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ABSTRACT

When teachers try to dramatically change the "pedagogic contract" - the prevailing classroom norms - their efforts are frequently met by resistance from students. My central question is: what do students' and teachers' voices tell us about breaking the pedagogic contract through the use of creative/imaginative writing in science classrooms? This paper draws only on the analyzed interviews of five teachers and twelve students from their schools. It will show that it takes considerable strategic effort on the part of teachers to establish a new pedagogic contract. These teachers addressed resistance by being explicit about purposes, classroom processes and assessment practices. The voices of these students illustrate that the efforts of their teachers have been instrumental in re-framing the boundaries of the pedagogic contract: students will accept a shift in pedagogy if they can see a pay-off for themselves in terms of their learning outcomes and/or their enjoyment of the learning experience. (Contains 43 references.) (Author/ASK)

Breaking the Pedagogic Contract: Teachersí and Studentsí Voices.

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Abstract:

When teachers try to dramatically change the "pedagogic contract" - the prevailing classroom norms - their efforts are frequently met by resistance from students. My central question is: what do studentsí and teachersí voices tell us about breaking the pedagogic contract through the use of creative/imaginative writing in science classrooms? This paper draws only on the analysed interviews of five teachers and twelve students from their schools. It will show that it takes considerable strategic effort on the part of teachers to establish a new pedagogic contract. These teachersí addressed resistance by being explicit about purposes, classroom processes and assessment practices. The voices of these students illustrate that the efforts of their teachers have been instrumental in re-framing the boundaries of the pedagogic contract: students will accept a shift in pedagogy if they can see a pay-off for themselves in terms of their learning outcomes and/or their enjoyment of the learning experience.

What is the Pedagogic Contract?

Students "have a certain expectation of a science lesson when they walk into the room (especially if that room is a laboratory)" (Susanne Lakin and Jerry Wellington, 1994, p. 186). As one of the teachers in their study said:

> They donít expect reading and discussion or drama and role play - they do expect bunsen burners and practical work. They donít want to learn that science is not a set of facts, that theories change and that science does not have all the answers - they want the security of a collection of truths which are undisputable. They see little place for their own interpretations or theories but want to know what should happen in a particular investigation and what this proves (teacher quoted in Lakin and Wellington, 1994, p. 187).

Practical work is certainly expected when the room is equipped with the infrastructure (benches, water, gas) and tools (microscopes, air-tracks, test-tubes) of science.

The daily interactions that create the lived experience of pedagogy in classrooms incorporate clear expectations of how the "pedagogic contract" will operate within the particular context of a classroom or school culture. I have re-labelled this term, called the "didactic contract" by Guy Brousseau, 1986, because I believe that it will now sit more comfortably with English-speaking teachers/researchers to whom the word ëdidacticí is clearly associated with transmissive teaching.

The pre-existing pedagogic contract has been generated by the collective approaches used by teachers in the past: and the particular set of pedagogical practices that has become so established can be labelled as hegemonic pedagogy within science classrooms. Teachers who look to the future, and to re-inventing science pedagogy so that is inclusive of all students needs whilst it also challenges ways of thinking with/in science, must choose to construct and offer their students a re-vision of the pedagogic contract ñ a new way of operating in their classrooms.

The pedagogic contract includes pragmatic factors such as: whether students are expected to talk and/or to listen; whether students are expected to answer questions and/or ask them; whether a climate of problem posing and/or problem solving exists; whether students are expected to produce and/or reproduce knowledge; whether negotiation occurs in both what and how science is taught; whether there exists a climate of support for diversity among students; what particular learning activities and forms of writing are acceptable practices.

The pedagogic contract sets the tone of the teaching-learning relationship between students and teacher - a relationship that requires a level of trust on behalf of the student that the teacher will indeed use their competencies, knowledge and skills to facilitate learning. The student-teacher relationship, fragile that it always is, is perceived quite differently by male and female students. Boys tend to de-personalise, "express anger and disappointment" when they perceive "poor teaching", whereas girls tend to react quite differently, and are open to "much greater personal vulnerability" when poor teaching is constructed by them as the teacher making them "feel stupid" (Fran Davis and Ariene Steiger, 1993, p. 736).

For the boys, the problem is an external one, beyond their control and not linked to their sense of self. To the girls, however, the problem is perceived as internal, a difficulty that threatens their own self-perception as learners. It is perhaps, more important for girls to feel confidence and trust in the pedagogic contract that the teacher offers them: for boys the contract can be broken with few consequences on their personal image of themselves; for girls however, a break-down in the contract, a failure to learn through the teacherís efforts, is perceived as a threat to the studentís personal resources as learners.

A pedagogic contract that enables all students to feel confident that they are learning would be a precious one.

Any time a teacher chooses to break the conventions, the prevailing norms, of the pre-existing pedagogic contract, they must expect student

resistance and be prepared to justify why such a break is occuring. Just such a situation arises when teachers ask their students to move from a model of learning based on transmission, to one based on constructivism; another occurs when teachers ask their students to write non-"factual" pieces in a science class.

Why would Teachers Deliberately Break the Pedagogic Contract?

> To invoke the importance of pedagogy is to raise questions not simply about how students learn but also how educators ... construct the ideological and political positions from which they speak (Henry Giroux, 1992, p. 81).

Pedagogy is how we re/present both our subject, science, and our value positions on it, to our students. It is not a neutral nor value-free technical application of teaching rules.

> Discourses are about what can be said, and thought, but also about who can speak, when, where and with what authority (Stephen J. Ball, 1993, p. 14).

Using the concept of a discourse it can be seen that in science teaching there are shared values and assumptions: about whose voice is heard, what is taken for granted, and what activities ënaturallyí lead to learning science. But discourses are not merely patterns of language use, they are contestable areas, where power and hegemony are pervasive or, in competing discourses, disruptive. The dominant discourse represents science/pedagogy as built on foundations that can be legitimately challenged from a wide variety of critical standpoints such as: sociology and philosophy of science, poststructuralism, and feminism.

The teachers in my study chose to break the pedagogic contract because their frame of reference on science and on pedagogy led them to a position where they did not wish to perpetuate hegemonic science and pedagogy as is, with its embedded inequities. They acted on their fundamental belief that to teach is to change the world. A common standpoint of each of these teachers was their commitment to feminism. There are two focus areas that these teachers chose to redefine with a new pedagogic contract: science and pedagogy.

About Science

Two clusters of reasons for change in studentsí views of science centred on teachersí acknowledgement of the feminist critiiques of science and their perception that science involves the imagination.

a) Feminist Critiques

One of the tools that poststructural feminists use to investigate power is that of deconstruction. I use that tool here to illustrate how hegemonic science and hegemonic masculinity are both underpinned by a common set of dualistic concepts.

Collectively feminist works, (e.g. Ruth Wallsgrove, 1980; Sandra Harding, 1986, 1991; Nancy Tuana, 1989; Linda Shepherd, 1993; Evelyn Fox Keller and Helen Longino, 1996) have shown that many factors in the paradigm of hegemonic science are aligned with those defining hegemonic masculinity, and are so deeply embedded in our understanding of what science is that they have become invisible to us, as scientists, as teachers and as citizens.

Deconstruction of the underlying beliefs show that constructions of gender and of science are both based on a common set of asymmetrical dualisms where the concepts in the left column, below, are valorised, taken as the norm and used as the measuring stick of worth. The terms of the dualism thus form an oppositional hierarchy, although it is more useful to conceive the two terms as opposing endpoints of continua. The concepts in the right column are associated with the ëotherí (not the norm), are of lower status and represent a supposed inherent inferiority. These asymmetrical dualisms thus create implicit assumptions about hegemonic masculinity and emphasised femininity (Bob Connell, 1987) and about hegemonic science and non-science.

rational - - - - - - - - - - intuitive

logical - - - - - - - - - - emotional

objective - - - - - - - - - - subjective

abstract - - - - - - - - - - holistic

fact - - - - - - - - - - story/metaphor

masculine - - - - - - - - - - feminine

For example, exploring the first pair of dualistic terms, the belief that science, as practised by scientists, is a rational enterprise, Ruth Wallsgrove noted that:

> You canít be rational if you pretend that everything you do is rational; if you donít examine and come to terms with what you feel, your feelings will interfere anyway, but in a hidden and uncontrollable way (Wallsgrove, 1980, p. 235).

In looking at the third pair of dualisms, objective/subjective, Lorraine Code (1991) asks ëout of whose subjectivity has this ideal [of objectivity] grown? ... whose values does it represent?í (p. 70)

Perpetuating a view of science as directly linked to masculinity was not a scenario these teachers sought to implement.

b) Imagination:

Science is powerful in our society. It is a ëregime of truthí in Foucaultís (1980) terms as it acts as a discourse of power, privileged over other discourses. To claim to be ëscientificí is to claim to speak from a position of power and authority. The dominant discourse assumes that scientific thinking is rational, logical, objective, abstract, and about facts.

"Imagination is more important than knowledge" (Albert Einstein).

A contradictory space emerges. Many authors have written about the importance of imagination, creativity, holistic views, speculation and intuition in science (e.g. Arthur Miller, 1996). For example, Roger Shepard, (1988) documents many interesting stories of the ëimagination of the scientistí. His examples cover some of the creative thinking of a large number of scientists from Albert Einstein to Nikola Tesla. Shepard argues that we need to provide opportunities in school for students to develop their creativity and imagination as it applies to science because of the importance of these characteristics within science. The championing of imagination, speculation and intuition as thinking that scientists do in practice, and the rejection of rationality or logic as the prime thinking tools for researching science can be read as a contestation of their centrality to a ëscientificí approach (Ian Mitroff, 1974; Ference Marton, Peter Fensham and Seth Chaiklin, 1994).

The teachers in this study strongly believed that to do science, students had to be creative and use their imagination.

About Pedagogy

Three facets of pedagogy that these teachers chose to challenge were: the way practical work constructs a positivist view of science; the way constructivism implies a new pedagogy; and how writing can be diversified to enable more students to enjoy and learn science.

a) Practical work:

One of our collective ideological choices in science education has been to premise much of what happens in science classrooms on an old Chinese proverb: I see and I forget, I hear and I remember, I do and I understand. This often-cited justification for physical activity, embodied within practical/laboratory exercises, has only relatively recently been criticised on a number of grounds. For example, the narrow ways in which practical work is often carried out in secondary school science has the effect of aligning school science with positivism. Milne and Taylor (1995) argue that teachers who hold an objectivist belief about science tend to focus on extensive practical work that works on a "cookbook" model, that "implies that there is only a single correct way to of doing science which, in turn, reinforces the objectivist belief that there is only a single correct way to generate proven scientific knowledge" (Milne and Taylor, 1995, p. 46).

When discussing how these recipe-style practical "exercises" are often done unthinkingly, Morris Shamos describes "hands-on" science as often being "minds-off" (Shamos, 1995, p. 130). A telling observation is Rosalind Driverís: "I do and I am even more confused." She presents the notion that practical work may not help students undertake the "intellectual leap" or "the paradigm shift in their thinking" that is required to shift firmly embedded alternative frameworks of science concepts (Driver, 1983, p. 9).

Derek Hodson argues that practical "exercises" have "seriously misrepresented and distorted the nature of scientific inquiry" (Hodson, 1996, p. 115) and what has emerged in the hegemony of the practical is a positivist view of science. This false image of science is one of the driving forces behind teachersí desire to change their classroom practice. They no longer wanted to teach science as if it were a continual series of experimental exercises.

b) Constructivism

Within the science education community we have constructed a discourse that has become the seemingly ënaturalí way of thinking and representing: science, learning, teaching (and writing). There seems to be a wide-spread recognition that the "prevailing pedagogy is based on an objectivist theory of knowledge" (Milne and Taylor, 1995, p. 39). This hegemonic pedagogy draws on a model of learning that largely operates from the transmission end of the learning continua, where students are perceived as acquiring or collecting science knowledge and skills and as passive recipients of frequently didactic teaching.

But now there are strong contestations of hegemonic pedagogy. Over the last fifteen years there has been a Kuhnian revolution in thinking about pedagogy in secondary school science, so that the preferred epistemology among science education researchers and teacher educators (and some classroom teachers) has become one or another branch of constructivism, from radical to social (Milne and Taylor, 1995). The constructivist model of learning is thus the currently dominant paradigm that informs much of the worldís science education research and some of its science classroom practice (e.g. Hewson, 1981; Driver, 1983; Ken Tobin, 1993). Constructivism is the loudest contestant voice of hegemonic pedagogy in science at the moment. This is another reason why many science teachers have chosen to break the pedagogic contract in their classrooms.

c) Writing:

David Locke (1992) coined the expression, "science as writing", because the artefacts of science are the written traces left behind by scientists.

Nobel laureate Peter Medawar (1963) wrote his classic exposé of the condoned writing practices in scientific papers pointing out that they construct a "fraudulent" view of science, clearly dissonant with the processes of science and its knowledge production projects. He says: "hypotheses arise by guesswork" and they are most certainly "not of logic" (as reprinted in Dixon, 1989, pp. 173). According to Medawar:

> the scientific paper is a fraud in the sense that it does give a totally misleading narrative of the process of thought that go into the making of scientific discoveries. The inductive format of the scientific paper should be discarded (in Dixon, 1989, p. 175).

Locke (1992) argues that while many scientists genuinely believe that "their language does not much matter, that it is merely the empty vessel into which the content of their scientific thought is poured" (p. ix), this is not the case. Almost thirty years since Medawarís exposé, the scientific paper is still taken as the definitive piece of scientific writing: the standard. Yet there are many other styles of writing produced by scientists: letters (to *Science* , *Nature*, and to colleagues), posters at conferences, jottings and unformed notes on their own ideas and other peopleís work, email messages, grant applications, textbooks for school and university students.

And science has also always been informed by imagination within writing: writing using metaphorical devices, allegories and imagery to push out the boundaries of our thinking. Even in preparing the published versions of their work, scientists carefully select and use literary tools such as understatement, metaphor, subtle emotive language and other rhetorical devices to persuade the reader.

> Scientists are tellers of tales, creative writers who make meaning and who choose the ways they go about doing so (Rymer, 1988, p. 244).

Cases such as James Clerk Maxwell, Michael Faraday, Friedrich Kekulé, Albert Einstein, Nikola Tesla (three-phase power supply systems; fluorescent lights) have been well documented as sources of inspiration for others (e.g. Shepard, 1988; Dixon, 1989, Locke, 1992). Scientistsí writing abounds with imagery that has led to new ways of thinking about the world.

However, the written tasks that students are asked to do in school science have tended to be in one-to-one correspondence with the public writing of scientists as they report their endeavours in journals. The so-called ëfactualí or ëscientificí genres used in school science have thus been: recount, report, procedure, explanation, discussion, and argument. For many students, overcoming the barrier of scientific language is like "climbing the fence around science ideas" (Mitch OíToole, 1998, p. 51).

Michael Halliday (1993) lists seven characteristics that he thinks distinguishes scientific English from other versions. These are its: interlocking definitions; technical taxonomies; special expressions; lexical density; syntactic ambiguity; grammatical metaphor; and semantic discontinuity (p. 71). Halliday says that these characteristics are not arbitrary, they "evolved to meet the needs of scientific method" (p. 84), telling us the Halliday thinks that science does have a unitary method and that science is positivist, if not Baconian.

Jay Lemke listed some of the other features of OíTooleís ëfenceí around science ideas, the norms of ëscientificí language used by teachers, and I summarise them as: being explicit, universal, abstract, decontextualised, using technical terminology and causal explanations; it avoids colloquialisms, personification, metaphoric and figurative language, referring to people, fiction and fantasy, and narrative and dramatic accounts. It is "serious and dignified" (Lemke, 1990, p. 133). After listing its rules, Lemke exclaims: "these rules are a recipe for dull, alienating language" (Lemke, 1990, p. 134). This is the very reason that it has come under considerable criticism from science education researchers over a long period of time (e.g. Paul Gardner, 1974; Robert Hattam, 1994) for contributing to the difficulties that many students have in learning science.

Lemke argues that while science involves "human actors and judgements, rivalries and antagonisms, mysteries and surprises" and is often "fallible", these dimensions are often not talked, read, or written about in science classes. He says that "the norms of scientific language veto most of the techniques that all good communicators know are necessary for engaging the interest of an audience" and this is why "all good science teachers find it necessary to break the rules and violate these stylistic norms, humanizing science as they communicate it" (Lemke, 1990, p. 134). The teachers in this study were prepared to break the rules of writing science to engage their students in the act of learning.

How was the Pedagogic Contract Broken?

I focus this paper on the use of creative or imaginative genres as a vehicle for science learning (Gianello, 1988; Hildebrand, 1998, 1996; Prain and Hand, 1996; Sutton, 1996). My central question is: what do studentsí and teachersí voices tell us about breaking the pedagogic contract through the use of creative/imaginative writing in science classrooms? By exploring this breakage insights may be gained that assist teachers who wish to alter the pedagogic contract in other ways.

For the purposes of this paper creative/imaginative writing is defined as any hybrid, or blended, genres that use "scientific" and/or "factual" genres in conjunction with imaginative genres (narratives, poetry, letters, cartoons, journals, anthropomorphic stories, etc). The genres for writing to learn science are thus considerably expanded. The following examples serve to open a window of possibilities on imaginative writing:

1. Imagine you are a water molecule: describe five changes of state that you have recently experienced. (anthropomorphic narrative)

2. Prepare a travel brochure advertising a trip to another planet. (advertisement)

3. You are a parachutist (dancer, basketballer...), describe the forces acting on you throughout a jump (dance, game...). (realistic recount)

4. Write a poem describing a monotreme, in the shape of that animal. (poetry)

By stepping outside the conventions of ëfactualí [sic] writing in science classes these teachers asked their students to think beyond the borders of hegemonic science/pedagogy.

This is but one way of breaking the pedaogic contract. Other ways include using student-designed investigative work, starting with their own questions, as the central laboratory work; using creative techniques such as drama and role play to explore scientific ideas; and structuring science lessons so that studentsí concerns and contexts are authentically explored through science rather than teaching science as a process of uncovering the facts that previous generations have ëdiscoveredí.

Methodology:

This work is one phase of a larger study mapping exemplar usage of hybrid imaginative writing within the context of secondary science across the three dimensions of interpretation, implementation and impact (both cognitive and affective).

The teachers whose voices are heard here, although disguised with pseudonyms, were purposefully chosen as typical of expert users of this pedagogical practice: they had each been using imaginative writing within science for a period of three or more years. Each of these teachers were known to me through our shared commitment to gender-inclusive pedagogy and they had all taken on imaginative writing as one facet of their work toward that goal. They were not novices to the practice, nor were they coerced into trying these writing genres. There is no random sample here.

In the collection and analysis of these teachersí perspectives, my role involved empathetic understanding and partiality, rather than detachment and objective portrayal; and the process rested on a premise of respect for the daily complexity of their pedagogical realities. This was foregrounded when I approached the teachers to share their work with me for this study. The act of participating in my research has engaged these people in a relationship of trust with me, as a documenter and analyzer of their views, experiences, and practices. I recognize that I have interacted with the co-operating teachers in this research, not just measured their views from a distanced vantage point at a particular instant in time.

I transcribed taped conversations with twenty teachers and followed this with participant observation in six of these teachersí classes. I then collected their studentsí views on the use of imaginative writing in science through questionnaires and through interviewing thirty students in pairs who were representative of the views of the larger group (identified through questionnaire responses). This range of views includes those students who are: male and female; like and dislike science; like and dislike imaginative writing in science; English-speaking and those with language backgrounds other than English (LBOTE).

For practical purposes, this paper draws only on the analysed interviews of four women teachers, "Alex", "Katie", "Rosemary" and "Sandy", and one man "Michael" and from twelve students - seven girls and five boys - from their schools. These interviewees were chosen as their voices reflect the perspectives of the larger group and their schools provided a student population that represented the ethnicity, race, first language and class patterns of Australian students. The teachers themselves are of mixed ethnicity, language background and class of family-of-origin. For the

purposes of this paper it is important to know that students were carefully scaffolded into and through the writing tasks: they were never simply assigned a task and left to do it.

The interviews with teachers and students were transcribed and then coded in "Kwalitan 4.0" (Vincent Peters, 1994), using a grounded theory approach (Barney Glaser and Anselm Strauss, 1967; Strauss and Juliet Corbin, 1990) to unravel some of the emerging themes and patterns. The analysis involved repeated listenings/readings of the audiotapes/transcripts and the continual re-thinking of applicable codes to sift and categorise the interview segments.

The interview data will be presented as a series of themes that illustrate important perspectives on breaking the pedagogic contract.

But: why did *these* teachers break the contract?

For the reasons articulated above. The view of science and pedagogy that the conventional pedagogic contract perpetuated did not mesh with their own understandings. Feminist critiques of science, and deconstructions that showed the creative and imaginative side of science played a part; as did a recognition that practical work embodies positivism; constructivism is a useful learning model; and writing in ways that indicate a broader view of science is a way of realising these contestations with science/pedagogy in practice.

Alex is one of the teachers who argues that much of the recipe practical work that is endemic in science classrooms is much less productive, from a learning point of view, than is imaginative writing.

> Some reading and talking that Iíve been doing over the last couple of years has convinced me that the value of prac. work can be an absolute zero if you donít really think about what youíre doing, and why youíre doing it, and make sure that your intention meshes with the kidsí intention for the lesson. So I could say prac work could rate very, very low, compared with imaginative writing, to reflect somebodyís understanding of something. It just depends on how you set up the prac work. If a kid has devised what the problem is going to be, and then worked out a way to solve it, and then writes about it, then that could be a really good reflection of somebodyís understanding - but if itís a recipe prac. then: itís ëcrap-olaí. (Alex)

Many teachers expressed the view that scientists were creative people who engage their imagination in working within science. They see part of their project as science teachers to be breaking down the mythical image of the stereotypical scientist who is totally reliant on logic and rationality.

> I think it's getting them [students] around the idea that scientists are these straight people getting around in lab coats and so on... and lots of scientists who have made interesting discoveries havenít been your conventional sort of scientist - as students perceive them. (Katie)

> Weíre fostering that side of science by telling kids ëitís OKí to use your imagination. (Rosemary)

All of these teachers saw science as dynamic, in a constant state of flux, with evolution, and sometimes revolution, in scientistsí thinking about our world. Some used this as an argument for providing opportunities for studentsí use of imagination in science classes: as a means of furthering an evolution in science.

> I guess what weíd encourage kids to do would be to start thinking, and not stop thinking, about stuff that they come across in the lab. And not to think about science as a collection of ëfactsí that havenít changed and wonít change. And to think that itís more of a dynamic process - and I think by doing things that encourage kids to write and think and talk divergently, by using kids talking to each other about their work, by using creative writing, by using role play, weíre encouraging them to move away from the stereotyped image of what science has been and to think about it in a more evolutionary way. (Alex)

An underpinning philosophy that became visible during these interviews was the notion that these teachers see their job as bringing science to the students - all students, not only those who intend making a career in science. This led these teachers to try a range of innovative practices in their search for new ways to bring science to their students.

> My original premise when I started teaching science was that ëscience is for allí, it isnít just for people who were going to be studying at university or whatever. Iíve always thought that science is empowering for people. ... Thatís the whole point of this: Iím trying to make things more accessible. (Katie)

These teachers recognised that the diversity amongst their students - due to gender, ethnicity, language background, ability and so on - required a multiplicity in the range of learning activities available to use as tools for learning. As Alex succinctly puts it, a broader set of pedagogical practices is available when imaginative writing is used.

> It extends the repertoire of learning and assessment strategies that you can use in a classroom. (Alex)

What Initially Happened When the Contract Was Broken?

1. Teachersí Voices:

a) On Teachersí Resistance:

Not only do students resist breaking the pedagogic contract in science classrooms, but several teachers described how hard it had been for themselves to risk failure by trialling innovative practices. Michael recalls his first reaction:

> My first reaction to creative writing was probably the same as a lot of other people, you say, ëoh, what a load of rubbishí. (Michael)

Sandy recalls her first attempts to introduce it to her new colleagues:

> I remember the first time I talked about creative writing here ... and the response was ëyouíve got to be jokingí. (Sandy)

The energy they had to commit to changing their teaching practice to accommodate new teaching strategies into their repertoire was recognised by several teachers.

> Iíve spent so much energy trying to find ways of putting the things they have to learn into some sort of fun, creative way - even to put it into context for them. (Rosemary)

b) On Studentsí Resistance:

Initially, upon hearing that they were about to write imaginatively in a science class, almost all of these teachers reported student reactions similar to those of Rosemaryís students:

> A lot of kids donít have a very positive image of science, so they come to my classroom ready to hate. And when we start doing all this stuff a lot of them are very confused and I get things like, ëexcuse me Mrs G, this isnít scienceí, ëweíre not in an English classí, ëwhat do you mean itís our assessment?í (Rosemary)

It is not just resistance to a new type of activity that the students activate, but a resistance to the threat of exposure of their lack of science-based understanding.

> Some of the kids who have had pretty straight science beforehand really find it a curve ball. The ones that were only used to writing in their notebooks, and who perhaps might be more at the academic end, and straight-down-the-line sort, want you to feed them: ëfeed me this and Iíll remember it, and regurgitate it backí. They quite often have problems with it, because itís not something theyíre used to doing, or practising. (Rosemary)

2. Student Resistance

> **"Pedagogy is fruitful ground to help us address questions of how our very efforts to liberate perpetuate the relations of dominance at the micro-level of local resistance" (Patti Lather, 1991, p. 125).**

As teachers we think we know how to empower students, but our interpretation of power is often a ëpower overí model rather than a ëpower toí model. But whenever we try to break the pedagogic contract, students will resist. Some typical resistance responses are classified by theme below.

a) Recognition of a break in the pedagogic contract:

Some students think imaginative writing is an activity thatís in the ëwrongí subject:

> It was hard getting motivated to do it because it doesnít actually seem like real science work, but just something to fill in time, because itís not really what you do in science. (Natasha, grade 9 girl)

Others compared it with a more usual activity in science classes, practical work, part of their expectations in science:

> I like doing more practical work than creative writing. Itís a bit boring but we have to do it - itís a project [the travel brochure task]. (Tuquhina, grade 7 girl)

b) Not a worthwhile learning activity:

> Itís not that great, you donít want to do it because you donít think itís worth it, itís just boring. (Tom, grade 9 boy)

c) Only worth doing because the writing product is assessed:

> If youíre not going to get graded on it whatís the point? (Rowan, grade 9 boy, Valley S.S.)

What do teachers do to minimise resistance?

Many of the teachers in this study were quite pragmatic in their use of a wide repertoire of teaching strategies and tactics as a means to minimise resistance to science, in general. But additional tactics needed to be put in place when a further disruption to the pedagogic contract occurs, such as when an unusual activity type like imaginative writing is first introduced. It takes time and much effort on the part of teachers whenever a new contract is to be established. They have to put in place careful processes and to minimise resistance and convince students that the new pedagogic contract will be a worthwhile one.

All of these teachers spent considerable effort in framing the task and providing structure for the process, so that it became a manageable activity for their students. Some of the tactics the teachers used to minimise resistance are classified into themes below.

a) Building a "shared understanding" of the purpose:

> I think you need to make it clear to the kids why youíre doing it. I think if you just give it to them, theyíll think - and not say - ëwhat are the objectives of this particular task?í. Or theyíll say, ëthatís English, why the hell are we doing this here?í But Iíve found that when you talk to kids about what youíre trying to gain from the task, itís not a problem.... [You need to] have some type of shared understanding of what it is theyíre doing with the task. (Sandy)

b) Providing a structure to write within:

> I think the kids feel much more confident, [having a structure], because, at first they felt a little confused, they didnít know where to start. But once weíve had a little discussion and thereís some structure to it, well, then they feel that they know where theyíre going with it. (Katie)

Michael tells us that in his experience the younger students require more structure and scaffolding than older students. Many of these teachers used these writing genres with their year 10 and 11 classes in chemistry, biology and physics, as well as with their general (integrated) science courses in years 7, 8, and 9 that are reported in this study.

> In all the work Iíve done with year 7s, Iíve given them a fairly detailed instruction sheet, which Iíve gone through with them before theyíve started. I did that deliberately, because I felt that there would have been some of the kids who would never have got anything done if Iíd have said to them, ëright, hereís a topic, I want you to answer these questions on it, go to it and do ití. Although I might add that with the year 11 task, all I did was gave them a question and said this is what I want you to do and they went ahead and did it. So I think the older the kids are, the better they can handle more freedom, and they probably enjoy that, too, Iíd say. (Michael)

c) Linking the writing firmly into a coherent unit of work:

All of these teachers incorporated the writing task into a unit of work and linked the writing tasks with other associated activities. Alex describes some of the activities in her Body Systems unit for year 9.

> They did an initial task where they had to draw a life size body diagram, showing the path of a marshmallow as it went through, to start thinking about things. Theyíve done a role play that theyíve video-taped. They did a worksheet that was for basic kinds of information about the parts of the blood. Theyíve done a road map as an analogy. And now theyíve done a creative writing piece. (Alex)

As Katie explains, the writing becomes, for some, the coherent thread that links the other activities together and provides them with a sense of purpose - the linked activities inform the writing.

> So what I normally do is I break the task up and get them to do other activities in between. I try and break it up so that they feel comfortable with it rather than just asking them to write a paragraph on something and I try and have lots of hands-on stuff as weíre doing it. (Katie)

d) Specifying the tasks explicitly:

In most cases the information given to students included specifications on:

ï a due date;

ï a guide to the length of writing required;

> ï key terminology or scientific concepts that must be incorporated into the writing;
>
> ï the assessment criteria that would be used to judge the quality of the final piece;
>
> ï options for the types of writing that could be produced (e.g. a newspaper article, a poem or a cartoon strip).

Some teachers specified the writing task in additional ways, requiring a draft to also be submitted; requiring a bibliography and/or acknowledgment of assistance in producing their work as well.

e) Providing for student choice within a structure:

> [In] the method of presentation I was more flexible - saying that they could write a story, do a poem, do a poster, do a comic strip. But they had fairly specific instructions as to what they had to include. (Michael)

Katie thinks that if students are giving a range of options to choose from, and an opportunity to negotiate a variation of the task that is of interest to them, as did some of her students who wanted to do a newspaper, they are more likely to engage with the task because they have some ownership of it.

> If there is room for negotiation, like you have a list of topics and they can choose, or they can come up with one themselves, you know they have a stake in that, in a sense. (Katie)

f) Providing classroom processes that assist writing:

> We do spend a bit of time planning. When I set a task I ask them to do a timeline Ö If you say ëyou have three weeksí, then two days before the deadline theyíll panic, and say ëwe havenít had enough time to do thisí. So itís useful right at the outset to do a timeline - even if itís changed on the way. Include things like: when you intend to go to the library - and whatís going to be involved in the library visits; working in the classroom; finding things at the local library; doing computer work; [time] in the labs, that sort of stuff. So they have to plan. (Katie)

g) Asking students to write for an audience:

Some of these teachers specified an audience for the studentsí writing - when unspecified the audience is usually the teacher alone. Alex also teaches English, and as such, has skills in teaching writing that can be usefully learned by other science teachers. However she has only recently begun asking her students in science to specify the audience for their writing in science.

> The concept of ëaudienceí is one that Iím just starting to play around with a bit. But Iíve decided that itís important because students need to be able to think about who theyíre writing for, and why. (Alex)

In Katieís class when they are writing ëchemicalí songs to perform for their peers, the audience is their classmates - and also students in other classes, and years, who see their music video clips. The audience is similar to one for a live performance of any musical/theatrical piece. The incentive of writing to perform in front of an audience generates a focus on what might be included - and helps motivate the students to write a quality product.

> Itís something that theyíre performing, so they have to know that material and they draw the bits out that they want. So we look at the handout of information and we discuss, ëOK, what might people want to know about these elements?í ... Eventually they do produce something reasonable together and then they perform it and Iíve got some videos there of them actually performing it. (Katie)

Another class of Katieís wrote books about safety with electricity for a primary (elementary) school audience: when they finished, the year 8 students took their ëbooksí across to the primary school and read their stories to children. The real audience gave another dimension to thinking about the writing, ensuring students had to try and explain the ideas very clearly. Katie says:

> Weíve said that itís for younger children and the reason for that is so that theyíll explain it really clearly. ... As theyíre doing that Iím hoping that itís clarifying ideas in their own minds. Weíve talked about what would make a book interesting for young students. We talked about large lettering and a character - a character with a name - and large illustrations, colourful and all that. (Katie)

The motivation level for these students was high as they saw their writing task as having genuine authenticity.

h) Creating space for talking about writing:

All of these teachers thought that imaginative writing provided a space for purposeful talk between students, and this enhanced their learning. Each of these teachers built a talking phase into the writing cycle. Sandy uses group activities to generate ideas for her students as part of the pre-writing phase.

> I get the kids to set up working groups on it, because the kids who donít know where to start can be supported. At least they can go away with a

bucket of ideas they can play with. (Sandy)

Katie believes that a wise teacher will utilise all the resources at their disposal and students are a wonderful resource for each other.

> If you send someone off individually, youíre not really using your resources to maximum effect. Other kids have read things and explored things and when they talk amongst themselves I can see that they really learn from each other. They teach each other, basically, they seem to like listening to each other more than they like listening to me! (Katie)

i) Requiring students to do a draft:

To assist their students in and through the writing many of these teachers incorporated a drafting stage in the writing process and provided mechanisms for feedback.

> I didnít want them thinking that they were just going to get one mark at the end of it, because the process is just as important as the product. ... You need to have done a rough copy first, to show your thinking and how itís going; and then you have to talk about it with somebody; and do some more thinking about it; and finally, go back and refine it and work out what you understand about the topic now. (Alex)

Alex introduced a ëdraft-buddyí system, where students worked in pairs to check each othersí work in a formal way, providing oral and written feedback to each other. But Alex went on to say that, because her students resisted doing a draft at first, she used tactics such as giving credit in her assessment regime for the submitted draft. With other teachers the students simply read their own drafts, or had a friend or family member informally provide feedback on their draft. Some teachers, like Michael, read and comment on the drafts themselves. In each of Michael and Alexís cases, the draft is submitted with the final piece as evidence of an improvement process, and in Michaelís case it must be shown to the teacher, before the due date, as evidence of progress towards the final goal.

> I always get them to do a rough draft for a start and then I look at that and get them to do their final product. Otherwise if they donít do a draft, there is the possibility they will come to the due date and they wonít have anything done, anything to hand in. (Michael)

Michael went on to say that he sometimes facilitates the drafting process by providing a ëdraft sheetí, a proforma, that helped focus students in their information collection phase, before their writing commenced.

j) Specifying assessment practices and criteria:

All of the teachers in this study felt it was very important to legitimise the writing by valuing it as part of the assessment regime in science. The writing is sometimes used as a diagnostic assessment tool (identifying pre-conceptions), but more commonly it as used as a summative assessment task to round off a unit. Many of the teachers agreed with Sandy that the imaginative writing tasks are high quality assessment tools because of the exposure of deep understanding, or lack of, that the written products reveal.

> If Iím looking at assessing concepts and big ideas Iíd rate creative writing right up there because Iíve not yet found a tool that tests the understanding of the big ideas in the same way that creative writing does. (Sandy)

Michael was one of several teachers who expressed the principle that the imaginative writing pieces can sometimes provide higher quality information than other assessment tools are capable.

> I think itís clearer to me than getting the kids to do a test, to show that they have understood what theyíve done... You can see straight away whether they understood or they didnít understand whatís happened. (Michael)

The other common feature for these teachers was the use of explicit criteria - given to the students with the task - as a means of assessing summative writing tasks.

> I think that, in order to be able to do a piece of writing that is going to address the concepts that weíve covered in the topic, you need to have specific criteria that youíre addressing - like the key words that need to be included, the type of person for whom you are writing, so the assessment is clear. (Alex)

The teachers in this study used the following principles in assessing imaginative writing:

ï assessment values a task;

ï assessment tools should reveal understandings;

ï imaginative writing tasks can assess over-arching concepts;

ï imaginative writing pieces can provide quality information on studentsí understandings;

ï not every imaginative writing task should be assessed;

ï tasks that require extended effort ought to be rewarded in the assessment regime;

ï teachers should provide a wide spectrum of ways for students to show what they know and can do;

ï when assessing writing students should know the explicit criteria on which they will be judged;

ï the uniqueness of each written piece of imaginative writing ensures it can be readily authenticated as belonging to the student who submitted it.

All of the above strategies and tactics helped reduce resistance to the break in the pedagogic contract. But they were hard work for the teachers to implement.

What Finally Happened When the Contract Was Broken?

Teachersí Voices:

As Rosemary says, with careful scaffolding as outlined above:

> Once theyíve gotten over the initial shock of having to do this, they usually enjoy the task. (Rosemary)

Sandy recognises that this is one of the tools she can use to detect alternative conceptions.

> Itís one of the quickest ways to pick up misconceptions the kids have about anything. You find if they havenít got a clue about this, or they havenít made the connection between this and that. (Sandy)

Sandy also argues that it is a most effective ëdiscriminatorí for students of what they understand and do not understand.

> ... helping to see what they knew and what they didnít know. It was a real discriminator for them: of the bits they could understand and the bits they were very confused on. Iíve found itís one of the most effective things Iíve ever used for kids - for themselves, to really see if they understand whatís going on. (Sandy)

These teachers believe that ownership of the language of science is also encouraged by developing a sense of playfulness with it as Rosemary says:

> For the mainstream student, it breaks down the fairly severe image they have of science, the remote image that they have. ... Itís the knowledge that it can belong to them, it doesnít have to belong to the people in the laboratories. ... They then feel they can cope with it, and understand it. Itís not precious - they can use it. They can feel in control of it. ...This makes it personal and says ëitís OK to jiggle this aroundí. They feel that it is so structured that theyíre not supposed to jiggle it. (Rosemary)

The notion that students can ëjiggleí the language of science is not usually found in hegemonic pedagogy. The close link between language and learning was clear in all these teachersí minds and some teachers recognised the sense of power that comes with ownership of, and control over, scientific terminology and concepts.

> It gives them [students] a sense of power, in a way, that they can actually use that language. We see that if theyíre to succeed one of the things they need to be able to do, is to use the language of science. (Sandy)

Recognising that, in doing imaginative writing, students cannot simply regurgitate unlearned material, several teachers commented on the power of imaginative writing as a means to force students to transform material into their own words. In particular, several teachers spoke of the increased access students now have to electronic information and the ease at which they can retrieve it - but that retrieval of information is not good enough.

> Doing it this way, kids canít just get a book or CD-ROM and copy stuff, theyíve got to put it in their own words. It worries me when kids go to the library to research something, and a group of them ask ëcan we use the CD-ROM?í. And what they do is, find the bit that they want, copy it off, and think ëIíve got it allí. And whilst I think it is a really terrific medium, it has got to be used correctly. Because, they can find the information all right, but then putting it in their own words, they find really difficult. And I think the creative writing makes them do it in their own words. (Michael)

Imaginative writing is seen by several of these teachers, as a memorable activity, even for learning those dreaded ëfactsí - like chemical symbols ñ with the learning gained becoming more firmly embedded in studentsí minds where it is retained for a longer period of time.

> Itís difficult to learn facts and if they can do it in a fun way they can associate it with something then it stays [in their minds] ... a couple of kids said to me the other day ëwe still remember those element songs from year 7í and theyíre in year 9, now. If they become actively engaged like this, theyíre going to remember at least the major things. (Katie)

Some teachers felt that students enjoyed the tasks because they feel comfortable when writing if they are given permission to use the first person and personalise their product. The familiarity of todayís students with fantasy and the self-centredness of teenagers makes this a relevant practice. This particularly applies in case of anthropomorphic writing tasks, such as ëImagine you are a water molecule ...í

> Itís partly because kids deal with fantasy so much all the time now. And they know itís fantasy. All theyíre doing is trying to put themselves into another situation. The other reason that I think they quite like it, is because kids are self-centred and they like talking about ëIí and ëwhat Iím doingí. Itís a stage of their development, especially for the younger kids. ... Itís an easier thing for them to do. To talk about ëIí rather than talk about something thatís more abstract, or divorced from them. (Sandy)

Getting the students to do work, and engage with science ideas, is a real incentive to use imaginative writing for these teachers. Michael sees completion of the tasks and a willingness to do unasked for homework as an indicator of motivation.

> Another good sign of motivation is the percentage of kids who actually hand in their work. I think itís probably the only set work that you get a piece from every kid in class. Whereas, with others, you might get it by pushing them - get it from 80% of them - and others just will never come up with finished products. Usually youíll get four or five at least who, after two weeks, still say ëitís in my lockerí or ëitís at homeí. But with this they all had it in on time and thatís a good sign for me because if you can get something out of them, thatís great. It suggests to me that they work on it at home, too, even though I donít specifically set it as a homework task. But they obviously do some work on it at home, and they borrow books from me to go home and finish it, so it obviously motivated them. Maybe they donít think of it as homework, maybe they think that itís fun or something! (Michael, Billabong S.S.)

Blended genres can help free students from the restrictive modes of thinking that hegemonic pedagogy in science has imposed on learners in the past. Thinking that is lateral or creative can help students move beyond a narrow, decontextualised view of science as summed up by Sandy:

> You can get some divergent thinking going and explore an idea more thoroughly. (Sandy)

Katie sums up several factors that interconnect with studentsí confidence levels.

> I think it actively engages them in their learning. Theyíve got to take an active part, finding out things, synthesising, putting it in their language, using scientific terminology. I think that builds their confidence. (Katie)

Michael thinks that imaginative writing is a gender inclusive strategy, but he also noticed that the style of student writing varied.

> It is something that I always imagined girls would be better at than boys, and would be more prepared to do. But I think itís probably one that actually brings the two groups more together, because I find both groups are equally good at it, and thatís a good thing... I suppose there is a tendency for boys to write adventure-type pieces, but you get some really good stuff from the girls too. Itís amazing how creative they can be, it is just one side that

you usually donít see in science, maybe other areas do, but often we donít. (Michael)

Writing imaginatively in science shows a facet of students that the science teacher does not usually see: the creative side.

Student Acceptance:

Once the teachers had managed the transition into a new pedagogic contract through tactics as those above, there was general (not universal) acceptance by students that the new contract was a purposeful one for them, once they have adjusted their expectations to the new set of prevailing norms. Some of the reactions from students are classified below into some emergent themes:

a) Being required to think and use their imagination

> Yes, itís different. Because you usually just do what the teacher writes on the board. Like the cell thing, that was really ... we had to imagine, like, because a cell is not going to tell you, so, you had to imagine what the cell would do, and like the atom, how they feel when they go through everything, and, like, the space station you had to think of how it would feel to be in space. (Jo, grade 7 girl)

b) Helps the process of learning:

Many students were highly complementary of imaginative writing as a learning activity, once they had given it a go. For example, Wesleyís, Johnís and Francescaís comment are very illuminating:

> You get to learn more about it: things that you didnít know and after doing it you know a lot more on it. (Wesley, year 9 boy)

> With the writing it tells you more about what you think youíre doing, [pause] it explains more things. (John, year 7 boy)

> Sometimes you have a doubt so then you come up with a question and then you have to answer it and then you learn even more by doing it, without realising it. (Francesca, year 9 girl)

c) Improves the outcomes of learning:

> When youíre doing creative [writing], itís in your own words, and it kind of just sticks in your head, so you always <u>know</u>, like, about the atoms and cells and things. (Jo, year 7 girl)

> Writing stories just sort of fixes it more in your mind. (Natasha, year 9 girl)

d) Makes learning enjoyable:

> I think itís a good idea because a lot of people enjoy doing creative writing so itís easier for them to understand science - if youíre not too good at it. (Lisa, year 9 girl)

> I like doing creative things - I think thatís a good idea. It gives everyone the idea you can have fun in class while learning. (Natasha, year 9 girl)

> I think it helps you like science, because it makes it more interesting in the end and helps you understand it more. (Nadia, year 9 girl)

e) Writing anthropomorphically is helpful:

> Itís a good idea because it helps you get an inside look at what happens. It gives you more of an overall opinion. (Hayden, year 9 boy)

As part of a long conversation I had with Anika about whether molecules actually had feelings (she thought it was very funny that I would think that she might believe that), she said:

> I think itís better, because you have a focus on what your story is going to be like. And you can pretend that youíre the molecule, and youíre looking around at everything, and youíve got feelings, you can see, and you can do things. But if you read the molecule stuff out of the text book youíd think ëoh, gee, this is pretty boringí but when you put it in an easier form, it just makes it easier to learn. (Anika, year 7 girl)

f) Better than the conventional alternative:

> Itís better than writing out notes because that gets boring and this is creative - so itís good in that way. (Natasha, year 9 girl)

Conclusion:

This paper shows that teachersí recognized that interrupting the conventional pedagogic contract could be difficult but worthwhile. These teachers acted courageously, taking risks in altering the pedagogic contract, making the act of teaching and learning much more of a knowledge production rather than knowledge reproduction exercise.

One down-side that Katie mentioned was that after having a lot of innovative activities and co-operative learning work her classes did not want to listen to her any more. As she says:

> In fact, it gets to the stage where they just donít want to listen to chalk and talk any more. (Katie)

As ëchalk and talkí has long been associated with didactic pedagogy, it is not surprising to me that these students reject it once theyíve experienced aspects of a more enabling pedagogy.

Changes in pedagogy can only ever occur within the space of a reciprocal relationship with those whose interests are embraced: students. The voices of these students illustrate that the efforts of their teachers have been instrumental in re-framing the boundaries of the pedagogic contract within their classrooms: students will accept an adjustment in the pedagogic contract if they can see a pay-off for themselves in terms of their learning outcomes or their enjoyment of the learning experience. Innovative teaching can be seen by students as purposeful and worthwhile if there are strategies put in place by their teachers to overcome studentsí resistance to changed expectations. For these teachers the use of clear purposes, structured classroom processes that incorporated choices and explicit assessment criteria acted as particularly useful strategies.

Critical pedagogy draws our attention to "conscientization [that] is knowing we know ... It means that we have a voice and the courage to question

ourselves and the role we are playing in maintaining educational processes that we do not value" (Wink, 1997, p. 26). The teachers here have resisted pressures to conform to a view of science, and science teaching, that they do not value. They have had the courage to break the pre-existing pedagogic contract and to cease maintaining that writing-as-usual is an acceptable way to learn science. In breaking the pedagogic contract they have taken carefully thought through steps to overcome student resistance. These are powerful teachers: they have taken on the challenge to disrupt hegemonic pedagogy and are re-shaping the future discourse on quality pedagogy in science.

A significant axiom that emerged as a key pedagogical principles for these teachers is: *motivate students by allowing them to enjoy themselves and they will become actively engaged in the learning process.* Surely a key for all teachers.

I think that these teachers are on the right track. The writing forms used for learning science do not need to be directly congruent with the writing forms that scientists themselves use in publicly reporting their endeavours. The two projects: reporting science and learning science are quite distinct and ought to involve different language practices, including writing. To uncritically perpetuate writing practices that are implicitly underpinned by an ideology that links science with power and masculinity is to choose to teach in ways that generate privilege for *some* students.

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