HAN02218
Mary Hanrahan

Note: For contact details visit my website at:
http://education.qut.edu.au/hanrahan or email me at m.hanrahan@qut.edu.au

# Applying CDA to the Analysis of Productive Hybrid Discourses in Science Classrooms

Paper presented at the Annual Paper presented at the Annual Conference of the Australian Association for Research in Education, Brisbane, Queensland, 1-5 December 2002.

Alienation from science has sometimes been linked to the dominant discourse practices of secondary science classrooms. Differences in primary language practice have been related to social class, which has been a major referent in the discussion of equity issues in education (cf. Bernstein, 2000; Bourdieu, 1974; Lankshear, 1994; Lankshear, Atweh, & Christensen, 1994; the New London Group, 1996). A mismatch between the expectations of educators and the primary language practices of the majority of students is seen as leading to a cycle of increasing disadvantage for already disadvantaged students. In some areas of the curriculum, mass education in recent decades has prompted empowering curriculum reform, with accompanying changes in pedagogic discourses, to accommodate the needs of students from a wide range of backgrounds and promote social justice. However, in secondary science education, with its tendency towards elitism (Lemke, 1990; O'Loughlin, 1992), evidence of such changes is harder to find. However, it does exist and I believe it should be highlighted. My current project will use CDA to explore challenges to the dominant discourse in teacher-student interactions in science classrooms (cf. Luke, 2002).

This paper applies the epistemological perspective and tools of critical discourse analysis (CDA) (cf. Fairclough, 1989; 1992; forthcoming; Luke, 2002) to textual analysis of the discourse of the science classroom to re-examine the general failure of science education to achieve its avowed goal of producing scientifically literate citizens (cf. AAAS, 2001; Fensham, 2002; Goodrum, Hackling & Rennie, 2001). Claiming that this discourse causes serious inequities as well, I examine instances where teachers have been able to creatively adapt the hegemonic discourse to make science accessible and relevant to the needs of a greater proportion of students, thus addressing two of Luke's (2002) challenges referred to in earlier symposium papers: documenting the positive use of hybrid discourses for emancipatory purposes, and using CDA to analyse texts derived from face-to-face interactions.

## *Discourse Issues and the Science Curriculum*

### The science curriculum context

For the last two decades "science for all" (or "scientific literacy" for all) has become an explicit goal of science curricula across many nations including the USA (AAAS, 2001), the UK and Australia (Fensham, 1998, 2002). However, there have been many reports of low retention rates in science in the post-compulsory senior secondary years, concern over low rates of enrolment in science and engineering courses at the tertiary level, a serious tendency for primary teachers to teach little or no science, and a general impression that the majority of students are being alienated from science during their secondary school years (Fensham, 1998; Goodrum, Hackling & Rennie, 2001; Hanrahan, 1999a, 1999b).

Researchers in both science and mathematics education (e.g., Fensham, 1998; Lemke, 1990; O'Loughlin, 1002; Taylor, 1994, 1996) have commented on the broader institutional and societal pressures that prevent curriculum change towards a science pedagogy that meets the needs of most students. Fensham (2002) argued that efforts for curriculum change in favour of making school science more relevant and interesting

for all students have generally been stymied by academic scientists, with the support of some science teachers, and a general climate of economic rationalism in the wider community. He explained that new strands have been introduced into science curricula around the world (to cover the new goals), but *in addition to* rather than replacing any of the old requirements for disciplinary content. The result is multiple agenda for science teachers, which they cannot possibly hope to satisfy, together with local, institutional, and societal pressures that favour the disciplinary content agenda in spite of the fact that it satisfies the needs of only a small proportion of all students. Taylor (1996, citing Britzman, 1991) also wrote about the difficult moral dilemma facing teachers, including those who try to implement more equitable teaching practices, and concluded that in the current climate of economic rationalism, "Teachers cannot be expected to single-handedly escape the "coercive influence of technical accountability" (Taylor, 1994, p. 22).

This inequitable way of trying to resolve the dilemma by many science teachers can be explained partly by the proposition that the aspects of the discourse of science education which make it serve technical interests are implicit and invisible to those immersed in it. Rather science and science education are seen to be entirely abstract and disinterested, and hence non-political. I suspect that any marginalisation is unintended by most if not all science teachers who presumably set out with the intention of teaching science to all their students and are consequently disappointed when, from their point of view, most students seem unable to engage deeply with the curriculum. In my experience (Hanrahan, 1995; 1998; 1999), they account for any failure on the part of students with two main reasons, both of which are student-centred and are seen to be only minimally open to control by the teacher:

1. The majority of students are not gifted (intellectually endowed) enough to understand scientific concepts which are, of their nature, inherently difficult; and
2. Most students simply do not apply themselves as they should, and would do better if only they made more effort.

As Taylor (1994) suggests, science teachers have generally been inducted into the hegemonic discourse of science education by the time they finish their professional training and do not have the cultural resources or social support to enact the science curriculum differently, despite their best intentions. In many cases, they are not even in a position to think critically about a discourse that is "second nature" to them, and which has, moreover, selected them out and rewarded them with relatively high status in the academic system (Lemke, 1990). As well as assuming that science is generally too difficult for all but a minority of "bright" students, they accept without question the myths that school science has to be abstract and impersonal, and to appear absolutely objective, authoritative, and non-negotiable (Lemke, 1990; Taylor, 1994). Any attempt to make it more relevant and attractive is seen as an attack on its status by those academics and teachers who act as its "guardians" (Fensham, 2002). The fact that more palatable science courses facilitate access to science knowledge by a far greater number of students is apparently seen as comparatively poor compensation for the loss of what they see as "basic" disciplinary content.

## *The Discourse Issue in Science Classrooms*

Sociologists and sociolinguists, such as Bourdieu (1974), Bernstein (1990), Gee (1993) and Lemke (1990) do not accept this explanation of failure being due purely to innate lack of talent and moral fibre. They provide convincing alternative explanations as to why many students do not succeed in academic studies, including science, explanations which have to do with the discourse of science or the discourse of academic education more generally. Bourdieu (1974) argued that academic education and schooling more generally operate under an assumption of certain cultural capital on the part of students, such that the knowledge of a minority of students is privileged and those who do not possess the cultural capital become increasingly marginalised as time goes on.

Similarly Bernstein (1990) explained this failure of a significant proportion of students to thrive academically in terms of schooling being designed for students who operate using an elaborated code which has been provided by their middle or upper class home backgrounds. He detailed the process by which schools operate with a "visible" or "invisible pedagogy", and with pacing and sequencing rules that penalise students whose home background has provided them with a restricted code. They are thus disadvantaged to begin with and have their disadvantage compounded the longer they stay at school, especially if there is an invisible pedagogy operating. Even with a visible pedagogy, he argued that, given its typically strong (fast) pacing, the two extreme groups end up receiving very different curricula. In the one case students rarely progress beyond initial facts, rote learning and lower order cognitive tasks, whereas in the other, they are invited to think, discuss, and extend themselves in challenging ways,

exploring the depth and relationships in new content.

> Indeed, where pacing is strong we may find a lexical pedagogic code where one-word answers, or short sentences, relaying individual facts/skills/operations may be typical of the school class of marginal/lower working-class pupils, whereas a syntactic pedagogic code relaying relationships, processes, connections may be more typical of the school class of middle-class children, although even here pupil participation may be reduced. (Bernstein, 1990, p. 709)

Gee (1991, cited in Lankshear, 1994, p. 5) distinguished this in terms of a dominant discourse (one most likely to lead to "the acquisition of social goods … in a society") and other discourses (the primary discourse(s) learnt in the home, and others learned consciously at a later stage), and pointed out that students whose primary discourse was similar to the dominant discourse of schooling had a distinct advantage over those who had to assimilate a new discourse at school, which they might or might not do successfully (cf. Lankshear, Atweh & Christensen, 1994).

Although looking at the discourse of science writing specifically rather than the discourse of science pedagogy, the work of Halliday and Martin (Halliday, 1989; Halliday & Martin, 1993) is relevant here because of the appropriation of the discourse of science writing in school science education. They identified textual features in science texts that could make it difficult for the lay person to read, including high levels of lexical density, abstraction and nominalisation, and complex sentence structures using causal connectives.

Lemke (1990) subsequently incorporated the views of both the sociologists and of the sociolinguists referred to above, to explain why even students from advantaged backgrounds might be alienated by science. In his text entitled "Talking Science", which is about school science, he agreed with the sociologists in suggesting that school science was inadvertently elitist and likely to marginalise many students (cf. also O'Loughlin, 1992). As well, after a major research project exploring the discourse of science classrooms, he explained the problem in terms of the "stylistic norms" (see Table 1) believed to be appropriate for talking about science. He pointed out that these tended to run counter to techniques known by good communicators to be "necessary for engaging the interest of an audience, helping them to identify with a point of view, and getting a point across to them effectively" (p. 134). He suggests that all good science teachers break these rules regularly and the success they have in engaging students is related to the extent to which they break the rules.

**Table 1. School Science Stylistic Norms (Lemke, 1990)**

"Scientific language that is correct and serious so far as teachers and students are concerned must follow these stylistic norms:

1. Be as verbally explicit and universal as possible....The effect is to make `proper' scientific statements seem to talk only about an unchanging universal realm....
2. Avoid colloquial forms of language and use, even in speech, forms close to those of written language. Certain words mark language as colloquial..., as does use of first and second person...
3. Use technical terms in place of colloquial synonyms or paraphrases....
4. Avoid personification and use of specifically or usually human attributes or qualities..., human agents or actors, and human types of action or process...
5. Avoid metaphoric and figurative language, especially those using emotional, colorful, or value-laden words, hyperboles and exaggeration, irony, and humorous or comic expressions.
6. Be serious and dignified in all expression of scientific content. Avoid sensationalism.
7. Avoid personalities and reference to individual human beings and their actions, including (for the most part) historical figures and events....
8. Avoid reference to fiction or fantasy.
9. Use causal forms of explanation and avoid narrative and dramatic accounts…. Similarly forbidden are dramatic forms, including dialogue, the development of suspense or mystery, the element of surprise, dramatic action, and so on. (pp. 133-134)

As I will explain further below in CDA terms, these stylistic norms represent not only a way of acting and interrelating between people, but also a way of representing the world and a way of identifying oneself and others. Hence they are likely to have material effects on students in terms of their roles as learners and later as citizens, their power to interact with both their teacher and with their world more generally, and in terms of their self-efficacy beliefs and motivation. Closely allied to this issue of stylistic norms is the issue of popular myths and Lemke (1990) identified two myths he saw as sustaining the tendency for science education to be elitist and alienating.

## School science myths

Many critics of science and mathematics education explain the difficulty of changing teaching practices in terms of myths that are widely held and reinforced in the classroom. Lemke (1990) identified the twin myths of science's infallibility and its opposition to common sense and argued that they represent the interests and values of a powerful technocratic elite who want to exclude all but their own experts from decision-making processes, at the expense of the educational needs of most students and ultimately democratic principles. Such interests depend on preserving "the `mystique' of science" (p. 134) and on obscuring the fact that science is a very human undertaking "involv[ing] human actors and judgments, rivalries and antagonisms, mysteries and surprises, the creative use of metaphor and analogy. It is fallible, often uncertain, and sometimes creatively ambiguous" (p. 134). Lemke explained how the language of science tends "to contrast science with human experience, to set the sciences in opposition to the humanities, to exempt science from social processes and real human activity, to oppose its language to the colloquial language of common sense" (p. 134). In a similar vein, Taylor (1994) wrote about the myths of "cold reason" and "hard control", which can lead to dehumanising and disempowering discursive practices on the part of teachers.

Fensham (1998), from a different perspective, wrote in terms of differing "emphases" in science curricula and discussed the relative failure of projects designed to incorporate new emphases. He pointed out how, in the science curriculum reform case studies he reviewed, "the academic scientists and some of the more academic teachers" downplayed the way science actually progresses as part of social and cultural processes, and emphasized science as being about "Solid Foundations, Correct Explanation, Science Skill Development" (p. 189). Seeing themselves as `guardians of the disciplines', such academics wanted to keep each discipline of science (physics, chemistry, biology, etc.) strictly `demarcat[ed]' from commonsense and from other disciplines, as well as from social issues and concerns. This could only be done by blocking curricula designed to enlighten the general public about scientific aspects of social issues. Fensham argued that the resultant restricted curricula had little appeal and little to offer in the way of personal or social relevance for most students, and came to the rather startling conclusion that "*Scientific literacy is too important to leave to scientists or to science educators!*" (p. 23) Similarly Roth (1992) and Tobias (1990) concluded from their research, the former with elementary school children, and the latter with tertiary students of physics and chemistry, that science has much greater appeal to a wider range of students when it is related to lifeworld issues, is treated in an integrated way and taught in relation to the larger picture, and takes place in a ethos of community learning.

Some consequences of these discourse practices, myths, and narrow emphases are that school science is seen as a "special truth that only the superintelligent few can understand" (Lemke, 1990, p. 149), language difficulties in science are not bridged, apart from explanations of new technical vocabulary and insistence on features of science investigation report genre (Hanrahan, 1999), and there is minimal integration between different units (physics, chemistry, biology) or of science with other subjects or social issues (Fensham, 2002).

## What CDA offers

Critical discourse analysis recognises both individual agency and social factors operating in the production of language during any particular event, within a particular type of practice. It is this dual recognition of psychological and social influences in human activity that particularly appealed to me, given that I could not subscribe totally to a of "death of the author" thesis (Hanrahan, 2001). Because of aspects it shares with a multifunctional approach to sociolinguistics (Halliday, 1994; Lemke, 1990), CDA can help to make visible the less explicit facets of classroom discourse: what is being communicated about ways of **acting and interrelating**, ways of **representing**, and ways of **being**, through looking at the formal and/or informal **genres** of the classroom, the **discourses** used and the **styles** of interacting respectively. Such ways of acting, representing and identifying are all dialectically related within texts (Fairclough, 1989, forthcoming).

Moreover, because it has roots in social theory as well (Fairclough, 1989, forthcoming; Luke, 2002), CDA can also be used to critique texts in terms of the ideologies they promote. Consequently, CDA has often been used to critique policy documents and other public texts. However, as Luke (2002), points out, it has less often been used to show how hegemonic discourses are being challenged, or in face-to-face contexts. He offers a challenge to CDA researchers "to begin to develop a strong positive thesis about discourse and the productive uses of power. … begin to capture an affirmative character of culture where discourse is used aesthetically, productively and for emancipatory purposes" (p.106). He takes this a step further and

challenges CDA researchers to use their critique for positive action, "If CDA is avowedly normative and explicitly political, than it must have the courage to say what is to be done with texts and discourse." (p. 107) . He suggests that the purview of CDA could include documentation of "emergent discourses of hybrid identity....counter to dominant pedagogic discourses".

### The research context

My earlier research in science education (Hanrahan, 1998; 1999b) located in a psychological framework with "affirmation" as a key term, suggested that science teachers inadvertently disaffirmed many of their students by their language practices which, unintentionally on the whole, conveyed implicit messages about power relations, for example, that the role of students was to be relatively passive learners (Hanrahan, 1994; Hanrahan, 1998). I argued that this affected how students engaged with science. This was followed by a trial of one way to affirm students as active participants in the science curriculum. That intervention was remarkably successful, considering that the students involved tended to be those traditionally least likely to engage with science and that the curriculum had previously been largely text and teacher-centred (Hanrahan, 1999). However, I later began to notice the social aspects implicated (1995, 2002). I saw how the problem originated in ways of representing the world and identifying students, and realised that it involved both psychological and discourse issues. As Bruner commented, quoting Adrienne Rich, "`When someone with the authority of a teacher, say, describes the world and you are not in it, there is a moment of psychic disequilibrium, as if you looked into a mirror and saw nothing'" (Bruner, 1990, p. 32). Hence I came to believe that it was the language practices of school science that alienated and de-motivated such students while providing some of the "wind beneath the wings" of more advantaged students.

My current project seeks to further test my theory about the relationship between psychological factors such as motivation and will, interpersonal teacher-student factors, and the role of classroom discourse. I am doing this by investigating the dialogue patterns of teachers in classes where students are thought to be positively engaged in science. I have sampled lessons conducted by 14 teachers who volunteered to participate in the project and recorded the classroom discourse, particularly the language practices of the teacher. I also interviewed the teacher to learn more about the particular local, institutional, and social contexts backgrounding the lesson observed.

## *Methods*

### Critical discourse analysis

My CDA analysis is in terms of what Fairclough (1989, forthcoming) refers to as interdiscursive relations, "relations in which different genres, discourses and styles may be 'mixed', articulated and textured together in particular ways". An analysis of interdiscursivity' is designed to determine the relations between genres, discourses and styles, as they are exemplified in the given text through a three-stage (but nevertheless dialectical) process of description, interpretation and explanation. The process involves looking in detail at semantics through grammatical, lexical relations and phonological or graphological relations in the text, the use of speech functions and grammatical mood, all in relation to the local, institutional and social contexts. Fairclough (forthcoming) explains that this "a relational view of texts and text analysis" takes place as follows:

> the 'internal' (semantic, grammatical, lexical (vocabulary) ) relations of texts are connected with their 'external' relations (to other elements of social events, and to social practices and social structures) through the mediation of an 'interdiscursive' analysis of the genres, discourses and styles which they draw upon and articulate together." (p. 27)

Any analysis is selective and the textual features in focus in CDA are those that are most significant for a critical analysis, an analysis designed to contribute to understanding of power relations and ideological processes in discourse (Fairclough, 1989). Through an analysis of both syntagmatic and paradigmatic relations in a text, CDA can inform one's reading of a text by providing evidence for identifying underlying experiential, relational and expressive values in the choices made in relation to vocabulary, grammar, and textual structures. CDA looks for clues in the text indicating ideological assumptions being made, including the way "difference" is handled or ignored, the way in which various voices are included or excluded, both within the text and intertextually, the way social events are represented, styles expressed, and values realized.

## Research aim

My aim was to collect and publish only positive exemplars of classes where the students were positively engaged in science and seemed to be enjoying as well as learning science, with the ultimate aim of informing professional development of preservice and inservice teachers wishing to teach with more equitable outcomes. However, my initial attempt to demonstrate what a successful teacher (in these terms) was doing that was special, seemed to fall flat, because those to whom I showed it (non-science teachers) could see nothing out of the ordinary in the text. The teacher in the exemplar was relating the topic to adolescents' interests beyond the classroom (such as TV shows and pop groups), but they thought any average teacher would do this in an attempt to involve all students.

They had no sense that pitching the lesson so that it could involve most students was extraordinary for the majority of science classes, and that while it might happen marginally in most science classes, it was not seen as an exemplary way to present science and, in any case, there was little time for such "frills" in a curriculum where one had to cover a great deal of content if one wanted—and it was assumed that one did want—to prepare students to be able to take senior science subjects. A junior science teacher had to try to ensure that all students were adequately prepared to do physics, for example, which meant that he or she must cover all the so-called "basic" terminology, principles, rules, genres, and theoretical and practical procedures associated with forces, astronomy, sound, heat, atomic structure, and so on). Similarly for chemistry, biology, and geology and all their sub-branches.

For most science teachers in my experience, as well as those reported in the literature (e.g., Fensham, 2002; Lemke, 1990; Hanrahan, 1999), this is what (school) "science" *is*. Anything less would be to cheat students of their right to a satisfactory standard of education, and could only be tolerated where groups of students were known to be intellectually disabled, and hence, by definition, incapable of profiting from such a curriculum. The fact that most students do not profit from such a curriculum in junior secondary school, and either give up science, or take Year 11 science subjects poorly equipped to deal with their exigencies, does not seem to lead to a questioning of the curriculum on the part of most science Heads of Departments or science teachers. [Please note that, as my current project demonstrates, there are many exceptions to the rule, examples of science teaching that *does* engage students despite pressures for technical accountability, but they are too few to prevent the general alienation from science and scientific careers during the years of secondary schooling that has been reported in the literature (cf. Goodrum, Hackling & Rennie, 2001)].

Given the situation described above with regard to myths and emphases (that science is inherently difficult and that only students with a high IQ can be successful in it; together with a belief (based in economic rationalism) that it is proper to use the years of secondary school science to select out those most qualified to study science (Lemke, 1990), and to give as many students as possible an "equal" chance to be selected, they see no reason to change anything, beyond trying harder to do what they are already doing, including covering as much content as they can possibly cover, and exhorting apparently "lazy" students to be more disciplined.

Given that this paper is not written for science educators who understand the pressures of science teaching, but rather for educators in other areas who may mistakenly assume that, as in other school subjects in an age of mass education, science, at least during the compulsory years of schooling, will have adapted to become accessible to the wide range of students, I have decided to include a negative example. It is still an actual example from my research project, but is one that at the opposite end of the continuum from the rest of my exemplars in terms of engaging students in learning science. It is almost a caricature of the worst features of "talking science" as Lemke (1990) described them, but is, nevertheless, not too far removed from what typically happens in science classrooms.

Using the methods of CDA, I will compare and contrast extracts from the texts of two classroom lessons (one extract from each), to illustrate both (i) how science is typically represented when it is taught in the generalised abstract way that is generally considered acceptable, and (ii) how a particular teacher has adapted her style to make science accessible to a particular class. The two extracts represent the first few minutes of each lesson observed and can be briefly summarised as follows:

1. A Year 8 science class taught by the male Science Head of Department (HOD) in an independent school in a semi-rural area; they are mid-way through a physics unit on energy changes and later in this class period the students are orchestrated to perform a practical experiment using laboratory equipment, an "experiment" designed to reinforce the principle that energy is never either created or destroyed but rather simply changes form;

2. A Year 10 science class in a Catholic girls college in a regional Queensland city taught by a female Science HOD; students are at an early stage in a physics unit on aeronautics and, later in the lesson, get hands-on experience with making paper planes, as they are prompted to think about factors affecting flight.

It is important to note here that I am not trying to suggest there is one right way to approach the teaching of science. In fact, no two teachers in the exemplars I collected took approaches which were similar, either to the exemplars described here or to each other, partly because they varied so much in terms of student population, Year level, content, and local and institutional contexts.

### First exemplar context

Mr DP, the teacher whose Year 8 class provided the lesson from which the first extract was taken, was Science Head of Department in a non-denominational independent school. Although academic subjects in general were mentioned in the promotional literature available in the school office, science had a very low profile compared to such activities as competitive sports, performing arts, and public speaking, and I was to learn that it had a low rate of uptake of physics and chemistry in the senior years.

In the initial telephone interview I found little evidence that the science teacher was engaging students and motivating them to learn science and apparently few students went on to study science beyond Year 10 in this school. I wondered if I was being used to impress the principal, or being used *by* the principal as possible free publicity for the school (I had written that I would publish exemplars on the Internet), or to give parents an impression that the school was performing well in science. However, I still went ahead with the school visit as this was my first volunteer participant and I saw that I could use the visit as a practice run through of my procedures for later exemplar-collecting visits. On arrival, the science teacher took me to meet the principal and later on, I saw him, accompanied by another person, stroll casually by the Year 8 science classroom where Mr DP was teaching.

Mr DP was a big man who towered over the students. He always remained standing, and generally spoke in a loud voice meant for all students in the classroom. During the class I attended, the students seemed to play passive roles, and to have no choice in anything that happened: the "experiment" to be carried out, the groups they were in, and the format for tabulating the data, were all given to them. They seemed quite accepting, and although they showed little enthusiasm, were generally very compliant.

In a memo I wrote about the class later the same day, I commented about his apparent lack of pleasure and enthusiasm, "I tried to catch him in a photo where he didn't look a bit disappointed with or ashamed of a student, but it was hard to get—there may have been a couple of moments but they didn't last. However he did sound positive, later on during the interview, when he talked about the "several really bright students" in the class. During the interview, he classified student success in relation to ability or behaviour or mental problems. During the science experiment which took place during the lesson, the students talked relatively noisily among themselves and he called out his instructions, which were repeated at intervals, above this talk, in a drone that came and went above the general noise of the class.

There was no discussion with the class about the theory behind the practical, either before, during or after the experiment, not even a comment to the effect that it was related to the energy change topic. As for the students, although I did hear one student explaining to another what (he thought) was happening, most talk that I heard seemed to be either social chat or at a practical level of what to do to set the experiment up, and what to do after that (copying down the table drawn on the blackboard, collecting graph paper, and recording the temperature events). The lesson concluded when students put the equipment they had used back on its original trays and showed Mr DP, standing by the door, their completed tables of observed temperature changes as they left the room.

What follows in Table 2 is an annotated version of the first minutes of the lesson. The text in the first columnis interspersed with comments with regard to the action taking place, as well as to auditory aspects otherwise lost intranscribing, such as pacingand tone, both of which I found to be remarkable. His pace was strong, and his tone highly monotonous, both with regard to loudness and lack of expressivity. Inflexions were used not to enhance conceptual meaning but only to signal the end of a sentence or question which required action on the part of students (e.g., thir-**teen↑)**. I have also highlighted words which act as linguistic markers for the aspects of communication that CDA highlights, and have noted their significance summarily in column 2 using dot points. As well as lexical items which are identifiable as belonging to particular discourses ( these words have dotted underlining), these include markers of the power relationship and ways of relating generally, ways of representing science (cf. Lemke's stylistic norms above), and ways of identifying both himself and his students, including any assumptions being

made.

**Table 2**
**Extract 1. Beginning of Mr DP's Year 8 science class on energy changes**

| | | General notes<br>**Grammar; vocab, textual structures** |
|---|---|---|
| Mr DP[1] | *[Outside classroom]* Right move in quietly please. *[Students move in with some talk, and two whispered "sh"s. Eventually stand silently behind desks.]*.Sit down, please. *[Noises of chairs scraping. Some talking.]* We've got a visitor this afternoon. *[Recites in an expressionless voice]* This is Dr Hanrahan who is from the Queensland University of Technology. She has been a science teacher for a number of years and has just come out to see how we do things at Hillrock for this afternoon. As you carry on and do your experiments she'll be just walking around the room. Last night's homework, please↑, was questions, 10, 11, 12 & thirt-een.↑ *[Whistling of kettle boiling goes unremarked. Then noises as students get books out]* So if you can get your homework out please. *[ 2 minutes as he walks around inspecting books, then with raised voice:]* Right *[Indistinct]* please,. *[Noisy talk continues.]* Ah, excuse me↑. *[As noise stops, reads in a monotone]* Questions what are some of the energy changes which are being described in each of the following: "The wind blew hard and turned the windmill as he pumped the water from underground to the top." Yes, John? | ▪ *scientific (kinetic energy, experiments, a number of)*<br>▪ *narrative (as he pumped …; 2,1,0 and the rocket…) &drama (the rocket belts fire and smoke … roar)*<br>▪ *metaphor (turning into)*<br>▪ *everyday terms (ground, top, rocket, fuel, turning)*<br>▪ *orderly workplace (move in quietly, homework, questions)*<br>▪ *Rare uses of 1st person during class; no assertive "first-person" statements*<br>▪ *Only rare instances of addressing the logistics of the lesson—no checkbacks to enlist cooperation*<br>▪ *Assumes one way only of doing things here*<br>▪ *Assumes student compliance with his plans*<br>▪ *`You' only used in this sense of all students*<br>▪ *`Just' – to negate any possible human impact of the university visitor?*<br>▪ *Orders implied simply by `please', `excuse me', `Questions', conditional clause left hanging*<br>▪ *Assumes scientific typology for energy and (later) a predetermined range of types of energy*<br>▪ *Reads in deadpan voice; no pauses, inflexion only to mark questions; dramatic or narrative text meaning disregarded*<br>▪ *Minimal affirmation; only students who know answers are named and affirmed, if then*<br>▪ *High lexical density; only abstract nouns / technical terms and de-particularised verbs accepted*<br>▪ *Much ellipsis*<br>▪ *"Creating" energy? Surely not!*<br>▪ *Statements as orders, questions*<br>▪ *Controls turns tightly, much rewording, interrupting*<br>▪ *Triadic Dialogue pattern* |
| S | *[Indistinct]* kinetic. | |
| Mr DP | Kinetic energy, yes. It is turning into ____? So the wind is kinetic, turning the windmill--what's it doing to the water? | |
| S | Pumping. | |
| Mr DP | Lifting it from↑? | |
| Ss | The ground. | |
| Mr DP | Lifting the ground to the top. So that means it's creating? | |
| S | Potential | |
| Mr DP | Gravitational potential energy. *[Continues reading rapidly in deadpan voice as though to get HW out of the way]* C1. "2-1-0 and the rocket belts fire and smoke the ground shook and with a deafening roar the rocket left the launch↑pad↓ What's the energy in the rocket? | |
| S1 | Fuel. S2: Electric. | |
| Mr DP | Which is? … | |
| S | Chemical | |
| Mr DP | Chemical. And it's turning into: | |
| S | Kinetic. | |
| Mr DP | Kinetic. [..] | |
| S | Gravitational | |
| DP | And as it takes off from the ground it's turning into gravitational potential energy. | |

## CDA of the Year 8 lesson segment

In summary, Mr DP can be found to adhere quite strictly to the stylistic norms of school science listed by Lemke (1990), with one notable exception in that his tendency to ellipsis (quite often one word or phrase stands in for an order, a question, or a full sentence) means he lacks explicitness and precision. Resulting contradictions, ambiguity and gaps remain unchallenged ("Energy is created"; what about "Electrical"?] partly because of the fast paced, tightly-controlled process. This could indicate his relatively powerful

[1] All proper nouns have been changed to preserve the anonymity of participants in both texts.

position vis-à-vis the students as they are expected to guess his meaning without much help. Or it is possible that he is covering up his fallibility?

He is serious and dignified at all times, avoids colloquial language including use of the first and second person pronouns and students' names (with one exception), uses only the correct scientific terms and rewords students' responses when they are less precise. He recontextualises the textbook narratives so as to focus only on their scientific content, avoids anything personal including personal references either to himself or the students, keeps the talk at as abstract a level as possible, and downplays the use of narrative and drama in the homework task by making as little of it as possible and not even acknowledging its presence. (The textbook was obviously designed by someone more concerned about engaging Year 8 students than in impressing them with the badge of scientific impassivity towards concrete events.) Even the minor drama of having a visitor from a university in the room is downplayed ("she'll be *just* walking round the room") perhaps to negate any hope of relief from this quarter or to indirectly communicate his expectations to me. There is no dialogue with her nor with anyone else beyond what is essential for the experimental procedure to be generally clear to students. Emotional expressivity is virtually absent, and talk kept to a minimum.

When there is talk, much use is made of the typical "Triadic Dialogue pattern" (initiation/question, response, evaluation or elaboration) that ensures the teacher has total control over proceedings (cf. Lemke, 1990, p. 8). Lemke (1990) refers to two kinds of dialogue which allow students to escape from this absolute control: True Dialogue and Student Cross-talk. There is no True Dialogue evident in the text above, either by way of the teacher asking questions to which he does not know the answer, or by student-initiated questions or comments. On the other hand, the teacher tolerates almost incessant cross-talk as long as students are progressing with the given tasks, but there is little evidence that such talk is relevant to the topic, with students not being invited, at any time, to think for themselves about the hypothesis underlying the experiment.

Lexical density is high both in the exchanges that take place as the homework is being publicly "corrected" and in the instructions for the experiment. In spite of this, the pacing of the talk is hurried, with minimal repetition and minimal elaboration. The experiment itself is relatively unhurried with students apparently having plenty of time to copy down the table, take the minute-apart temperature readings, and tabulate the results. When I asked the teacher later how students had learnt the theory, and what proportion of the class would probably understand the concepts under study, he told me the terms had been introduced in the previous class, and that most, "well, about a third" of students would know the different types of energy and be able to state the main principle presented. When challenged on this, he reverted to commenting on how bright several of the students were. The excerpt reveals little meta-talk that might be seen to detract from the science talk, not even at the level of classroom management. There is no checking that students are ready to move on to the next stage of the lesson, or checking for understanding of concepts or the purpose of the particular experiment, or even checking that students are clear about how to proceed with the experiment. (Continual repetition of instructions to the class as a whole seems to stands in place of the latter during the lesson).

Students appeared contented enough, happily chatting their way through the period with their friends, perhaps enjoying a welcome break from the alternative teacher-centred lessons. However, I was surprised that the teacher considered them sufficiently motivated and engaged with science to warrant his self-nomination for the project. From my point of view, student tasks seemed to be relatively passive and of a lower order of intellectual challenge, and students did not seem to be engaging beyond the minimal level expected of them, completing a homework task in which the answers were probably available in the previous few pages, and carrying out the simple steps of the experiment. listed in their text, in both cases without any prompting to integrate or apply their knowledge.

### Second exemplar context

This teacher, Mrs DP, was both a Science and Mathematics Head of Department, and had a few years previously been a Sports and Physical Education HOD. She was teaching in a girls secondary Catholic school in a large regional city in Queensland. In her mid-forties, hyperactive by her own description, labelled a "livewire" by another science HOD in the area, she was of short stature, and was almost indistinguishable from her students when she mingled with them for group work, both in terms of voice, and visibility, though her voice was louder and she uses more emphasis in the instruction segment. The Year 10 class was described as a middle level class, with students who were having trouble passing having been filtered into another class, and another Year 10 class being described as more advanced. The school had an unusually high rate of enrolment in senior physics and chemistry, and commendable results.

Because of a team-teaching arrangement, this lesson was the first Mrs LW had conducted with this class since term I when teacher and class had "had a ball" ("because I …realised that I needed to be quite structured and I'd go back over every idea every time").In this lesson, after telling her little tale about how "Mrs LW" learnt to make and fly paper planes (which included searching the Internet for useful websites that she plans to have the students use in the following period), Mrs LW demonstrated her three planes which she then provided as construction models. She had told me that, in this lesson, her goal was simply to have the students work in groups of three to make three different paper planes to gain hands-on experience ("These kids need hands-on"), as well as to provide practice in following directions and diagrams requiring spatial as well as verbal intelligence.

Students were told that, in the following lesson, as well as researching real planes and trialing a fourth design of their choice, they would also have a flying competition using *their* choice of one of the planes their group had constructed, it was implied they would be thinking about what might affect how well their planes flew. In fact, during the initial discussion during which Mrs LW demonstrated her expertise, they covered more concepts than she had expected when students' answers to her questions about variables affecting the "trajectory" of her planes showed that some of them, at least, were already familiar with terms like thrust (a "lovely word" that she makes the most of!), lift, drag and weight, and she made a big fuss of a girl who introduced the term "aerodynamics" and was able to say a little about it. After students collected a worksheet that they were told they would need to complete for assessment during this unit, they spent the rest of the lesson, seriously but also with great hilarity when things did not work out, making the planes. One student, perhaps prompted by this activity, discussed with Mrs LW whether physics was a viable option for her in Year 11, and Mrs LW was honest with her about the costs and benefits of doing such a relatively "rigorous" subject.

Table 3 follows on the next page. Parallel to my treatment of the first lesson segment, Table 3 provides an annotated version of the first minutes of Mrs LW's lesson. Again the text in the first column is interspersed with comments with regard to the action taking place, as well as with regard to auditory aspects otherwise lost in transcribing, such as tone, which was also remarkable but in a very different way from the lesson described above, and non-verbal responses, such as giggles or silence from the students. Again notes in the second column explain the significance of the highlighted or underlined words or phrases.

## CDA of the Year 10 lesson segment

In summary, my linguistic analysis of this short except from Mrs LW's Year 10 physics class reveals evidence of it enacting a more democratic teaching practice than that evident in Example 1. Students may apparently initiate questions and comments without fear of repercussions for taking control from the teacher (including a potentially challenging question about the teacher's role in the research project), the learning environment seems to be one where all students count and where science is not treated as over-riding and excluding everything else, and to be a place where the teacher can express ignorance and take risks in trying out new unfamiliar behaviour. As well as being evident in the student practice of initiating dialogue with the teacher, True Dialogue (cf. Lemke, 1990) is also evident in the type of questions the teacher asks of the students ("Who's ever **flown** a **paper** plane?") and the way she enthusiastically welcomes responses by the students ("Excellent!"). Students are permitted cross-talk but not when Mrs LW is addressing the class as a whole. Meta-talk is used to manage the class and check that students are ready to proceed ("Are you ready? … alright?). She uses many questions, thus involving students. They are questions which recognise difference and assume a range of student responses. At the same time they are closed questions which allows her to keep tight control of interactions, once the lesson is underway.

The "bedroom" story could be seen as very transgressive in the context of teaching a serious subject like physics, not only because it is personal, but also because it is a narrative of an actual event, and is introduced humorously as a third-person narrative with overtones of "girl-talk". It was possibly calculated to appeal to this particular group of girls and to help them to begin to negotiate the difficult identity conflict involved in being a female and doing physics, a subject traditionally seen as almost exclusively the province of males and hence one whose uptake might damage the reputation of a girl where boys are concerned. At the same time this story subtly demonstrates both that the activity can be a fun social activity that you can share with a male, and one that she has chosen to do in her own personal time. Her use of the pronouns I, me, you, she, is also more personal, thus transgressing the stylistic norm of personification (cf. Lemke, 1990).

**Table 3.**
**Extract 2. Beginning of Mrs LW's Year 10 class on physics**

| | General notes<br>Grammar; vocab, textual structures |
|---|---|
| Ss *[Noises and talking as students come into classroom.]*<br>Mrs LW *[To a student who shows her something]* O-oh! Very well done! *[Gives handout to MH]* You can [indistinct] That's the task [MH: Oh, OK.]<br>Mrs LW Do we have that choir thing today or tomorrow?<br>Various Ss*[Continuing noise as student move to desks, etc. Indistinct snatches of words]* … I couldn't find …Unknown *[Indistinct]* What is it? Tomorrow? In the morning. *[Raucous laughter]* Yep.<br>Mrs LW Now, **you're** with Miss C's group and Mr L's and *[indistinct]* together [Ss: *Indistinct]* Ar, can't remember. *[Student noise continues]*<br>Mrs LW *[Raises voice]* Ar, girls, excuse me, are we all here? *[Indistinct]* [S: *[Indistinct]* Alana in 102 or 304.]<br>Mrs LW A-a-ar, yes. It's one, two. Thanks. Sh-h. *[indistinct]* happening. [Ss: *indistinct]*<br>Mrs LW Oh, it's tempting, Tessa, isn't it to play with that?<br>Ss *[Giggles.]* [Mrs LW: U-um.] [*Giggles peter out]*.<br>Mrs LW *[Quietly, as though to the one student]* Thankyou. *[Raises voices to announce]* Ah, I have a **guest** who would like to introduce . herself to you↑ and tell you a little bit about why she's here with me↑ and then we'll start the lesson.<br>MH *[Introduces herself explaining she is mainly interested in their teacher and is recording her, not them.]*<br>Mrs LW Right, so it's to do with looking at me. Alright?<br>Ss *[Indistinct question]*<br>Mrs LW Ar, no, I volunteered, didn't I? [MH: Yeah.]<br>Mrs LW Are you ready? Yes girls, alright?. Who's ever **flown** a **paper** plane? [Ss: *Inaudible, perhaps raised hands]*<br>Mrs LW Excellent! How many different types have you made?<br>Ss [*Several voices including distinct* `One'].<br>Mrs LW Have you made only one? *[A couple of exchanges follow about how many kinds of paper planes there are]*<br>Mrs LW Are you ready? *[In amused self-mocking voice]* Mrs LW has never studied paper planes in her life↑ until ..<br>S [Indistinct]<br>Mrs LW We'll just check that she's got her –until—a true story girls *[Slight giggle, adopts ironic confidential tone and gets polite giggle from one student in response]*<br>Mrs LW ..until, the other night. I will share with you a bit of my personal life. The other night I decided I wanted to look at paper planes a bit because we're studying **physics.** This is really interesting and my computer's in my bedroom. So the other night—this is true—my husband and **I**^ were **throwing** paper planes in the bedroom *[Indistinct]* room of our house. | ▪ *Colloquial: "that choir thing", "a little bit about", "the other night"*<br>▪ *Lifeworld words: "bedroom", "our house", "in her life", "my husband"*<br>▪ *Instructional: "the task"; "start the lesson"; "studied":*<br>▪ *Relational: "guest", "you're with", "are we all here?" "We'll just"*<br>▪ *Managing (transitions): " ready?"*<br>▪ *Expressive (value): "Very well done!" "Excellent!" "true", "really interesting"*<br>▪ *Negatives: "never" "only one"*<br>▪ *Does relationship-building work*<br>▪ *Enthusiasm expressed towards student object*<br>▪ *Student may initiate contact*<br>▪ *There is a task pre-set*<br>▪ *Doing science not divorced from rest of students lives or hers*<br>▪ *Uses colloquial language.*<br>▪ *Students do not expect to play submissive, silent role*<br>▪ *Teacher does not have to be infallible authority (but sets tasks)*<br>▪ *All individual students are valued; True Dialogue happens*<br>▪ *Humanness accepted; empathetic teasing/reproof*<br>▪ *Visitor treated as a person in her own right*<br>▪ *Half statements, half questions*<br>▪ *Student is permitted to question teacher and is answered honestly*<br>▪ *Puts students in active role, included if at all possible*<br>▪ *Sets self up ironically as naïve subject of an amusing (3rd person ) narrative*<br>▪ *Treats self as a learner as well as a teacher*<br>▪ *Introduces the very personal into science in cheeky but somewhat formal narrative structure which gets appreciative giggles from the students*<br>▪ *Metalevel comment: she relates this to the topic explicitly so students will know the purpose of the exercise.* |

She also chooses to talk in terms of actual concrete events and does not shy away from either humour, or hinting at possible drama.

Mrs LW is also very expressive emotionally. She commits herself to a range of value expressions ("Excellent", "true" "really interesting") and seems to mean it at the same time as speaking "tongue in cheek". She is very affirming when someone has achieved something they believe is important ("O-oh!

Very well done!"), very enthusiastic when they join in the discussion and answer her questions, and empathetic even when indirectly reproving a student for playing with something prohibited (at least for the moment) ("Oh, it's tempting, Tessa, isn't it to play with that?").

She represents students as active agents (makers of planes) and later directly relates this activity to physics. Making paper planes in itself might be something that any science teacher of the topic might refer to, but there is novelty in giving a whole class period to it (in other cases, experience in making them might be assumed, be seen as unimportant, or even as a threat to future control by the teacher).

Mrs LW uses inexact colloquial language ("that choir thing") in a way that a typical, self-respecting scientist or science educator would be unlikely to do, and she also mixes talk about physics with talk about her (and the students') personal experiences, and mentions the word "physics" in the context of a personal tale, something that some male physics teachers I know would see as inappropriate. Her talk is much less dense lexically, but given that she does talk more extensively with the talk developing along a designed track, she does eventually include the main technical terms, expressed as abstract nominalizations, that go with the topic, however taking care to stress them and repeat the words so that all students have a chance to hear and think about them explicitly. Her language is also more open to negotiation with students ("a guest who would like to, etc." rather than a guest who is going to, etc.").

My interpretation of both contexts can be seen to be partly based on a descriptive linguistic analysis of the text itself but also on my knowledge of both the local and wider institutional and social contexts. Fairclough describes CDA as being a multi-stage process with interpretation and explanation following a descriptive analysis but also informing it. The following discussion section will take the interpretation and explanation further, in terms of the issues related to problems in science education and equity, and struggles over power in the science curriculum.

## *Science Curriculum Reform and Science Pedagogic Discourse*

### Ways of Representing

Science was represented in different ways by the two teachers.

- ***Lexical Density***

In Example 1 science classroom talk was represented as necessarily highly dense lexically, with a high proportion of the words being relatively new technical terms for the students. In fact, familiar language, including concrete, dramatic narrative was glossed over and disposed of quickly. In Example 2, new material was apparently expected to be surrounded by much everyday conversation, including a story. In the first case, therefore, science was separated off from everyday talk and happenings with students being encouraged to only "talk science", while in the second, science was made directly relevant to everyday happenings and social experiences, and could be approached using non-specialised language. In the first case, consequently, science is presented as something not open to discussion except by experts whereas in the second students are more likely to identify with the talk and join any discussion that takes place.

- ***Teacher Control***

In Example 1, the teacher was the arbiter of how classroom science would proceed, with students allowed little or no participation in deciding how the curriculum would be enacted. Discussion was not entered into. Science was therefore represented as being the domain of experts and knowing or understanding science could be equated with knowing what answers the teacher wanted. In Example 2, although the teacher also tightly controlled the activity structure and assessment, she shared control to some extent with the students by allowing them to initiate comments, ask questions for their own purposes and by meeting them on their territory where they were psychologically comfortable and pleasured, viz the story with its humorous overtones. The message about science in the latter case seems to be that the process of learning can involve approaching concepts indirectly, starting from everyday knowledge, with the teacher being a facilitator of the learning process rather than a source of information.

- ***Workplace versus "Learning community" orientation***

Roth (1993, citing H. H. Marshall, 1990) describes different approaches to teaching science by comparing a work-oriented classroom with a "learning community" oriented classroom. Mr DP's class typifies a work-oriented classroom, with completing tasks (preferably all at the same time), being obedient, observing strict hierarchical roles, and having right answers all taking priority over personal understanding. Mrs LW's class, on the other hand, typifies a learning community ethos, with personal understanding

being a high priority, and taking risks, making mistakes within a supportive community environment being acceptable, and different people taking different amounts of time to learn things depending on factors such as prior experience. Roth (1993) commented that the work-oriented classroom gave students restrictive messages about themselves as learners and about learning that she no longer wanted to endorse, whereas the "learning community" environment supported a notion of learning as both personal and social development and science as something students could identify with. When she moved from enacting the former to enacting the latter, Roth argued that, without changing the basic syllabus, the curriculum had changed to positively address new emphases such as exploring the nature of science and its relevance to students' personal and social needs.

## Acting and Relating

There are several aspects of these texts that relate to Fairclough's (1989) ways of acting. They include aspects related to Lemke's (1990) stylistic norms, to pacing, and to the use and type of dialogue used.

- ***Stylistic Norms and Engagement***

Mr DP's ways of "talking science" are generally consistent with all the (Lemke, 1990) stylistic norms, with an important exception that he is not as "verbally explicit. … as possible" (which may, as I suggested above, serve to hide some lack of expertness which he makes up for by being extra particular to use scientific terms only). Mrs LW, on the other hand, transgresses them on the whole, especially in this segment of the lesson. The level of student engagement, as Lemke would have predicted, was low in the first classroom, and very high in the second.

- ***Pacing***

In Mr DP's case, pacing seemed to exemplify what typically happens to students in their first years of high school, when a teacher uses a fast pace to cover the full range of basic terms, facts, principles and experiments in relation to what are considered to be foundation disciplines. Bernstein (1990) saw such strong pacing as beginning an increasing cycle of disadvantage for all but the most advantaged students, On the other hand, Mrs LW pitched her teaching in such as way as to engage and carry students with her, as well as providing safeguards such as monitoring their attention level, engaging them in dialogue, and allowing them to question her or give her feedback as to how well she was performing. Between them, they provide strong support for Bernstein's thesis that "pacing rules regulat[e] the economy of the transmission and so these rules become the meeting point of the material, discursive, and social base of the transmission." (1990 , p. 79)

- ***Dialogue***

The use of True Dialogue (as defined by Lemke, 1990) also differentiates between the two classrooms in accordance with the level of sharing of power.

## Identifying

Ways of identifying both oneself and others is highly related to one's way of representing the world and one's ways of acting and relating interpersonally. However, it has its own distinctive features. In the texts above, it is exemplified in the differing meanings attached to scientific literacy, and the differing ways the teachers identified themselves and the students.

- ***Scientific Literacy***

The two teachers had very differing approaches to helping their students become scientifically literate and this gave them very different roles. Mr DP presented himself as an expert scientist and the students as passive recipients of the knowledge he gave them. The laboratory was used as an extra way of demonstrating his knowledge and expertise rather than a real place of investigation with the students as active scientists with real questions. Making the practice of technical competencies a high priority also dictated the passive nature of students' relationship with science.

- ***Teaching Style***

The stylistic norms also act to identify the teachers and students in relation to each other in these contexts, in the first instance with the complementary single identities of "powerful teacher" and "passive, obedient" students, with the former likely to be reinforced by his role as HOD. This may not have been how all the students saw this, however, as passive resistance is not only likely but probable in such a situation (cf. Lloyd, 1990). Students gave the impression of complying, but some of them may have withheld the kind of commitment the teacher was likely to be seeking. The second teacher presented with a hybrid identity, with different facets becoming visible as the lesson developed, from friendly community-member, (gently) controlling teacher and classroom manager, amusing story-teller, and goal-oriented task manager. The

students were positioned as cooperative community members, answerers of personal questions, and audience to be engaged and charmed. They, too, may have had some resistance, which may have been signalled in the question put to her regarding my visit, and if the "entertainment" had been more prolonged than it was—only a matter of seconds—students who saw themselves as serious workers may have objected openly, or have passively resisted. However, Mrs DP's status as HOD, the high profile of science in the school (including excellent senior school enrolment and results) as well as the students' experience with her insistence on high standards may have removed such doubts. As it was all students seem to actively engage with the hands-on task that followed and there were student-initiated questions about the follow-up tasks.

The interviews provided some clues about where the above lessons would be situated in genre chains and/or networks. Mrs LW seemed to envisage the Year 10 lesson as being a link in several genre chains and/or networks, firstly in relation to school science (between the syllabus document and student writing/assessment and reporting, secondly in relation to the professional development of both herself and her science staff (in that she was trialing a new learning activity), and in relation to research and development in science education, with the researcher as an obvious but not necessary link, given that Mrs LW attended science education research conferences and presented at science teachers' conferences herself. The interview with Mr DP suggests a much more restricted role for his Year 8 lesson. Given his lack of interest in pedagogical professional development, curriculum development and change (which became evident in the interview), his lesson seemed to belong to a more restricted genre network, in fact serving mainly as the link in the school science genre chain, somewhere between the science syllabus document and student writing/assessment and reporting.

## *Part 3: Conclusions*

### CDA as a tool for documenting emancipatory and multi-modal discourses

As indicated above I found CDA particularly useful for my purposes in researching science. Briefly, it made it possible for me to demonstrate, in the concrete detail of the classroom talk, how the discourse of science classrooms may empower or disempower students with respect to scientific knowledge, in such a way so as to prevent or allow the exercise of better-informed control over their lives andmore equitably participation in decision-making about policies that are likely to have an impact on their quality of life, or the quality of their environment.

However, CDA has been criticised (e.g., Luke, 2002) for not being useful for picking up gaps and silences, and for not having the tools to deal with multi-modal communication. In relation to gaps and silences this need not be a major problem, since CDA does not depend entirely on the text itself, but also relies on accessing one's knowledge about the wider social and cultural context as one analyses a text. Consequently, if one is informed by wide reading and alternative comparable experiences and is thus more sensitised to likely absences in a discourse (e.g., Lemke's assertion that classroom "talking science" (?) is notable in its absences (see Table 1 above), and is very restricted in style), such absences are plainly signalled in the text, for example in the lack of use of 1st or 2nd person pronouns, in the lack of words or phrases expressing enthusiasm, or in a complete lack of response to dramatic and narrative content in the textbook homework exercise.

With regard to the multi-modal nature of communication, CDA may need to be supplemented by other types of analysis. I have largely ignored visual elements in my analysis though, in as far as I remember them from my visit and revisit the digital images I captured in the field, they will have been part of my subconscious resources as I analysed the texts. However, without doing so to the extent that many conversational analysts do, I have attempted to deal with non-verbal auditory elements which seem to me to be essential in communicating the tenor or register of social interactions, and hence of particular importance for my work. I have done this by focusing on aspects of communication which are often omitted from audiotaped scripts, such as intonation and pacing. To make them visible, I have insisted on both genre-related formatting (e.g. punctuation and paragraphing to indicate my interpretation of the participant's meaning) as well as explanatory notes and signs in the text to be analysed as important additional channels of meaning. Such annotations help communicate meaning which would seem to me to be essential if the multiple purposes and effects of language are to be adequately represented (in Fairclough's terms: acting/relating, representing and identifying), especially when issues of power and identity are involved.

## Implications about curriculum reform

Curriculum reform in science has generally been seen in terms of content (Fensham, 1998), with the discourse being seen as a separate issue. However Fensham's comments above do suggest that it is the representational, relationship and identity features of new curricula that meet with the most resistance from those in positions of power in deciding the curriculum (university academics and senior science teachers). This supports Bernstein's (1995, cited in Tyler, 2000) comments about school curricula having their own discourse and that it is this discourse that is the barrier to equity rather than the content of the curricula as such, as though the two could somehow be separated. Given that the teacher participants in the cases of the two extracts presented above, were operating in the same State (Queensland) and hence in accordance with requirements of the same senior science (i.e., Years 11 and 12) syllabi, the marked differences between them is not so much a matter of the disciplinary content requirements as a matter of style. That said, if the curriculum is viewed as also communicating attitudes and beliefs about the nature of science, about how students identify themselves, and about how empowered they are to act in relation to science-related issues in society, then we are looking at two different curricula. Both teachers above reported that scientific literacy was an important goal of their teaching but enacted this in very different ways because of their divergent interpretations of the term.

One has to ask oneself after comparing the two classrooms referred to above as exemplified in an analysis of the given extracts whether curriculum reform should change its explicit focus from *content* to *style* if one wants to cater for the needs of the majority of students (to use science for their own personal and social purposes, rather than be subjugated by it). Are we talking here about a new kind of "invisible pedagogy" (cf. Bernstein, 2000), one which is to the advantage of previously disadvantaged students? (Or just a less oppressive way of enforcing the current hegemony? [*To be addressed in next version of the paper. Cf. comment in my 1999 paper on scientific literacy])

## Professional development

Another question we might ask is whether this kind of pedagogy can be taught, or whether it is rather a matter of personal style that is not available to most science teachers because it is based on personal experience and beliefs, and depends on a self-confidence that allows the teacher to take risks and adapt the curriculum at the local level. I suggest that preservice education for science teachers needs to include a greater emphasis on the uncertain nature of science, its modest role in explaining and participating in social issues, an exploration of the values and needs of the average citizen and society in relation to science, a stronger and more explicit challenge to prevailing, disempowering myths about science, and the importance of the personal style of the teacher in according active learning roles to student, all modelled by preservice educators who believe and enact these beliefs in the way they relate to their students.

I would also note, on the basis of my current research, that the expression of an emancipatory style of teaching seems to require significant social support, for example, by a whole school emphasis on literacy, on middle schooling, and on equity, or at least a focus on such issues at the disciplinary level by a powerful Head of Department (cf. Lingard, Mills, & Hayes, 2000). As Taylor (1994, see above) and advocates of social justice through critical action research (e.g., Atweh, Kemmis & Weeks, 1998; Carr & Kemmis, 1986) have argued, a single teacher on his or her own cannot hope to challenge what is deeply embedded in interdependent practices, discourses, and institutional structures.

There are many implications of the point made in this paper about the importance of teaching style. On is that, at both the preservice level, and more broadly, and as part of collaborative action projects within schools, science and other teachers and administrators may benefit from critically reflecting on CDA of classroom discourse in their disciplinary area. Other collaborative processes may also be helpful, such as cross-disciplinary team teaching of science-based with humanities-based teachers, as happens in schools trialing "rich tasks" in Education Queensland. Another move in this direction is the "middle schooling" movement, which has explicit goals of re-aligning schooling to be relevant and attractive to young adolescents. In fact, I found that many of the teachers in my sample are active in advancing middle schooling, including promoting links between primary and secondary schooling.

## Final comments

As I have begun to demonstrate in this paper, CDA can highlight the ideological assumptions underlying discourse, the messages being conveyed about the nature of science and the relative needs (and value) of students, about how exclusive or inclusive it is, about the relative power or powerlessness of students in relation to school science, and so on. As such it can show how science teachers, rather than being rendered powerless in the face of the student lack of intellectual endowment or "application", can engage and

energize students by enacting an appropriate hybrid discourse, one which uses scientific terminology and argument when necessary, but which appropriates other pedagogic discourses better able geared to teaching and learning. However, as well as enhancing their critical language awareness, attention would also need to be given in preservice courses, as is happening increasingly in other professional courses for scientists (e.g., engineering, medicine), to developing more generic skills, such as interpersonal communication skills, to enable science teachers to adapt their teaching style to engage and respond to the particular needs of particular classes and students. Training in communication skills where they are deficient would empower science teachers to bridge the gap between the discourse of science and students' language resources, rather than expecting *students* to be the ones to do the bridging. It would help them appreciate that a teacher who is aware of the differences between the two discourses is better equipped to interpret between the two cultures and engage students at an appropriate level.

However, given that such communication skills also depend on both teachers' scientific knowledge and their pedagogical content knowledge (cf. Shulman, 1986) this may seem like a tall order for a preservice course in which a teacher generally has more than one teaching area of specialisation to become familiar with. There may be other ways of ensuring the hybridity that seems to be necessary for creative/active challenges to a restricted hegemonic discourse (cf. Fairclough, 1989, *X&X our reading on hybridity? Luke, 2002). At the preservice level, this could be to encourage preservice teachers to take up new combinations of science and humanities subjects, or to encourage professionals or graduates from other professions to enrol in preservice science education courses. According to Mr DP, the Karmel report in the 1970s advised science teachers to take some time away from teaching to work as scientists, which he himself did. My research suggests that time spent in a helping profession, or even in non-paid work, such as parenting, may be just as valuable if not more valuable training for a science teacher who aims to teach both scientist and non-scientist future citizens. My current research seems to indicate that most teachers who are most capable of hybridising school science discourse have benefited from alternative training or experience in a current or earlier career (e.g., primary teaching, business, resource teaching), personal experience as a parent or youth worker, and/or being a HOD in a discipline other than science. Such experiences seem to have given them a meta-level awareness that allows them to escape the elitist hegemony of traditional school science and assert themselves in relation to the needs of all students in their classes.

## References

American Association for the Advancement of Science. (2000). *Designs for science literacy [Project 61]*. New York: Oxford University Press.

Bernstein, B. (1990). *The structuring of pedagogic discourse* ( Vol. IV Class, codes and control.). London: Routledge.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity* ( Revised Edition ed.). New York and Oxford: Rowman & Littlefield Publishers, Inc.

Bourdieu, P. (1974). The school as a conservative force: scholastic and cultural inequalities. In J. Eggleston (Ed.), *Contemporary research in the sociology of education* (pp. 32-46). London: Methuen.

Fairclough, N. (1989) *Language and power*. London: Longman.

Fairclough, N. (1992) *Discourse and social change*. Cambridge: Polity Press.

Fairclough, N. (Forthcoming), *Analysing discourse and text: Textual analysis for social research.*

Fensham, P.J. (1998). The politics of legitimating and marginalising companion meanings. In D. Roberts & L. Ostman (Eds.), *The many meanings of science curriculum* (pp. 178-192). New York: Teachers College Press.

Fensham, P. J. (2002). Time to change drivers for scientific literacy. *Canadian Journal of Science, Mathematics & Technology Education, 2*(1), 9-24.

Gee, J.P. (1993). Postmodernism and literacies. In C. Lankshear & P.L. McLaren (Eds.), *Critical literacy: Politics, praxis and the postmodern* (pp. 271-295). New York: State University of New York.

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

Halliday, M.A.K. (1989, July). Some grammatical problems in scientific English. Paper presented to the SPELT (Society of Pakistani English Language Teachers) Symposium on Language in Education, Karachi. (ERIC Document Reproduction Service No. ED 330 203)

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

Hanrahan, M.U. (1994). Student beliefs and learning environments: Developing a survey of factors related to conceptual change. *Research in Science Education*, *24*, 156-165.

Hanrahan, M. (1995, September). *"Investigating is fun but I'm no good at science." Preventing loss of motivation in middle school science students by focusing on language learning*. Paper presented at CONASTA44, the Annual Conference of the Australian Science Teachers Association, Brisbane.

Hanrahan, M. (1998b). The effect of learning environment factors on students' motivation and learning. *International Journal of Science Education*, *20*, 737-753.

Hanrahan, M. (1999a). *Conceptual Change and Changes of Heart: A Reflexive Study of Research in Science Literacy in the Classroom.* Unpublished PhD thesis.

Hanrahan, M.U. (1999b). Rethinking science literacy: for all: Action researching literacy difficulties. *Journal of Research in Science Teaching, 36* (6), 699-717.

Hanrahan, M. (2001). The body in question in research methodology: "Death of the Author" and "the Pearly Gates of Cyberspace". In P. Singh & E. M. (Eds). (Eds.), *Designing Educational Researchers: Theories, Methods and Practices.* (pp. 233-248). Flaxton, Qld, Australia.: PostPressed.

Hanrahan, M. (2002, July). *Learning science: Sociocultural dimensions of intellectual engagement.* Paper presented at the Annual conference of the Australasian Science Education Research Association, Townsville, 11-14 July.

Lankshear, C. (1994). Literacy and empowerment: Discourse, power, critique. *New Zealand Journal of Educational Studies*, 29, 59-72.

Lankshear, C., Atweh, W., & Christensen, C. (1994, December). *Social and pedagogical factors associated with the successful practice of school subject literacies in contexts of educational disadvantage*. Paper presented at AARE, Newcastle.

Lemke, J.L. (1990). *Talking science: Language, learning, and values.* Norwood, New Jersey: Ablex.

Luke, A. (2002) Beyond science and ideology critique: Developments in critical discourse analysis. *Annual Review of Applied Linguistics, 22*, pp. 96-110.

Lingard, B., Mills, Martin & Hayes, Debra. (2000). Teachers, school reform and social justice: challenging research and practice. *Australian Educational Researcher, 27*(3), 99-115.

Lloyd, C.V. (1990). The enactment of literacy in high school biology classrooms: Two case studies. Paper presented at the Annual Meeting of the national Reading Conference, Miami, FL. (ERIC Reproduction Service No. ED 337 747)

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching, 29*, 791-820.

Roth, K.J. (1992). *The role of writing in creating a science learning community* (Elementary Subjects Center Series No. 56.). East Lansing, MI: Michigan State University, The Centre for the Learning and Teaching of Elementary Subjects. (ERIC Reproduction Service No. ED 352 259)

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Taylor, P. C. (1996). Mythmaking and mythbreaking in the mathematics classroom. *Educational Studies in Mathematics: Special issue on Sociocultural Approaches to Mathematics learning.*, 151-173.

Taylor, P. C. S. (1994, March). *Establishing a critical discourse on cultural myths that shape the social reality of the science classroom.* Paper presented at the The annual conference of the National Association for Research in Science Teaching,, Anaheim, CA.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier* (An occasional paper on neglected problems in science education). Tucson, AZ: Research Corporation.

Tyler, W. (2000) Pedagogic identities and educational reform in the 1990s: The cultural dynamics of national curricula. In F. Christie (Ed.) *Pedagogy and the shaping of consciousness: Linguistic and social processes.* London: Continuum.

### *Acknowledgements*

I am indebted to the members of the CDA group based at QUT, which includes all my fellow symposium presenters: Wendy Morgan, Sandra Taylor, Delia Hart, Jennifer Alford, Sue Thomas, as well as Helen Nicolson, for constructive feedback on earlier drafts, and a year of wonderfully rich reading-group workshops.