9.0	30.4	60.6
4. Turtle killer tackle	Symbiosis	Echinoderm, regeneration, clown fish, intertidal zone, uni-valve, bi-valve	14.0	27.5	58.5
5. The green car			0	0	100
6. Weedy Water Bay	Photosynthesis	Sea grass, angiosperm, nutrients, fertilizer	10	22	68
7. Mangrove madness	Predation, food chain, reproduction	Hermaphrodite, mangrove	10.6	57	32.4
8. Iforgot Island	Adaptation	Sea cucumber, detritus, cone shell	7.0	16.8	76.2
9. Bye-bye baddies			0	1.6	98.4
10. All's well that ends well			0	3.2	96.8

Table 2

Sequence of class activities and research procedures during 2005

Month	Related Class Activities	Artifacts	Research Procedures
Jan	Teacher reads *Hidden Secrets* to whole class. Students read in groups. Teacher reads other mystery genre books to the whole class.		Observations Videotapes Group interview
Feb	Students begin writing play. Students start naming and illustrating locations for the story. Students choose/draw characters for their story. Students choose a marine animal to research.	Draft play scripts Drawings	Observations Videotapes Group interviews Individual interviews
Mar	Research report – structure Starting writing Ch 1 Research reports/charts Play writing/roles	Drafts of research reports Ch 1 drafts Play scripts	Observations Videotapes Individual interviews

	Visit by "Turtle man"		
Apr	Whole-class & group writing	Science reports	Observations
	Mangroves video/book references	Ch 2 drafts	Videotapes
	Experiment with salt water		
	Present science reports	Worksheets	
	Visitor (father) – commercial fisher		
May	Story Writing	Chapter drafts	Observations
	New writing process-pairs	Acrostic poems	Pair interviews
	Mangroves acrostic poems		Individual interviews
	Debate		
	Finish Ch 6 on mangroves		
June	Story writing.	Play scripts	Observations
	Rehearse and perform plays	Book draft	Videotapes
July	Beachathon – Excursion to beach		Observations
Aug	Re-draft rock pools' section in Ch 3	Revised draft	Observations
Sep	Totally turtle day – visit to aquarium		Interviews
Oct	Draft revisions	Revised draft	Interviews
Nov	Draft revisions & illustrations	Final draft & illustrations	Observations Videotapes
Dec	Designing advertising brochure for book	Brochures	Observations

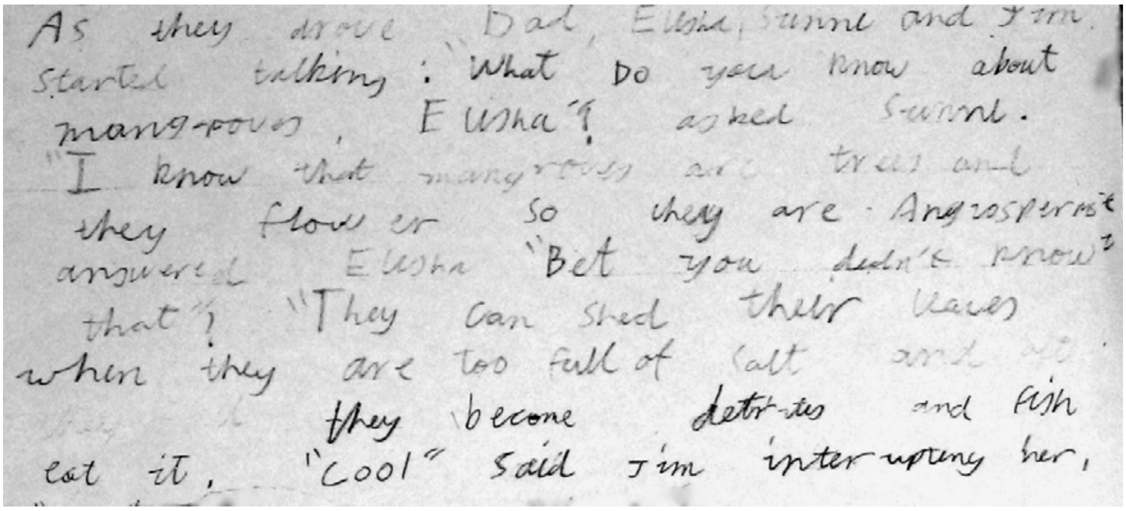
As they drove, Dad, Elisha, Sunni and Jim started talking: "What do you know about mang-roves, Elisha"? asked Sunni. "I know that mangroves are trees and they flower so they are Angiosperms" answered Elisha "Bet you didn't know that"? "They can shed their leaves when they are too full of salt and [illegible] [illegible] they become detri-tus and fish eat it, "Cool" said Jim interupting her,

Figure 1. Extract from Angus's story on mangroves

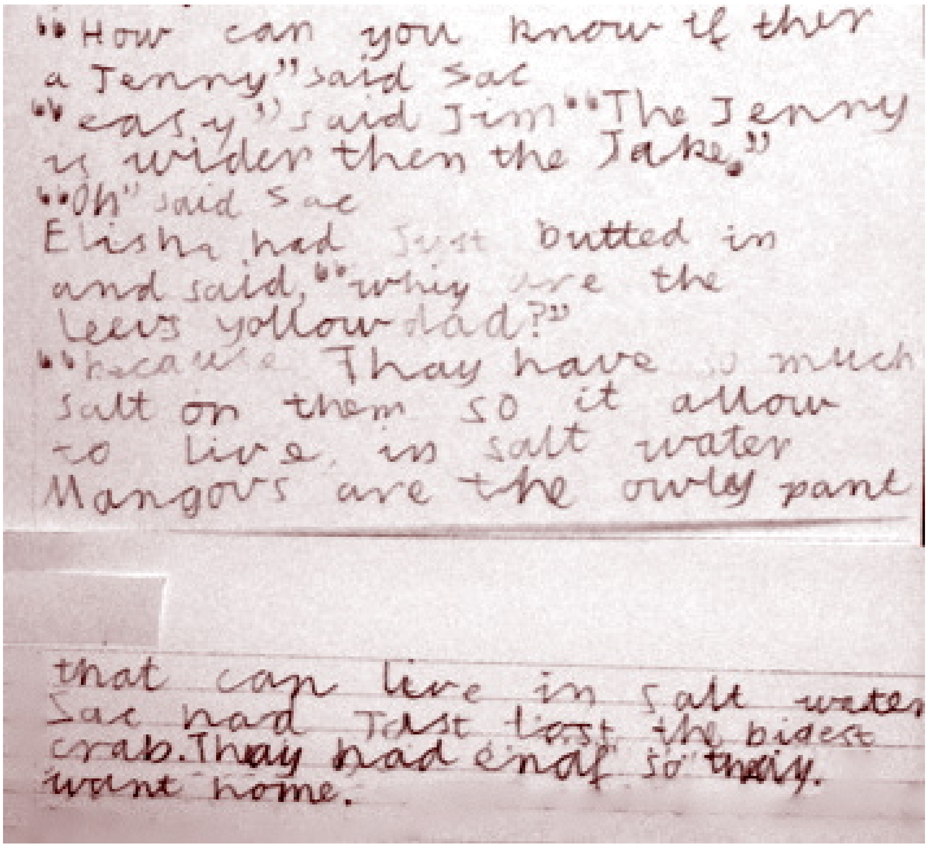
"How can you know if ther
a Jenny" said Sac
"easy" said Jim "The Jenny
is wider then the Jake."
"Oh" said Sac
Elisha had Just butted in
and said, "why are the
leevs yollow dad?"
"because Thay have so much
salt on them so it allow
to live in salt water
Mangovs are the owly pant
that can live in salt water
Sac had Just last the bidest
crab. Thay had enaf so thay
want home.

Figure 2. Excerpt from Max's hand-written story on mangroves.