Learning science: Sociocultural Dimensions of Intellectual Engagement

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ABSTRACT. *This paper takes a sociocultural perspective as it addresses the problem of engaging all students in learning science, in contrast to a companion (ASERA '02) paper where I address the issue in relation to psychological issues, both papers arising from the same set of research studies in science education. In both cases I am asserting that the interaction between the teacher and student is critical in either engaging or alienating students, and, in this paper will address the language aspects of the relationship. Seen in the light of sociocultural, including sociolinguistic, theories, my research findings imply that `science literacy' could usefully be reconceptualised as the learning of a discourse, or as the learning of a literacy or language—as literacy or language teachers might define these. This paper addresses the development of science literacy as a process of situated learning within a meaningful social context, what Lemke (1995) called an "ecosocial system". From this perspective, learning science is the learning of a discourse. This includes becoming familiar with genres but not in isolation from meaningful community practice. I conclude that if science is seen as a distinct discourse practice, then this has implications for the learning and teaching of science and for teacher education.*

Science as a Distinct Discourse

Scientific knowledge can be seen as a meaning system in which words have meaning not in themselves but in relation to thematic patterns and social practices in science as a whole (Halliday & Martin, 1993; Lemke, 1990, 1995; Martin, 1990). This is a socio-linguistic perspective on science learning which is part of a much broader socio-linguistic, and more generally, sociocultural perspective (e.g., see Collins, Brown & Newman, 1989; Gee, 1993; Halliday, 1994; Vygotsky, 1934/1962). Such a meaning system is not built through step by step logic but rather is a matter of becoming familiar with a particular way of viewing and dividing up the world, based on particular beliefs, values and practices. This contrasts with the way science is often taught in schools as though it is a set of facts and definitions which present stand-alone, self-evident truths, with meaning not being dependent on or relative to understanding a much broader system of ideas, beliefs, values and social practices.

In secondary science, students are generally taught about elements in the system without ever having the system as a whole explicitly referred to as a different system from that of everyday life; instead everyday common sense is undermined (Lemke, 1990). As I explained in my ASERA 2001 paper (Hanrahan, 2001), more often than not it is not even made clear to students that science has a language of its own. For example, in using everyday terms in special ways, students are expected to know that everyday usage of such terms is "wrong". Similarly Western science has been identified as having particular values, such as being masculinist, Eurocentric, and middle class (Harding, 1991; Kelly, 1987; Lemke, 1990). These values are rarely made explicit or even addressed (with teachers perhaps not even being aware of them), and yet, in my experience, students are expected to share these values without any explicit discussion about them having taken place.

School science is thus presented as though it is a simple matter of fact, of following the

teacher's logic, and learning to use technical terms correctly. Yet, it is not a simple process of accumulating facts or of logical deduction. Rather it is known as a subject which most students find difficult, and which too many find alienating (Fensham, 1988; Lemke, 1990). It is presented as though its use of language is the only correct use, can be learnt word by word, fact by fact, definition by definition, and that any problems students have with it are due to a lack of innate intellectual ability on their part, and therefore beyond the control of the teacher.

I see this situation as unfortunate and as potentially leading to injustice. Feminist writers (e.g., Kelly, 1987; Harding, 1991; Tobias, 1990) have argued that girls in particular are disadvantaged by the way science has traditionally been presented in our schools as decontextualised knowledge, divorced from social and cultural issues. More generally, one legacy of constructivism has been the general belief that all students learn more easily if new elements are introduced in relation to knowledge which is already meaningful to them. Sociocultural theorists would take this even further, arguing that learning is likely to be most meaningful when it is part of the development of the sociocultural practice of a community that students belong to or want to belong to (cf. Lemke, 1995; The New London Group, 1996; Roth, 1992).

This is not to say that there are not some students, particularly among those who come from higher socio-economic status backgrounds, who find science easy. I would argue that this may not simply be a matter of better handling of abstract concepts but that these so-called "abstract" concepts may have much richer associations for them in terms of their past practical experience, than they do for more disadvantaged students. Tobias (1990), quoting a chemistry lecturer, wrote, "There has to be room in science for people who did not ask for a chemistry set at age five" (p. 44). The implication is not so much that you have to be precocious to be a good science student, but that the science curriculum favours those from a particular cultural background and particular cultural resources, what Bourdieu (1974) called "cultural capital".

Approaches to teaching based on constructivist beliefs may be consistent with a teaching goal of making learning more meaningful by relating new learning to old, but they can still be used in curricula which are essentially abstracted from real-life issues and concerns, abstracted from any lifeworld concerns besides those of scientists' lifeworlds (and even then these may be idealised rather than real as I have suggested in my other ASERA 02 paper). `Lifeworld' is generally used to refer to the social practice and personal relationships of various settings (including institutional ones), in contrast to practice governed more directly by explicit institutional conventions and rules (The New London Group, 1996).

I find Lemke's (1995) conceptualisation of language as part of practice in an ecosocial system helpful as it highlights the interdependence of language and all the other elements in the social system, including community roles and relationships, and social practices. The idea of an ecosystem of social practice, including beliefs, values and practices, allows for subconscious elements in the system, and means that language is likely to be constrained by customs and habits within relationships. It also allows for the way language and relationships change as one moves between ecosystems or, to a lesser extent, between different niches within an ecosocial system. Hence it explains the existence of different discourse (systems) within different communities, with discourse being defined as the semiotic (meaning-making) system used by a particular community, a system whose structure, content and relationships will depend on the community's practices, beliefs, values and attitudes. Moreover, for me it explains why the discourse of school science is so easy for some students to adopt and so difficult for others, and also why major change in language practice can be so difficult.

Situated Learning

When I began my research in science education, I had already been very impressed by theories of learning which implied that learning was deepest, at its best, when it was a context-dependent, holistic process. I could not help but contrast this with the way science was often taught, with each topic being broken down into small components and taught separately, the big picture and social implications only becoming visible after many years, perhaps not even until learners graduated and began working as scientists.

Yet, in both learning to read, and foreign language learning–two areas in which I had taught and hence had first-hand evidence–the prevailing belief was that the students who were most successful were students who learnt the parts in a meaningful social context. For example, in the literacy area, success in learning to read with comprehension seemed to depend as much on a deep cultural understanding of the value and purpose of (a wide variety of) texts as on learning the mechanics of decoding letters and words. This meant, for example, that pupils who had little prior experience of being read to at home were likely to have the greatest difficulty in learning to read and use written genres at school. Similarly, in foreign language teaching I became familiar (in spite of having learnt French atomistically myself, and having first been trained to teach using drill methods) with methods that required immersion in the foreign language, to a greater or lesser extent depending on the context. This meant that students were required to use the foreign language to interact with the teacher and each other as they learnt the foreign language and even as they learnt other subjects, which resulted in the development of greater fluency and idiomatic usage than did older methods which relied more on rote-learning lists of vocabulary, verb endings and grammar rules.

In both language-learning cases, it seemed that what was involved was the learning of a world view, or a "Discourse" (as defined by Gee, 1993; however, henceforth I will use a lower case "d" to indicate the same concept). This implied that words could not be properly understood without also learning about the values, beliefs, attitudes, and practices which gave them their meaning. Learning was seen as a holistic process depending on cultural values to provide the significance which made individual words or concepts make sense. The New London Group (1996) citing sources from cognitive science, social cognition and sociocultural approaches to language and literacy, also proposed that "situated practice" was necessary if mastery learning was a goal of pedagogy. They wrote, "There is ample evidence that people do not learn anything well unless they are both motivated and believe that they will be able to use and function with what they are learning in some way that is in their interest" (p. 85).

Such success with situated learning, however, was not limited to the area of language learning, but has been found in a wide variety of classroom situations, not to mention in training in the major professions, such as medicine or engineering (cf. Billett, 1992). For example, Bransford, Vye, Kenzer and Risko (1990) reported its successful use in many settings including an integrated curriculum at the primary school level, and emphasised its importance for transfer of learning from the classroom to other settings.

Another good example is the `cognitive apprenticeship' model of Collins, Brown and Newman (1989), derived from the examination of successful learning in three different areas–reading comprehension in science, problem solving in mathematics, and written composition in English. It posited that ideal learning environments had sociological characteristics which were as necessary for learning as factors related to content, methods and sequencing of the matter to be learnt. They saw successful school learning as depending on positive epistemological beliefs and as likely to be most successful when it took place in a community context in which (a) such learning was valued by the community, (b) learning strategies were made explicit and modelled by experts, and (c) all students were seen as being worthwhile within a supportive community setting.

Roth's (1992) case study of a "learning community" approach to teaching and learning is a good example of setting learning in a meaningful classroom community where learning is gradually built up as part of the classroom culture based on supportive interpersonal relationships. In the Roth study, this included the use of personal writing by the students. Comparing it with the traditional "work-oriented" classroom setting, where getting right answers, finishing tasks, and listening to the teacher as expert, all in a depersonalised way, were the main goals, Roth argued for a "conceptual change science learning community" where sense-making and learning was the main goal, where learning required authentic situations and emotional involvement, where personal ownership and commitment by students were necessary, and where "everyone's ideas [were] valued and respected in the learning process" (p. 5). Roth wrote

> A learning-place environment requires a particular kind of social context that enables learners to practice and exercise particular kinds of actions (inquiry, questioning, collaborating, etc.) surrounding knowledge that is connected and useful." (p. 6).

Bruner's (1990) theory about humans making meaning through narrative logic rather than abstract logic could also be seen as support for a situated learning approach.

The conceptual change literature in general provides evidence for the need for a meaningful context in which to change alternative conceptions in science. Some researchers argued that alternative scientific conceptions seemed to exhibit the characteristic resistance to change expected of *beliefs* rather than of neutral concepts (e.g., Gunstone, 1988; Loughran & Northfield, 1996; White, 1993). However, the conceptual change approach of these Monash researchers differed from the situated learning principles implied above in that, on the whole, it looked at learning as an individual/ psychological rather than a sociocultural change process. On the other hand, when referring to *teacher* change, White and Baird (1991) and Baird and Northfield (1992) did cite sociocultural factors, such as social support, as being important for change in practice.

Other constructivist approaches were more directly aimed at enculturating students into a scientific perspective, using strategies such as small group discussion (Driver & Easley, 1978; Solomon, 1994). These approaches, however, still seemed to see problems in learning science largely in terms of intellectual processes and not in terms of the "emotional, personal and social lives" of pupils (Head, 1989). This is in contrast to more holistic sociocultural models of learning which do take affective factors into account. I see my own research in science education, which I begin to address in the following section, as fitting into the latter group of approaches to learning. The part of my research which is relevant to this paper, consisted of three studies: a period of observation in on Year 8 science class, followed by an bi-part action research study in another Year 8 science class that developed simultaneously along two relatively distinct paths.

Applying Science as Situated Learning in my Classroom Research

In the writing-to-learn part of my action research study (Hanrahan, 1999), I collaborated with another Year 8 teacher to trial a dialogue journal writing intervention. The students were encouraged to express their feelings, their opinions, and their suppositions in their own words. The teacher and I responded affirmingly to the students' anonymous diary entries in writing (see Hanrahan, 1999, for a more detailed account). This intervention had a very positive effect on the learning environment and, as well as giving the teacher better insight into the needs and motivations of his students, gave the students more confidence to participate actively in class discussion and in their own learning.

In my other ASERA '02 paper, based on my own research in science education, I also discuss the importance of the teacher-student interpersonal relationship for student intellectual engagement. There I address the issue from a psychological perspective. However, this issue makes even more sense in the context of science learning as the learning of a sociocultural practice. From this perspective, science is not just about content (i.e., making sense of the

world), it is also about context (i.e., relationships with people and with oneself, and relationships between events) and is therefore heavily loaded with cultural connotations related to values, beliefs and emotions, involving both the social and individual aspects of the learner.

I believe the affirmational dialogue journal writing intervention created a dialogue situation which related much more to the lifeworlds of the students than the more regulated science activities, and that it reduced the feeling of alienation the students expressed before the research started. The New London Group (1996)[i] highlighted the importance of making such connections with students in an age when it no longer makes sense to impose the discourse practices of a single discourse community on students who collectively have a variety of needs and interests. This cross-disciplinary group of authors concluded,

> To be relevant, learning processes need to recruit, rather than attempt to ignore and erase, the different subjectivities – interests, intentions, commitments, and purposes – students bring to learning. Curriculum now needs to mesh with different subjectivities, and with their attendant languages, discourses, and registers, and use these as a resource for learning" (The New London Group, 1996, p. 72).

My research recruited the personal perspectives students brought with them to science and I see this as responsible for its positive effect on the learning environment. I also see it as more equitable way to relate to students than an approach which disaffirms students not already enculturated into a scientific world view.

Although the New London Group authors were talking in terms of literacy pedagogy, or rather "multiliteracy" pedagogy, their approach seems to me to be very relevant to the teaching of science, as they re-examined the goals of teaching in the light of a diversity of goals for education in a world which recognised increasing cultural and linguistic diversity and the pragmatics of students needing to be able to negotiate their working, civic and private lives. This has direct implications in a discussion of science literacy and I will address these in the following section.

Science literacy as a literacy

When I first framed my research question (in my research proposal) in terms of "search[ing] for approaches ... of facilitating the type of environment thought most likely to ... promote scientific literacy", scientific literacy was a much more limited term than it is for me now. I meant it in the sense it generally has for science teachers and science education researchers (e.g., see volume 31, issue 9, of the *Journal of Research Science Teaching*, 1994), that is, as a facility with science concepts based on an understanding which is deep enough for purposes of application and as a basis on which to build further learning. I read the Glynn and Muth (1994) article which cites a 1989 American Association for the Advancement of Science definition of a scientifically literate person:

> one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognises both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (AAAS, 1989, p. 4, cited in Glynn & Muth, 1994)

However, like Glynn and Muth, who advise teachers to use authentic reading and writing tasks to get students to take a constructivist, metacognitive approach to learning, including using process writing and mnemonic aides to provide a "minds-on emphasis in the learning of science" (p. 1058), I still had a largely logico-deductive method of learning in mind. Their literature base and outlook is similar in many ways to the "individualist" conceptual change approach referred to above, in spite of the inclusion in the definition of a functional component.

However, since I knew that most of the students would not go on to specialise in science academically, I was less interested in the correct usage of technical vocabulary than teachers would be, and more interested in a grasp of principles which would allow students to better understand their world and be more empowered to make wise decisions in the world outside school, because of what they had learnt in school science. Inevitably this would have included having at their disposal the necessary tools of language to think scientifically, but this knowledge was implicit at this stage, and, consequently, as yet unproblematic. I had not connected my research goals to my previous experience in teaching literacy to adult learners, nor to my teaching of English or my teaching of a foreign language to secondary school students.

Yet the AAAS definition is quite obviously taking a functional and sociocultural perspective. Incidentally, in a recent review of scientific literacy, Christensen (2002) has concluded that policy documents on scientific literacy on three continents now define it largely in functional terms, even though research on classroom practice does not reflect this (e.g., the review of science education in Australia by Goodrun, Hackling & Rennie, 2001,). Note that "Science literacy" and "scientific literacy" have been used somewhat interchangeably, with either being interpreted in a variety of ways, according to the speaker's views of the goals of science education, and being used to describe the user's ideal in terms of outcomes. For my purposes I prefer "science literacy" which is the term the AAAS have used for their initial document, "Science Literacy for All Americans" and subsequently for their "Benchmarks" and "Designs for Science Literacy" (AAAS, 2000). I see what I am referring to as analogous to terms like "computer literacy", "film literacy", with "science" meaning what people encounter in their everyday life, in contrast to "scientific literacy" which suggests the worldview of a specialist, a scientist. Hence "science literacy" seems more appropriate to me when I am talking about the goal of science education for "all".

Science Literacy as a Functional Literacy

If science is a particular discourse system, then the teaching and learning of science can be seen as the teaching and learning of a particular discourse, and science literacy as a particular literacy comparable to other literacies. Literacy, as the term is used in other contexts, has developed to mean much more than being able to read and write in a technical sense of being able to spell words, decode them in text, use correct grammar, and so on. It has been broadened to have a functional meaning and to include being able to use such skills for practical purposes in life situations, to satisfy one's personal and social needs. Wickert (1989) in a large-scale survey of literacy in Australian adults, defined literacy as `using printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential.' (p.4). She argued that if literacy has a functional definition, they what one defines as literate will depend on the literacy needs of the social context one wishes to refer to.

Science literacy—as most science curriculum documents use the term when defining the goal of school science as being "science literacy for all" (cf. AAAS, 2000; Queensland School Curriculum Council, 1999)—is described in such functional terms, which implies thus that it should be read to imply teaching it in such as way as to be applicable to everyday life problems and issues. Hence this means more than being able to use apply technical terms and scientific principles correctly in assessment tasks at school, college or university (that could better be termed *science classroom* literacy or *science student* literacy). Functional science literacy implies being familiar with, and willing and able to participate in the literacy practices of a particular discourse community, whether that be a professional science community or a non-science community. The "science literacy for all" goal as used in the above curriculum documents refers to the latter. In this light, describing science as a discourse and science literacy as a literacy both imply using science in a way that links science to the social practice of everyday life. I believe there is considerable value in seeing

science literacy as such a literacy, especially for most students who will not go on to specialise in science, but who, as non-scientists, would benefit from the application of scientific knowledge to everyday problem solving.

A Language Teacher's Perspective

After two studies in both of which the focus was on motivation from a psychological perspective, I then began to make connections with sociocultural theories underlying my former practices as a language (English), foreign language (French), and adult literacy teacher. It was during my "pre-research" phase, in the first Year 8 classroom in which I found myself, that I became aware of the teacher-student interactions—what I would later call the "language practice"—of the science classroom in a new way. This was the class where I did not get as far as introducing an intervention, but saw myself simply as establishing a working relationship with a teacher and becoming familiar with the classroom culture. This lack of an immediate research goal allowed my mind to roam more freely, to play with ideas outside my formal research questions, and to make new connections. In fact, this was to become as significant a piece of research for me as my later more structured studies, because it allowed me to gain a new insight into issues of motivation.

What I learnt was that learning science for some students was almost like learning a foreign language, with a new grammar as well as new vocabulary. However, this was bedevilled by the fact that neither the students nor the teacher could see this state of affairs and so didn't behave as students or a teacher of language would in the face of language difficulties. They just treated it as a memory (and probably IQ) deficiency, as an intractable lack of either ability or commitment on the part of the students. However, at the time, I didn't realise the significance of my insight, but saw it as incidental learning, not relevant to my research issue. I put it to the back of my mind and got on with the "real" research, when unforeseen circumstances meant that I had to move on to another classroom.

Nevertheless, as the story recounted in the CONASTA paper I presented the following year (Hanrahan, 1995) shows, I had begun to see the language practices of science teaching as analogous to the teaching of a foreign language. Once I had had this insight, I could understand many of the problems the teacher spoke of in a new light. For example, she had spoken of students seeming to understand at the time what they were taught, but never "remembering" what they had learnt when tested up to four weeks later.

As a language teacher, I started noticing how little practice students got in using new words they were supposed to have "learnt". I thought students would have a better chance of becoming "science literate" if they had the chance to play with the new language more actively, using it to create sentences to communicate ideas which they themselves were the author of, rather than copying sentences from the board and doing cloze exercises from the textbook, both of which many students seemed to perform in a passive way, without taking much notice of what they were doing. In teaching French, I got students to use new words or phrases in situations which were meaningful to them, either orally or in writing, to give them rich, personal associations which would help them remember the new elements. At the time, this insight into the connection between learning science and learning a foreign language and the power of personal associations, seemed to me to provide yet another reason for the journal writing intervention I had proposed, as it seemed a good site for such meaningful practice for all students.

However, as far as language learning went, the journals did not get to the stage where students got much practice in using new terminology. They were used far too infrequently for this, and I did not feel entitled to ask that more time be given to them, especially early in the research while the teacher was still concerned with "covering the curriculum" to keep up with parallel classes. (Nor would I allow students to take them home, as, based on my experience with Year 8 boys previously, I feared that many of the little notebooks would be lost or fall

apart from irreverent handling, a risk I was not prepared to take.) However, I do think the journal writing activities were an important element in the development of literacy, when literacy learning is taken to be a complex process involving authentic communication between people between whom there is a socially meaningful relationship.

Furthermore the purposes and success of the journal writing intervention can be more clearly understood when learning science is seen as a process involving interpersonal as well as personal factors. I have discussed the difficulty of conceptual change in my other ASERA '02 paper. This can now be reviewed in light of a discussion of the change involved in the development of competence in a new literacy.

Literacy Learning as a Process of Change

Lemke (1995) has written, "I believe that matters of meaning and matters of social relationship are so interdependent that we must understand both to understand either" (p. 1). This has particular significance when viewed in the context of literacy teaching, and in particular, teaching for science literacy. Halliday and others influenced by his systemic functional linguistics (eg. Fairclough, 1989; Halliday, 1994; Lemke, 1995) have asserted that language always serves several functions simultaneously. At one and the same time a speaker or writer is communicating a message/ideas/content, is setting up or maintaining a particular relationship with the audience or reader (e.g., expert to novice or peer to peer), establishing a particular identity (or social roles) for the self and the audience, representing the world in a particular way, and playing a role in a known practice or genre in a particular social context. Hence its meaning is dependent on, or at least in dialogue with the situational, social and cultural contexts, and cannot be interpreted except in relation to them.

In the context of adult literacy teaching Treloar (1994) argued that literacy learning involved much more than learning to read and write words/sentences/whole genres in particular contexts according to particular rules. More fundamentally it involved learning new ways of relating to other people and to one's world, including changes in the power dynamics in relationships and even in one's self-concept. She pointed out the psychological difficulties involved in changing one's identity— a possible or even likely outcome of becoming more literate—and commented that such difficulties may only be overcome with a struggle. She argued that what was missing from the argument of the critical theorists was any attention to the process by which individuals undergo change. There is no sense that this may prove difficult or may be resisted" (p. 15). She argued that it might be resisted as long as students have not changed their conceptualisation of themselves as individuals who do not use a range of literacy practices or are in particular power structure arrangements with other people. Even though Treloar is interested in the psychology of developing new literacy practices, her point of view would be consistent with a sociocultural systems perspective in which people are seen as developing social practices (including language) in response to their environment, and only changing them when the environment and meaning system permits this (also cf. Lemke, 1995; Maturana & Varela, 1992). For Treloar, one's level of literacy cannot change without changing one's identity (which can be seen as involving one's practice as a whole) and one's relationships, and she saw these as necessarily involving conscious struggle, and hence agency at the personal level.

Further evidence of links between learning and personal identity, this time in science and mathematics classes, is provided in Loughran and Northfield's (1996) account of patterns of acceptance and resistance among Year 7 students in relation to the teacher's goal of getting them all to become confident, independent learners. Students who saw themselves as failures, or who saw themselves as wanting to avoid a reputation for being in a `goody-goody' class, were more likely to resist the teacher's attempts to get them to participate in learning activities. These researchers concluded that meaningful learning cannot take place without the students' consent, and that that consent depends on where science fits in with the students' overall goals in life at that given point in time.

The adult literacy teaching approach to learning that I am familiar with has the advantage of taking into account the possibility of resistance and alienation–two factors, which are frequently discussed in association with the teaching and learning of secondary science. In Freire's (1970/1992) conception of literacy "teaching men to read and write is no longer an inconsequential matter of ba, be, bi, bo, bu, of memorising an alienated word, but a difficult apprenticeship in naming the world" (p. 511). It thus involves the learner in repositioning and re-envisioning herself. This seems to me a more useful way to look at the learning of science, a different way of seeing and naming the world, as an apprenticeship to a particular community with a particular valued world view rather than an imposed and possibly alienating experience.

The use of journal writing in my own research intervention, I believe, changed both identity and relationships in the Year 8 classroom where it introduced a new way of students and teacher relating, and hence changed the ethos in the classroom. Without it, it seemed as though the learning of science was being imposed on students whether they consented or not. With the journal writing, students were being invited to enter a dialogue about learning science and hence to become apprentices, as it were, in the school science community. They were being treated as people with their own concerns and questions which needed to be addressed in the exchange of ideas involved in becoming enculturated into the new community. The affirmational dialogue journal writing was based on an appreciation of science learning as being part of a sociocultural process of change and as such as being a difficult process involving changes in attitudes, beliefs and in relationships. The processing of new information cannot, I believe, be seen as separate from this process of personal and social growth. This raises the issue of how best to teach sociocultural practice, or whether it should be taught directly, an issue which is also relevant to my science education research.

Science Literacy and the Genre Debate

In another second part of the action research study (overlapping to some extent with the first part), my host teacher and I addressed some of the genres used in the science classroom and introduced activities designed to help students participate in them more successfully (see Hanrahan, 2001, for a more detailed account). Only later did I realise that some sociocultural theorists (see particularly Martin, in Halliday & Martin, 1993, pp. 265-266) would see the personal journal writing and the genre teaching as belonging to opposing ideological positions.

Martin's criticism was a contribution to the "genre debate" in Australia in the late 1980's (see particularly *English in Australia,* December, 1989), a debate about how students learn new language practices, with the teaching of traditional science genres being at issue. On one side of the debate were parties such as Sawyer and Watson (1989), defending a "process-conference approach" or a "writing to learn" approach from a position based mainly on humanistic theories of change. They asserted that learning is facilitated in a context which leads students to grapple with new terms in their own words first. From this point of view, one could say that there is no point in teaching students discourse practices before they assent to learn and use such practices, particularly if they would see such practices as alien to their identity and hence as inauthentic and improper for them to use. This is consistent with a personal growth model as illustrated in the adult literacy teaching approach alluded to above. Sawyer and Watson (1989, citing Cambourne, in press) preferred to see genres as being acquired more naturally when the personal or social need to use them was present. The practice of teaching genres without setting up a context in which students have authentic needs to use such genres, could be seen as the kind of "domestication" which Freire (1970/1992) warned was really replacing one kind of oppression with another.

The contrary position was argued mainly by Christie and Rothery (1989) and Martin (1990), who asserted that empowerment would follow from giving (presumably receptive) students strategically planned modelling and practice in using the genres which would facilitate their

participation in the dominant discourse, even if they felt no current need or right to participate in that discourse. It would seem better aimed at a well-motivated, middle-class student for whom the school culture—as well as the social practices to which it referred—was familiar, rather than the students in the disadvantaged schools program to whom it was subsequently applied, with somewhat lacklustre results.

Moreover, it seems to have been assumed (as Sawyer & Watson pointed out) in the disadvantaged schools program intervention that genres traditionally taught in school subjects are appropriate and should continue to be taught. In terms of science education, which is most relevant here, Sawyer and Watson (1989) implied that some genres, such as "scientific" report writing, were inauthentic ways of participating in the learning of science for most students and needed to be resisted or changed. It should be noted that they would find some support from those who have led movements for change in science curricula, particularly those who have argued for Science-Technology-Society (STS) curricula. Such curricula would be more relevant to the interests of most students and more compatible with postmodern environmental concerns (cf. Fensham, 1998; Gough, 1998). Halliday and Martin (1993) admit that what is usually known as the scientific register is becoming less appropriate, given present-day thinking about the limits of scientific knowledge and a growing concern for democracy. For example they have written:

> [T]he language of science ... is likely to back off from its present extremes of nominalisation and grammatical metaphor and go back to being more preoccupied with processes and more tolerant of indeterminacy and flux. (p. 20) ... There are signs that people are looking for new ways of meaning – for a grammar which, instead of reconstructing experience so that it becomes accessible only to a few, takes seriously its own beginnings in everyday language and construes a world that is recognizable to all those who live in it. (Halliday & Martin, 1993, p. 90).

More recent work seems to cast doubt on the suitability of teaching formal genres of the dominant discourse to students from other sociocultural backgrounds (including minority and low socio-economic status backgrounds) on both effectiveness and moral grounds (the New London Group, 1996).

Lemke (1990), while supporting the teaching of scientific language to the extent necessary to teach the "thematic patterns" of science, believed that genres should only be taught in response to a need for them, and that scientific language should not be used when it obstructed good communication between teacher and students. Nevertheless he pointed out that the discourse tradition in science was so strong that even students were likely to try to enforce it, in cases where the teacher was seen to be indulging in “non-scientific” talk.

Conclusion

This paper has reviewed a series of research studies in science education, in the light of sociocultural and sociolinguistic theories of learning. It proposes that science is the sociocultural practice of a distinct discourse community which is only easily accessible to a minority of students. Hence it suggests that if the majority of students are to engage in science rather than be alienated by it, then the teacher needs to establish a meaningful dialogue with them that allows for their personal and social agendas and issues. This is not merely a matter of relating new (impersonal) knowledge to prior knowledge, as happens in teaching based on constructivist principles, but takes into account the interpersonal and personal components of intellectual engagement, and the likelihood of resistance to anything involving changes in social relationships and identity.

Secondly, it proposes that science literacy (when it is a goal for the whole population) be seen as a functional literacy, where that implies that it serve to needs and interests of all citizens as they function in society, rather than only to prepare those students who will specialize in the study of science. One implication of this is that it needs to be made more

directly relevant to the likely issues and problems of everyday life that students have to face. Another is that students need to see science as related to such issues. They will also need to participate in authentic tasks as they practice using the skills they will need to apply outside school. Finally, the curriculum may need to be adapted to make sure the practices it engages students in have relevance to the present and future lifeworlds of most of the students.

In conclusion, I have presented a view of science teaching and learning as a process of enculturation into a new discourse or as the learning of a new literacy, and believe that this throws some light on some of the intransigent problems in science education, such as lack of intellectual engagement.

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[i] Co-authors: Courtney Cazden, Bill Cope, Norman Fairclough, Jim Gee, Mary Kalantzis, Gunther Kress, Allan Luke, Carmen Luke, Sarah Michaels, Martin Nakata. Members of the group [who met for a week in September, 1994, in New London, New Hampshire, USA, to discuss the state of literacy pedagogy] "It was our intention to pull together ideas from a number of different domains and a number of different English-speaking countries. Our main concern was the questions of life chances as it relates to the broader moral and cultural order of literacy pedagogy." (p. 62)

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