Chapter 9

The Dialogical Classroom - 1997 -1999

Questions:

What does good scientific dialogue sound like?

What facilitates good dialogue and dialogical opportunities?

What impact does a dialogical classroom have on student learning and being?

Introduction

So far in relating my journey I have kept to some sort of chronological order. While particular threads might overlap in time there is still a sense of a movement forward in my own understanding and questioning. This chapter is concurrent in time with the last one (*The Significant Classroom*) but is now looking at a different thread - exploring the issues of creating a dialogical classroom. This draws on my previous play with constructivism, meaning and questioning and is contextualised by my concerns to make physics significant.

What might it mean to develop pedagogical tools for helping students to immerse themselves in scientific and inquiry based thinking? What mind shifts do I need to help me in this process? And what might I see and wish to question as a result of such mind shifts?

I ended the last chapter in confusion, wanting to break out of the bottle. It remains to be seen whether this chapter can help me in reconceptualising myself and the bottle in order to find freedom to become something more… or whether it just adds to the confusion.

Is dialogue happening in my classes?

1997. It is the beginning of the school year and I have a new physics class. I am reading a range of constructivist literature, some of which (Driver 1994) includes students' dialogue within small groups in their science classes as they try to make sense of a concept or an experiment. As I read the different case studies I wonder about my own students… are they teasing out ideas as well as the students in these papers when they are working in their groups? Am I giving them enough open ended opportunities to do this? What does good scientific dialogue sound like? What fosters it?

I decide to listen into group conversations with a new sensitivity. Previously, I have *participated* in conversations, listening not as a *researcher*, but as a *teacher* whose aim it is to encourage students to tease out ideas, to apply more rigor, or to ask *"what if?"*

The first thing I notice is that I am very good at stimulating group conversation… in fact as I go around the room interacting with groups there is a wave of thinking and activity following me. I am the catalyst, but it seems that I haven't empowered my students to initiate good dialogue for themselves. I realize that this is also true in my journalism class when students come to me saying "I have no idea what to write about next". I bounce ideas with them and they get all excited, but still come to me next time when they are stuck, rather than being empowered to generate ideas for themselves. Hmmmm. Yet, it eventually does rub off on my physics students… after a month or so of modelling inquiring dialogue students begin to get better at it. But is there a shortcut?

I decide to say to groups after we have had a good conversation to think back to what questions helped us in our thinking about the ideas. How could they use these questions deliberately when discussing their next issue? I have just initiated some meta-cognition about dialogue and as I listen into conversations now I hear students asking questions like *"How might we test that?", "What do you mean by that? Can you explain further?", "So, if that theory applied what would we see?", "How could we model that?"* .

At the same time, I decide to design an activity based around the concept challenge process (Duit and Confrey 1996) to reveal and challenge 'alternative' views that students might have about concepts of motion. I ask the students to individually work through a revision quiz which has multiple choice options, some of which relate to typical student 'misconceptions'. I ask them to select what they think is correct, to rate how sure they are and why they think it is true. They then get into groups, sharing their answers, their degree of certainty and their reasons and try to come up with a group agreement about what the answer might be.

As I go around the groups I listen in to their conversations. Most groups are teasing out the issues quite deeply. Students say to me how surprised they are about each other's views. What particularly interests them is to hear the 'uncertainty' factor. Some girls tell me that for the first time they feel comfortable talking about their tentative ideas - usually the boys seem so certain about physics ideas that as a result they (the girls) often will not express an alternative view or participate in the conversation, hanging back, unless they are really certain. However, in this exercise, even the boys are admitting when they are uncertain, rather than acting as if they do know. This freedom to be uncertain and tentative seems to open up new possibilities for discussion and the girls now seem better able to read other people's seeming confidence (bravado or bluff) in a new way – sceptically!

I ask one group what questions they found most helpful in their discussion. They all said the question that Mary had asked. She said "I felt really dumb asking the question, I felt I should have known the answer, but I realized that I didn't… *what really is momentum?"*
"But it wasn't a dumb question at all", said Nathan, "we realized that none of us knew it either, we just thought we should know it and were afraid to ask!"

Between 1992 and 1995, I was part of a state-wide group which looked at ways of encouraging more girls to participate in the physical sciences. The 'solutions' we looked at then were using more essays, more ethical and social issues, relating physics ideas to more personal rather than mechanical contexts, and helping girls be more comfortable with the technology. But what I was beginning to see here was that a major barrier to participation by the girls was the nature of science discourse and ways of knowing which seemed to come from a culture of 'knowing' and 'telling' – it was based on propositional claims to know and usually debated in a logical and rational fashion. One that had indeed disempowered me, when I first became a member of the physics teaching culture.

When I started including more 'girl friendly' pedagogies in those early years of teaching physics I found that not only did they benefit the girls, but that the boys too became very engaged, enjoying social and ethical issues. So now I wonder again, can I make the culture of scientific discourse more inclusive and what might that mean?

Now I think perhaps there is a **WHAT** of good dialogue and a **HOW** of good dialogue. We can learn effective questions to ask, or active listening skills, but perhaps we also need to bring a *state of being* to the process…. A state of tentativeness, a state of willingness to look deeply, to be open to surprise, to nurture those who are tentative. So critical scientific discourse needs to be balanced with care, mindfulness and openness.

And how could I model this? How could I be more deliberate in facilitating this? What sort of discourses am I experiencing and what makes them work?

Now begins a period where I am listening into many different conversations – eavesdropping as well as analysing at a meta-cognitive level conversations that I am having. I am listening to the patterns of conversation, the types of questions, the body language and tone, the energy of the conversations, the outcomes and how people are relating with each other.

Some conversations seem to be a sharing of information which seems to go no further, while others enable the participants to gain in understanding or perspective. Sometimes just talking to another enables one to order one's thoughts, and the feedback from the listeners enable greater clarity. Some conversations seem much more propositional and debate oriented, entrenching participants in their own views, while other conversations are more speculative and inclusive of non-conforming views. Some seem creative and generative and others seem to deepen the relationships between the participants.

Cycles of Discourse

I wonder if the patterns of conversation can be described using the Julia Atkin model for Whole Brain Learning? Perhaps **inquiry based conversation** has a cycle?

For example, one cycle (**Relating**) could involve finding ways to connect to the others in the conversation – find a shared language, experiences, perspectives. You might share personal anecdotes or look together at particular incidents and in doing so find common ways of exploring these. Then you could move onto a more **procedural** phase where you can extract patterns, meaning or essences from those experiences or anecdotes – these anecdotes then become a common language which help make the abstract concrete, constantly being referred to and deepened in understanding. You can then begin to **analyse** and theorise. Then you might go into **creative** mode where you imagine possibilities, take risks with your thinking. There would be a reflexivity between the different aspects as you move back and forth.

Julia Atkin's Whole Brain Learning Model

Logical Deconstructs Analyses Theorises "Why, how?" "How is that feasible?" "What is the evidence?"	**Creative** Takes risks Possibilities "What if?"
Procedural Detail Method Patterns "How do we do that? "How do we find out?" "What are we seeing?"	**Relating** Feelings, intuition Sharing "How do you feel?" "What is your experience?" "What do you mean?"

Fig 9.1

Good dialogue might feel different for the different stages. When you are being creative in a group there would be a sense of excitement, playfulness, energy and even synergy. When you are listening to each others' ideas or stories there might be a feeling of receptivity (or perhaps for some people they might experience impatience). When you move into a more analytical mode then you would expect to bring a critical lens to things and possibly would start hearing some debate. This could feel uncomfortable unless you learnt to separate yourself from your ideas which are being criticised.

For me, the conversations I value are ones that move me forward in understanding while deepening the relationships I have with the participants. These excite me because I feel myself and others are engaged in *insight making*. It is a very co-creative process and one which gives me a sense of experiencing the 'other'. Although we might be talking about something abstract in order to come to understand it better, the very process of doing so opens us up to each other. There is the sense of 'being with' the person in such a way that brings a deep respect and interest in them and their ways of thinking and being.

I remember conversations I had in an academic group where we carefully nurtured a person in helping them to articulate and birth their ideas before opening up the ideas to a general discussion where we might critique the ideas, theorise, leapfrog from them, compare to our own experiences and create together deeper understandings. I wonder whether I can help my students to recognise when students are vulnerably trying to make sense of something – to realize there is a time and place for critique or debate. Perhaps you need to signal that you are in the birthing stage… using language like *"I wonder….", "Help me express this…"* And then perhaps you need to signal your readiness for the others to play with your idea taking it into the next stages.

So the language and body language could be quite different for the different stages. For example, *"That reminds me of that…"* could signal to the conversation participants that this is moving into the anecdotal stage which has an important role in building up group stories. So rather than thinking *"hurry up and tell your story"* perhaps we need to listen to it for the richness of itself, honouring the other person, as well as how we might be relating it to our own experiences, and also what principles we are beginning to extract from it.

I wonder how I can help students to successfully experience these different stages through setting up specific activities which develop skills of a particular stage – e.g. **Community circles** to improve sharing of anecdotes and listening to others, **brainstorming** which emphasises non-judgement, group **concept mapping** where you are looking for patterns and connections, **critical thinking** which seeks plausibility.

How I can encourage students to create rich discourse cycles leading to greater insight and meaning? Do we need to have a structure like De Bono's six hats where we together put on a certain hat or visit one of Atkin's quadrants? This enables movement away from debate or defending point of views. It reduces ownership of ideas and everyone can participate in each stage – equally coming up with ideas as well as finding flaws in them.

6 Hats

Blue hat: what processes are we going to use?
White hat: what information do we have?
Red hat: how do you feel?
Yellow hat: positives
Black hat: negatives and obstacles
Green Hat: possibilities

Fig 9.2

Or can we operate as a complex diverse system interacting in such a way that enables emergent understanding?

How can I make the processes of scientific and inclusive discourse more explicit with my students? Is it just as easy as saying "I notice you are stuck in a debate – what happens if you move out of this mode and brainstorm some solutions to the dilemma you have?"

I am also quite interested in how girls and boys converse and whether there is a gender difference. Are boys naturally more propositional, monological and assertive about their ideas whereas girls are more reflective, self-doubting and dialogical? Do some students have greater flexibility in playing with ideas – a sense of distance - while others seem to entangle their sense of self with their ideas; some becoming very defensive while others feel stupid and dumb.

Here are some comments by some girls from their journals at the beginning of the year:

> Sometimes I feel really intimidated in class, especially by all the guys who have done electronics or something similar.
>
> Sometimes I am really annoyed by Scott interrupting people in the middle of what they are trying to say, and then he won't even have the courtesy to let them finish. That is one thing that really pisses me off about him. I know he is really smart and all, but that is just not on. OK.
>
> Freaky science people in this class make me feel dumb. They don't make me feel dumb, I make myself dumb.

I become interested in *Women's Ways of Knowing* (Belenky et al. 1986) and wonder what sort of *knowing* my female students are experiencing. How many are silenced by the monological propositional authority of science? How many have confidence in their own voice?

Do they, like me, wish to experience a more *connective knowing* of what they are learning – needing to understand how the ideas arose, what they mean and needing to create personal relationships with the authors of the ideas? (Remember how Tiffany wrote dialogue for Isaac Newton and gave him a song list in the last chapter.)

Are they coping with multiple inner voices and self doubt and trying to reconcile these? Are they identifying too much with their ideas and yet to find objectivity? Are they seeking to remove compartmentalization and find integrative explanations?

What do their journals tell me? How can I listen harder to 'between the lines'? What strategies can I give them that might help them move into *constructed knowing*?

Women's Ways of Knowing

1. **Silence:** total dependence on whims of external authority.
2. **Received Knowledge:** receive and reproduce knowledge.
3. **Subjective Knowledge:** truth and knowledge are conceived of as personal, private, and intuited.
4. **Procedural Knowledge:** rely on objective procedures for obtaining and communicating knowledge as well as connected knowing based on empathy.
5. **Constructed Knowledge:** view all knowledge as contextual. Seeking integration of heart and mind - communion.

Fig 9.3 (Belenky et al. 1986)

Creating a shared meaning – the language of physics

How can we begin to discuss ideas in physics without having a common language to do so? And how can we develop this common language? Is it a matter of having the opportunity to talk, or is it something more? How do we build up shared meaning? What sort of questions or activities promote this? What tools might help us?

What is the language of physics? In articulating explanations in physics, students need to draw on various physics tools – using terminology with precision as opposed to everyday usage, visual representation of situations, vector diagrams, mathematical equations, logical development, extrapolation, interpretation, data manipulation and representation.

Somehow from the beginning of the year to the end of the year my students become competent in use of the language. In a group there will be a shared piece of paper where students are drawing diagrams, writing formulas or sketching graphs as they are talking to clarify to the others what they are saying. They are checking that everyone is making the same meaning, building on each other's ideas.

But at the beginning of the year there is not this ease in using diagrams or visual prompts as they speak. Language is used far more sloppily and there seems to be little attention to how others might be making meaning from what they are saying.

I wonder what it is that I am doing that promotes this change in competence. Is it the expectation I create for the class that we should all understand? Is it the activities I do or the way I do them? I wonder now about the students who drop out of my class. Perhaps they haven't mastered the language?

There is one activity which I do at the beginning of the year where students as a group have to come up with an explanation of a physics action using physics terms like energy, momentum and forces. I notice that this activity is in fact problematic. Students begin to discover that they each use these terms differently, some inappropriately and some equate concepts like energy and force. I wonder whether this activity is problematic because students are having to draw upon learning from several individual topics which they did in Year 11 Physical Sciences - having to compare and relate, rather than being given a question that can be purely situated in one way of thinking. Perhaps we only begin to interrogate our assumed meanings when we are put into such problematic situations?

I wonder then at the power of conversation as a testing place for the meanings students are making… I become interested in Vygotsky's theories about the role of language and conversation in learning and I wonder how I can give more opportunities for students to learn in conversation from each other. For example, writing answers on a piece of paper for a teacher doesn't seem to give students the immediate feedback as to the rigor and understandability of what they are saying. How do I encourage conversation around solving problems?

I become aware of how I am modelling this with my students… how I use diagrams or physical demonstrations to get across my ideas and how I encourage students to come to the board and draw diagrams of their own or to grab props to demonstrate what they are saying.

I have butchers paper and textas ready when we go into groups so that students can use the paper as a place for shared workings and diagrams.

I use very well set out exemplars of how to solve problems so students see how important it is to explain their process and reasons to an audience as well as merely doing calculations to solve the problems. They begin to do problems this way which is further reinforced when they are peer assessed on their tests. As I go around the class listening to pairs marking each other's work I often hear someone say "What do you mean here?" After listening to the explanation the student might make suggestions about how their partner could better write down their answers so the examiner can understand them. Their working on tests improves very quickly as does their verbal explanations.

I also begin to realize the power of stories. How each experience we have together - such as jumping off desks to explore momentum - becomes something that can be referred to again and again and almost seems to become part of our mythology. So when we move into abstract thinking we have concrete experiences which we refer back to as we converse. It seems that the language of physics is a living thing which grows. While one might expect the language of physics to be objective, for each class its meaning actually rests on different experiences and shared learnings. We have our own 'in house' speak. But there is also a rigor which can be transferable to new situations and people.

Am I moving into a *social constructivist* classroom? What might happen when I introduce critical thinking into this mix?

A Meta-cognitive model for critical thinking

Concept Challenge Theory

- Is it clear?
- Is it plausible?
- Is it useful?

Fig 9.4

In 1997 I started to experiment with the concept challenge process (Duit and Confrey 1996) to help move students from their 'alternative view' of the world to the 'scientific view'. The key to this process is that the new theory needs to be shown to be more useful for them in their lives than the one they currently have. So to get to that point you need to ensure that students first understand the scientific view, find it plausible and then can see where it is more useful.

But then I remembered back to 1994 when my top student said to me he didn't really believe in Newton's 3rd law. I questioned him and tried to explain it better …. use real contexts …. put his body into an experience of it. "No, no, Sue," he said, "I understand it, but I am just not convinced about it. I have a philosophical problem with it. But don't worry, I will write the correct answers on the exam."

I think there is a difference between naïve understanding based on ignorance, or undiscerning felt experience, and then that discerning critical thinker who makes up her own mind and creates her own theoretical frameworks. Myself, I don't really believe in quarks (after having three years of solid Quantum Theory and particle physics at university under my belt). Surely I have a right to my skepticism? Einstein was critical of Quantum Theory to the very end.

The concept challenge theory doesn't seem to take this into account – the room to allow someone to determine their own beliefs. But my students, at 17 and 18 years old, are at the stage where they are moving out of the family influence into determining their own values and standards – the *self authoring* stage. Surely then we should be encouraging them to make up their own ideas about science? Or is that scientific anarchy?

I decide, however, to introduce a modified concept challenge process as our *everyday process* for discussing new physics concepts, putting forth our own ideas and exploring our understanding. I call it **critical thinking**. It is based on four stages of questions and I ask students to be explicit when they ask a question to designate what stage they are asking it from. We begin to use it in listening to each other's presentations, students use it to challenge me when I am explaining stuff and begin to use it in dialogue with each other.

Critical Thinking

1. **Is it intelligible?** What further explanations or experiences can help me understand it?
2. **Is it plausible?** How is it convincing, logical, relevant, authentic, trustworthy, connected, supported by evidence, practical, meaningful, intuitive, humane or fit a bigger picture? What might be the flaws or limitations?
3. **Is it useful?** How does it have greater explanatory or predictive power compared to other models? How does it have more elegance, simplicity, order or symmetry? How does it fit into other ways of explaining the world? How does it uplift, inspire or advance the world? In what ways can it be ethically applied? How is it significant?
4. **Is it believable?** What are my underlying beliefs and values about the world and how do these new ideas interact with these? How much of this idea am I willing to take on board and with what provisos? In what ways have I been convinced to accept this idea and am I happy that the type of validity claims are appropriate? Does this idea challenge my own fundamental beliefs and values and what new ones am I moving to?

Fig 9.5

What does it look like in a class? Here is an example:

1998. It is the 3rd lesson of the year in Physics and students have been doing a quick revision exercise of what they learnt last year where they examine 8 physical activities like walking or whizzing a bucket full of water around their heads. They need to come up with scientific explanations of what is happening and why; using ideas from forces, momentum or energy as appropriate. Each group is going to present one of the 8 activities, so all activities are covered.

The first group are about to present their findings – a group of 3 boys holding up a big sheet of butcher's paper with diagrams and white board markers at the ready. Before they start I say "As we listen to this presentation I want you all to ask – is it clear and do you understand it, is it plausible, is it useful and do you believe it?" *I write those up on the board and explain them further. I also say that the presenters can also participate in critiquing their own explanations.*

The boys now present their explanation of why water stays in the bucket as it is whizzed around your head – but in a confusing and complex way. I am sitting now at the side of the room and all the students in the audience look at me expectantly when the group are finished. What are they expecting me to say… "Any questions, no, well thank you and next group" or "Well, to summarise that…" or "Well, there were a few flaws with the presentation…. Here is the correct version." But I say none of these.

I can see that many of them didn't really follow the presentation and are just sitting politely as part of the ritual that we go through for this sort of thing. There is a lot in the looks that they are giving me, or so I believe. They don't really know me yet and what I do now will set the tone for the whole year. I smile inwardly and perhaps a little diabolically.

"OK", I say, "how many of you understood the explanation?" They look at me surprised. About half the class put up their hands.
"Ok, those of you who didn't, what sort of questions do you need to ask to make it clearer?" And so students start asking questions and gradually we get a clearer picture.

"Now," I say, "how many of you find it plausible?" Now about a third of the class put up their hands and I ask them to ask questions again or to say why they think it is implausible. By this time no-one is looking at me for approval or for closure. The focus is on the presenters and the board where they are expanding their theories. I can see the students

transformed from a passive audience waiting their turn, to people really engaged in teasing out this issue… after all everyone has done this activity so they have already thought about it.

"How many find it plausible now?" Well, this time there are even less people putting up their hands. I then ask how useful it is… does this explanation help us in predicting more complex situations?

By now the group members are arguing amongst themselves as well and we all pretty much agree that the explanations so far are not very useful - they are overly complex. We discuss why some explanations might do the job for one situation but unless they can be applied to others, or help predict they are not that useful. Other alternative explanations are proposed but no-one is really happy that their theory meets the requirements for usefulness or plausibility. "So at this stage how many people would take this explanation on board… would believe in it?" I ask.

"There is no point believing in something if you don't have the evidence for it, or it if it doesn't offer a useful way of explaining the world!" one person sums up. Excellent!

"Well what is the explanation they all ask?"
"Do you think there is a right answer?" I say. "Don't you mean; what is the best explanation at this stage which is the most useful? Hmmmm, can I leave this one open and not answer it now… can we see it as something that in the next month we will find a useful answer to as a result of our explorations?"

And the lesson finishes. We have spent 30 minutes just with one group. I am not sure I will have time now for all the other groups to give a presentation. Perhaps that doesn't matter because I feel that this has been a very significant exercise creating very positive habits of mind. I thank the group for being guinea pigs and congratulate them on being such good sports in the face of all the criticism. "It can't have been easy standing out there and being grilled like that. Thank you for providing such a good example to start with… it enabled us to have a really good conversation where we could tease it out. Excellent!" I say.

Next lesson I come in and the 3 boys are already sitting down, heads together, drawing diagrams and totally engaged in figuring something out. It is still this issue with circular motion but now one of them has come with another example. For the next three weeks in *their spare time they are working on more and more complex examples that they are trying to explain.*

In 1998 and 1999, I use the critical thinking model explicitly at the beginning of the year and then it just becomes part of how we talk with each other in examining our physics ideas. I use it as part of a discourse cycle and I progressively hear student conversation become a lot more rigorous, precise, complex, speculative, generative, imaginative, engaging, and supportive.

Not every student is the same; each bringing particular skills or different levels of maturity. However, I believe I see an increase in this critical discourse ability over the course of the teaching year. I am constructing in my own mind indicators for good discourse which I am modifying and adding to as I listen into student talk. I am theorizing what activities or explicit instruction helps students become more aware of their discourse and helps them improve. I am looking at how this type of discourse is affecting the way we do science and think about science.

In previous years I encouraged inquiry through asking the weird and big questions of life; now it seems that inquiry can be stimulated by the actual course content. It seems that everything becomes problematic and I don't need to create interesting and complex problems to initiate discussions. I feel I am in an inquiry based classroom even though we are not doing any long term open ended project inquiry based on student choice. We are still moving through a content bound course. But is this real scientific inquiry, or just conversation?

In my constructivist classroom we were interested in exploring contexts and running on-the-spot experiments to test emergent ideas and hypothesis. We are still doing this but going deeper. I now hear students question the appropriateness of applying theories to particular contexts and then begin to question whether the underpinning physics theories themselves are correct. It is an iterative process of investigation into the very building blocks of what we know or think we know. In finding out we are using many tools – role plays, experiments, research, conversation.

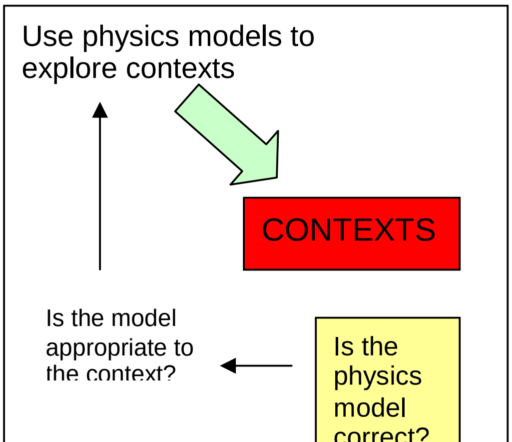

Fig 9.6

It seems we have moved from learning *about* physics to being engaged in a rigorous critical inquiry *into* the physics concepts. Am I moving towards Doll's (1993) notion of *curriculum as conversation*? Physics becomes the object of our conversation. We are moving from merely ensuring we have a shared meaning to now inquiring into the viability of that meaning.

I find that some students become completely engaged in the questions that come up; some go to great extent to pursue things further, choosing to investigate it as their major presentation, playing with possibilities or getting into chat groups. Students come early and stay late and continue on discussions into their next classes. Discourse into physics seems to be a vibrant living thing.

On one occasion I had a boy model the diffraction properties of light by writing a computer simulation. It was an extremely intelligent and creative piece of work, probably at the level of 3rd year university physics and completely unexpected. Luis told me "I just felt that the topic didn't go deep enough. It wasn't enough just to see the patterns that waves made around objects, I really needed to understand why that happened. What caused the curves? How do the wave fronts move? Why does light act like a wave front? I thought by computer modeling it that I would work it out. I had to define for each pixel where it would go next and how it was related to those on either side. I just kept modifying the formula I had come up with until the wave pattern looked like it was supposed to be. So now I wonder whether this computer formula has any relationship to what is actually happening. Because the relationship between pixels would be different to what is happening in matter."

To say I was astonished and in awe is an understatement, particularly since prior to that Luis hadn't really excelled in class assessments, not being good at writing and putting his thoughts on paper. I was pleased that my deeper coverage of previous topics had set up an expectation of him wanting to fully understand something, but I wondered now whether our assessment processes favor some intelligences rather than others. Luis was demonstrating understanding way beyond the questions on tests, yet he still had difficulty doing these.

I also found it very difficult to understand what he did in order to have an intelligent conversation with him. It really stretched me and caused me to think deeply about the physics. And this is now happening more and more often as a result of this critical discourse– it is no longer me sharing my understandings and knowledge with the students –

it is me and the students creating our understandings together. There is a democracy and recipricocity to it.

In end of year focus group interviews of the 1998 class, a student said: “In physics we learn *with* Sue – in other classes you learn *from* the teacher… learning *with* is far better.” Another said how much help it was to debate ideas and think critically about them. Another said “It takes time to understand a concept really well, but once you do it certainly saves time later.”

I asked some students whether this critical thinking and discourse was a skill they could transfer to their other classes and they told me that in two of their classes they didn’t have the opportunity to talk – either they had to sit quietly when working or the teacher was the talker. I realized then how important it is to give plenty of opportunity for discourse as well as building up the capacity for scientific discourse.

Parker Palmer (1998) in *Courage to Teach* discusses how we tend to think of teaching as either *teacher-centred* (where knowledge comes down from on high from the teacher) or *student-centred* (where the students find whatever truth they can and the teacher is a necessary evil). He suggests a third view – that of *subject centred* where the classroom is focused on the great thing (the subject) which keeps both the teacher and the student honest.

Has the critical thinking process helped me to shift into a *subject-centred* approach? Can I be *teacher-directed, student-centred* and *subject-centred* at once? What might it mean to be *soul centred*?

Now where does *trivial constructivism* (see Chapter 5) come into this? Surely I have moved beyond a trivial constructivist classroom? (That is a problem when one progresses in development stages – one is inclined to reject the previous stage as being wrong rather than transcend and include.) But we are using constructivist techniques as we develop shared understandings - we are using probing questions to determine what each other already knows, we build up ideas, sometimes using logical sequencing.

But something has changed. Rather than me being the director or conductor *owning* the constructivist process… taking my students on a journey *with my ends in view*, the students now seem to *own* the process for themselves. I hear them construct understandings for others as they frame questions, give explanations or give presentations. They add questions in their explanations to the class to encourage audience thinking and promote discussion.

Once we have built up the explanations so we all understand them we can now move to the next stages of exploring plausibility, usefulness and believability. In these stages it feels like we are *playing* with ideas … critiquing, imagining, looking for alternatives, exploring the edges, looking at consequences. So we first need to develop a body of knowledge that we can manipulate and trivial constructivism provides a vital role in helping us do this. It is a reflexive process – as we play we build up greater understanding which enables us to play in new ways, seeing new things.

We can play with the explanations because these students are able to manipulate abstractions as well as the concrete. Not only do we play with the explanations themselves but we start playing with the underlying rules and examining those (the philosophy of science). We are now moving into *critical constructivism* (Taylor 1998) where underlying paradigms and ways of knowing are being questioned. The students are now involved in several levels of scientific discourse and meta-discourse.

Perhaps because of this philosophical viewpoint of the tentative nature of knowledge it is a lot easier to separate self from ideas… ideas do not define who we are… we can play with them and be *playful* with them. Students do not now need to explicitly say how uncertain they might be about ideas to ensure a speculative conversation because we are together oriented within a particular mindset. Though there are some students each year who find it difficult to be playful with ideas. These students might be less mature, or are less able to work at abstract levels, or have poor social skills or self esteem issues.

What is the impact on the girls? It is hard to say whether discourse alone is the cause of improvement in their confidence as scientists because I am using such a broad range of holistic pedagogies in my classes. However, throughout the year, I see girls become a lot more confident in conversations with boys; more empowered to voice their viewpoints and a lot more resilient to the critique processes.

Some seem to think naturally but privately in dialogical ways – multiple voices in their heads, as evidenced by their journal entries. So now, rather than having to speak in one voice and be propositional, or be silent because they feel too confused, I hear conversations where they enable all these different voices to take part no matter how contradictory. They also seem to be more confident in naming what is happening in group discussions which might shut down or marginalize others… not just writing it in their journals but taking action to challenge behaviours of their peers.

As well as assisting students in becoming critical and articulate thinkers, the Critical Thinking model also seems to encourage students to think critically about their own **belief structures**. By just asking the 4th question of the Critical Thinking model - "*Do you accept this?*" - students are challenged to relate the new models they are exploring to what they know already. Sometimes the new information perturbs the old, causing them to question their underlying paradigms, sometimes it fits right in. Sometimes the students reject new information choosing to use it but not to believe in it. From Tiffany's journal:

> **"God does not play dice with the universe"**
>
> What a dumb quote. Albert Einstein, you are an idiot. How do you know? That's one thing I can't stand about good old Albert. He was so arrogant. He refused to believe in an expanding universe, that black holes would form etc when his theories pointed to it. And now in quantum he says lets make this photon thingy. It has no mass, no charge, but it does have momentum and energy.
>
> Correct me if I'm wrong, but I thought to have momentum you had to have mass. Even if it is 1/10 ^{100th} of an electron, that's still mass. If a photon doesn't have mass how can it move? P= mv, so mass must be present as in $E_k = ½ mv^2$ and E_p = mgh. Anyway forget that. I've just got to, at this stage at least, accept it. Later I will worry about it in more depth.

Yes, we are all aware of the exam. Even though we might be coming up with rich speculative versions of physics theories we have to also have an exam version. For most students this is not a problem; they now see the exam as a small subset of what we are actually learning in physics, but for the less able students it can be confusing because they are still grasping with the concepts and trying to apply them successfully.

I notice that some students experience more self-questioning than others and that it might correspond with much broader questions they are having about their own identity and values. Some seem to compartmentalize physics from their bigger lives and then something may happen which perturbs this compartmentalization and opens everything to question.

How am I supporting this process? Being there as someone who they can talk to, who is caring of them and their issues. By helping them build up a meta-language to understand the processes they are going through as they question their belief structures, for example by developing understandings of the nature of paradigms and paradigmic change (as I have discussed in the previous chapter.) Some students are very articulate and confident in discussing physics in this way, while for others it seems quite foreign as they seem to be more situated in Egan's (1986) *Romantic knowing* where they are interested in detail and concrete things, rather than philosophic ways of knowing (see Chapter 8). But even with these students I see a shift – one boy saying to me that initially he thought the philosophy stuff was a load of bollocks, but now he actually likes it and finds it is important to be able to think in that way.

My students are at varying development levels and respond in various ways – so one size doesn't fit all when it comes to the effectiveness of my activities, yet this critical thinking model does seem a useful one in helping students move across Egan's stages.

Jenny wrote on the back of a questionnaire I gave the 1998 class at the end of the year:

> "Your teaching has taught me not to accept things just because we are taught them, but because we believe, understand and agree with them. I have always questioned things that I don't find acceptable, but when a teacher encourages and promotes this questioning it truly is an inspiration."

Jenny is someone who seems to be going through the self-authoring stage; determining her own values, trying out different identity roles (being a Goth), rebelling. So perhaps for someone in this stage we need to provide a style of teaching which matches their needs; giving them the right to negotiate their own meanings and thus give them the freedom to develop.

Perhaps I am moving into the area of *critical constructivism* which is interested in the power structures within a classroom – how are students able to negotiate within a classroom? (Taylor 1998). But in my classes students are not so much negotiating what they do (because I am still very much directing the learning), but what they believe.

I have been thinking that I have been empowering my journalism students through enterprise learning, whereas I have been disappointed that I haven't been able to give my physics classes similar experiences in science. But now I begin to wonder if there are different types of empowerment. While my journalism students seem to be empowered ***to do***, perhaps my physics students seem to be empowered ***to think*** and empowered ***to believe?*** And perhaps this is even more important for this age group.

In 1998 one of my ex-students, Kimberly, told me of an incident in her first year university lecture on Psychology. As she listened to the lecture she started to question the underpinning paradigm – the concept of the human being which the lecturer was using. She felt that the lecturer was situated within a limited view that caused her to interpret along narrow lines.

She went up after the lecture and asked the lecturer about the research paradigm that the case studies were based on. The lecturer told her it was a stupid question and not to bother her with stuff like that. Kimberly then went away and did some research which critiqued the approach and presented it to the lecturer who got very upset saying “This is what we are studying and that is that.” Kimberly dropped out of the course.

Kimberly is demonstrating here sophisticated understanding – to listen to an argument and be able to unpack the underpinning paradigms… and to expect that this is what you do. She voted with her feet when being forced to go back into the conventional thinking box. What way of teaching at university level would have supported her?

This stage that Kimberly is at seems to correspond to aspects of Stage 5 of *Women's Ways of Knowing* – **constructed knowing** :

> Once the knower assumes the general relativity of knowledge, that their frame of reference matters and that they can construct and reconstruct frames of reference, they feel responsible for examining, questioning, and developing the systems that they will use for constructing knowledge.
>
> (Belenky et al. 1986)

And could this process be one leading to emancipation and self realization – a path to spiritual freedom? Hegel suggests:

> Freedom in itself carries with it the infinite necessity of attaining consciousness – for freedom, by definition, is self-knowledge – and hence of realizing itself: it is itself the end of its own operation, and the sole end of spirit.
>
> (From Childs 1996, pp 170)

So although our scientific discourse is based on abstract ideas, with the main purpose to gain understanding and insight, I am beginning to feel that what we are doing is part of a spiritual journey. That building self-reflective capacity is an important tool for that journey and part of the evolutionary process. My role as a teacher of science can be both building up scientific capacity as well as developing the human being.

So now let us just go back to the notion of student transformation and examine it from my 2006 perspective. Now during 1997 to 1999 my notions of transformation were limited to the development models of Egan and Steiner. Now, in 2006, I have a greater understanding of the integral development spectrum and transformative learning theory. I can see that I could have been a lot more pro-active in seeing and supporting student transformation, and helping students become aware of the nature of transformations. So while making explicit the idea of scientific paradigms and *nature of paradigmic change* was helpful in giving students a meta-language, I could have been a lot more explicit about the *nature of personal development*.

Indeed I should have been aware that in asking students to question their own beliefs with my Critical Thinking model I was setting up situations for self-transformation, not just creating a tool to improve their learning of science theories.

Mezirow (2000) describes transformative learning as follows:

> Transformative learning refers to the process by which we transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mindsets) to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action. Transformative learning involves participation in constructive discourse to use the experience of others to assess reasons justifying these assumptions, and making an action decision based on the resulting insights.
>
> (pp7,8)

Transformative Theory

Transformations often follow some variation of the following phases:

- A disorientating dilemma – also paradox, enigma, anomaly
- Self examination with feelings of fear, anger, guilt, or shame
- A critical assessment of assumptions
- Recognition that one's discontent and the process of transformation are shared
- Exploration of options for new roles, relationships and actions
- Planning a course of action
- Acquiring knowledge and skills for implementing one's plans
- Provisional trying of new roles
- Building confidence and self-confidence in new roles and relationships
- A re-integration into one's life on the basis of conditions dictated by one's new perspective

The transformative process may also involve:

- Encountering a "missing piece" that provides the integration necessary for a transformative experience
- A revisioning of self in the eyes and responses of similar others
- Making public, primarily for ourselves, the historical dimensions of our dilemma - and confronting it as a difficulty to be worked through.

Mezirow (2000)

Fig 9.7

Transformation can be incremental or discontinuous; it could be caused by meeting a paradox, or just the process of critical reflection of underpinning assumptions.

> ... we transform frames of reference -- our own and those of others -- by becoming critically reflective of their assumptions and aware of their context… Assumptions on which habits of mind and related points of view are predicated may be epistemological, logical, ethical, psychological, ideological, social, cultural, economic, political, ecological, scientific, or spiritual, or may pertain to other aspects of experience.
>
> (pp 19)

By encouraging students to critically examine their paradigms I was opening the doorway to transformation, perhaps without understanding all the ramifications. It was lucky for me and my students that I also had created a supportive learning community and deep relationships that could help us pick up the pieces. But understanding transformative theory would certainly have assisted all of us in the sometimes difficult processes we were going through.

Was I seeing transformation in my classes? In the case of Justin, who we saw staring into space in Chapter 2, his transformation related to both his understanding of science but also the way he thought about knowledge. Emily, who ran out of the room, was going through a painful examination of self and self purpose and direction. What I saw with most of my students was perhaps both flourishing and transformation – becoming more self-authoring, self-determined, self-discerning, and moving towards being pluralistic and relativistic.

Developing a meta-cognitive tool for the scientific inquiry process

Since I first started teaching physics I had thought long and hard about what science really is, and what scientific inquiry looks like, relating back to my own experiences and that of other scientists I knew. Prior to 1998 I thought I had a good handle on what scientific inquiry is - a spiral of inquiry going through different phases. But in 1998 I was perturbed afresh through my reading of the critiques of Guba and Lincoln (1994) about science and Wilber's (1998) diagnosis of the scientific method.

Wilber's take on the scientific method:

1. an injunction to do something
2. do it
3. compare it with others

Fig 9.8

Wilber's notion of the scientific method is a very condensed version of the scientific method which is taught in our schools (Observe, question, hypothesize, design experiment, test, analyse, conclude, compare). The science that Guba and Lincoln were describing was also quite limited – in terms of Wilber's quadrant model, they had firmly situated it in the **IT** quadrant. Yet my own experience of science as a working scientist was that I couldn't separate the **I** from the **IT**.

Science on the Quadrants

I Personal meaning Existential questions Connected knowing Insight and creativity Sense of wonder My beliefs and values	**IT** Measurement Information Inquiry process Critical Thinking Problem Solving Modelling
WE Discourse – shared meaning Natural caring Philosophy and history of science Science paradigms and metaphors	**ITS** Significance Connection to big picture Ethical, social, political consequences

Fig 9.9

The **IT** of my research would not happen if I was not bringing my reflective, intuitive and creative self to the party. Yes, science happened because of the **I**, but this aspect of it was not considered as ‘science’. Was it possible then to put the **I** back into science? And what about the **ITS** and the **WE**? These now were both important aspects of my *teaching* of physics. Could they be made an explicit and valued part of the *science story*?

And what is scientific inquiry anyway? I decided to really reflect on what I was doing as a scientist while working in the paper-industry.

What was the process of inquiry that I was engaged in? When I think about the different projects I worked on they each had a different style of approach. I was dealing with a complex multi-variable mechanical/chemical/human system. The application of a cycle of inquiry (Observe, question, hypothesize, design experiment, test, analyse, conclude, compare) was probably very good for particular experiments in the laboratory which we sometimes did when we wanted to check the relationship between two variables we had isolated, but was inadequate for dealing with complex data sets within an interactive environment.

I didn’t necessarily do things in a logical order… there was a lot of simultaneous experiencing of the machines, getting data, thinking and talking to others. There was time for incubation, hunches, and times when doing something on a completely different task suddenly generated understanding about another. For me there was a difference between the notion of *science as empirical method*, *science as a cycle of inquiry* and the messy being/doingness that was *science in action*.

In teaching the more rational and empirical notions of science to students, were we in fact giving the wrong impression of what happens *as someone does science*? Yet, in my teaching pedagogies I was valuing all these non-rational ways of knowing as a teaching tool, but not actually being explicit to my students about their usefulness as part of an inquiry process.

I wondered then if the scientific method could be explicitly taught as something broader. Both the Kolb *Learning Styles* and Julia Atkin’s *Whole Brain Learning* model (Fig 9.10), which I had been using in my classes to help students understand their learning styles, suggest a cycle of inquiry.

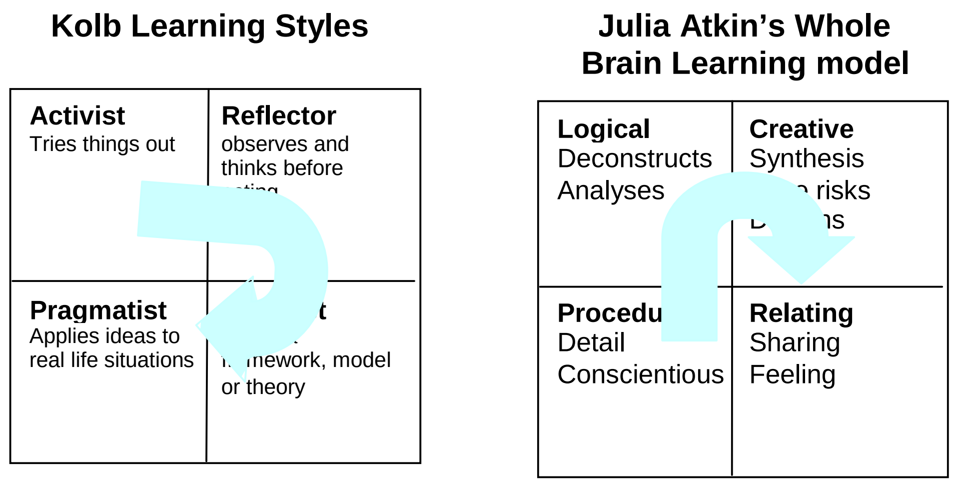

Fig 9.10

Based on these approaches, I had been designing open ended case studies using different learning style entry points or different entry points into the inquiry cycle. I had noticed that it didn't matter the order I had set, the students would skip a bit if it didn't engage them, and find an aspect which did. So a student, say, who was firmly operating in the logic quadrant, might actually turn over to the back of the handout and start with the concluding problems.

Initially I got quite cross at this… "Start at the beginning," I would say… "you can't do it without doing the investigation and developing the theory." But I soon realized that just because I had given a range of investigations with different starting points, didn't mean I had actually catered for the entry point individuality needs of students.

So here I was at the end of 1998. I had Wilber's 4 quadrant model on my mind as well as the Kolb and Julia Atkin models and I just doodled cycles around them trying to explicate how I did science. I just couldn't get my process to fit and in the end I thought "Why do I need to think of this as a set iterative cycle? Perhaps it is more like chaos theory where there is a whole lot of activity which as you map it you eventually see a strange attractor and that might be different for different students and different types of problems?"

Then I took elements from all of the quadrant models, modified them a bit (as one does), and came up with an 8 sectioned model where I allocated specific **aspects of scientific inquiry**.

I then asked myself what *plausibility* might look like for each of the sections, using notions of plausibility from various types of qualitative research (Denzin and Lincoln 1994) which I have marked in italics on the map (Fig 9.11). (These notions of plausibility I then used as part of my Critical Thinking model.)

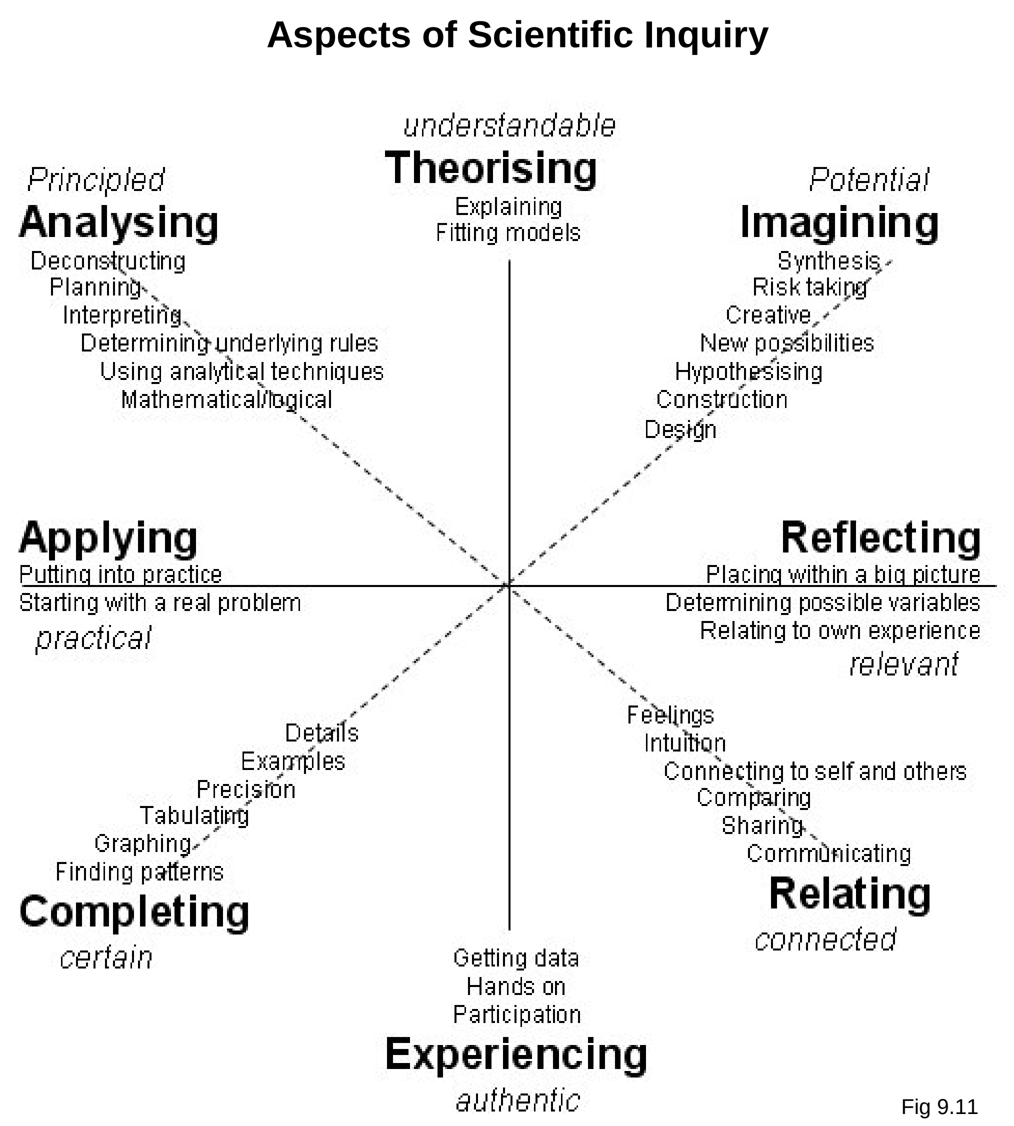

Fig 9.11

How do you use this inquiry map?

The key part is that you map on it your journey as you are inquiring about something. Circle the word that applies to that stage of the process and then move to the next process you used drawing a line in between with a directional arrow. Continue.

Now sit back and look at it. Is there a habitual pattern? Is this how you normally do this? Does this particular process of inquiry help you to learn and investigate better?

What sections of the map have you missed and should you be visiting them? What are the obstacles to doing them? What words might you add?

How do different people in your group operate differently and how can you use this to be a more effective team? How do you mediate your differences?

What can you learn about your own learning as a result of using this map?

In my 1999 Physics class, I introduced the students to the *Scientific Inquiry Model* by first playing the Julie Atkin *Whole Brain Learning* game after we had already completed a week of open ended investigations. The students seemed to make sense of the inquiry model straight away and got right into mapping different investigations they had done in big arrows around the map. They looked at each others' maps with interest, seeing how each had different routes around it and we discussed that it didn't matter the route, just that you covered the territory.

But could they actually apply this understanding to future investigations?

1999. Beginning of the year. I have just given the students some case studies to investigate. Here are two boys arguing in their group about what they think might be happening in the case study. This is supposed to inform their experimental design. One of the group members, Rachel, comes to me asking me to come over to their group "We just aren't getting anywhere. They just keep arguing. Please help."

We both go over and listen. I turn to Emma and ask "Can you summarise their key arguments?"
She thinks about it and then comes up with a very concise and insightful explanation of the differences that they have. "Oh," she says as she finishes explaining , "I can see it now, they are both right; they are just coming from different perspectives."
The boys are very surprised at her insight and now include her in their discussions. I go away feeling that now they would be able to move onto the next stage – the experiment.

Later I come back and I ask them how their experiment has gone.
"Oh we didn't need to do it," says Travis airily, "We've got a theory which now explains what is happening and we are quite happy that it is right."

I try not to grimace. "Hmmm. Okaaaaay, that's interesting." I ask them to look at the inquiry map and to look at their process so far. What have they been doing?

Rachel says "Oh, oh…. we have only done the theorizing and hypothesing stages."
"Do you think that that is enough? What does it mean to be scientifically rigorous? Is it OK to do just one aspect of this map, or do you need to cover all aspects?" I ask.
Travis argues that theorizing is enough but Rachel thinks that science is more than that – you need to get evidence for your theories. "I think we need to cover ***all*** *of the map," she says.*
Travis eventually very reluctantly agrees.
"What part of the map do you think you need to do next?", I ask. "Is it important that you do it in a certain order?"
"I think we now need to test our theory", says Daniel, "and then perhaps after we have analysed the results we could ask other groups what results they got so we can check our findings."
The others agree on this and they start talking about how they are going to test their theory.
"What do you think you have learnt from this?" I ask at the end of the lesson. And I am pleased to hear that they have taken the lesson to heart… they all assure me that in their next case study they will be using all aspects of inquiry.

So for a while I explicitly use the map when I move around groups, encouraging students to refer to it when they are stuck or when they are having difficulty in their groups. I use it to help debrief them after they have done an experiment. It seems that the more practice students have in using the chart, the more autonomous they become and the quality of their investigations improve. After a while we don't use the map – there is no real need to refer to it. I hear students asking different questions from the different aspects of the map without needing to be prompted. It seems that it was a stepping stone which helped make something explicit which then became integrated 'know how'.

In using the map with my students I wasn't really saying anything different to what I had been saying to them before as I had gone around and talked with different groups. What was different then about it? Before, I had owned the process – wearing De Bono's blue process hat – trying to facilitate my students to find the questions that help effective experimental inquiry. Now, they had something which gave them ownership of the process - a schema, based on a pattern, rather than a list of questions that you might forget. Perhaps now they could wear their own blue hats. However, it was still my map – I didn't really invite them to play with it, question it or value-add it. I did ask for feedback on how useful it was:

> Nina: “I needed to feel things first, hold it in my hand or actually do it, then it clicked, but at the same time I also wanted the theory, I needed to do both. In chemistry we were given a lot of demonstrations by the teacher… I never got to do it myself, like titrations. I realize now how important that has been for my learning because I totally failed in the titration competition.”
>
> April: “ I needed to do several things simultaneously… theory, experience, needed to imagine it. The map helped me see where I could go next rather than get stuck in my head like I often do.”
>
> Amanda: “Well, before I saw the map I thought I was very bad at science because I couldn’t do the logic part. It was really good for me to see it was only one small part and that in fact I was good at the others. It gave me the confidence to develop that aspect.”
>
> Sue: “What helped?”
>
> Amanda: “It was really important that you could come along and see what I was doing and be able to say whether I was leading somewhere useful or not and ask me questions to help me think about it. It put me on the right track and I began to trust my own judgment and realize how close in fact I was. I realize that I had given up too early before if I wasn’t getting the right answer. It was good to know that there could be several ways of going about things – it didn’t have to match your solutions.”
>
> Sue: “Are you doing this now in engineering?” (They are all first year engineering students)
>
> Amanda: “No, because the tutors only know the answer the lecturer has given. They can’t see if another way could lead to a good result. There was never enough time to do it my way in the tutes and work it out for myself…. We were onto the next problem. I had to give that up and learn the correct answer.”

Now in the same year (1999), one university physics lecturer who I was working with as part of a project to improve first year physics teaching at university also introduced this map to his first year applied physics students as part of an experimental project they were doing. However, he didn’t construct an understanding of it and as a result his students did not use the map as he intended. Perhaps heuristic tools are only useful if you understand them, feel that they are plausible and useful.

I look back on this model from my 2006 standpoint and see its flaws, yet it served a purpose in moving students from a naïve view of the scientific method to a more complex one which could still be strategic and rigorous. It was certainly an important transient model for me in helping me be much more explicit about teaching scientific method. What model might be appropriate for the next level of development? How might one include incubation or integral theory?

Dialogical Community – the soul of scientific discourse?

Fig 9.12

Between 1994 and 1998 there was a strong sense of community in my classes. Relationships weren't just between me and the students but also between each other. They valued the sense of community in the classroom… celebrating this with parties and designing class T-shirts with the big questions, jokes and quotes that the classes had enjoyed. We were a community at many different levels… a community of learners, of inquirers, of reflectors, scientists …. of souls.

When I see ex-students, this sense of community is something that they really remember, often reeling off the names of people in their class and wondering what they are doing now… or telling me what they are doing because they are still in contact. They tell me how important their T-shirt is to them. Some say that they have never again experienced that strong sense of collegiality, caring and community. And I wonder how I could have empowered them better to create such communities for themselves.

How important was discourse in fostering such a sense of community? Is discourse more effective when there is a strong sense of community and caring? Did the practice of discourse assist in developing a sense of community?

I first introduced this formal approach to discourse in 1997 to my physics class. There was a high degree of homogeneity within the class in terms of stable student family backgrounds and ways of being and operating. With little work on my part (some initial mixing of groups), this class knitted together into something very special… a very caring and close group who ably supported one of the students whose brother died during the year… and were very supportive of me during a very difficult year.

When students were in conversation with each other there seemed to be a *natural sense of care* underlying their critical thinking. So rigorous scientific discourse was taking place within a caring community... and the discourse itself helped build that sense of community – a reflexivity.

However, my 1998 class could be best described as an eclectic mix of individuals, with some quite opinionated speakers more interested in the ideas than in people. It was a real challenge to get a sense of natural care underpinning the scientific discourse. But, as a result of participating in discourse and meta-discourse processes, many students began to be more flexible not just in their thinking about ideas, but also their thinking about other people…. able to appreciate others and their unique views and perspectives… to value how the different perspectives added to a whole understanding. From just grudgingly putting up with others, it seemed that many students moved to a point of appreciating the 'otherness' of their peers. So while some students might be pedantic or know-it alls, or some moody, or others very shy there was accommodation for everyone…. there was a sense of inclusion.

Perhaps here we were seeing each other and allowing space for that person to be themselves. So while not all students had or developed good interpersonal skills, never-the-less they valued the sense of community and participated in it in their own style.

At the end of 1998 I had an interviewer interview eight students from this class in a focus group with a two hour video recording. She had been interviewing science students around the state and found my class an absolute surprise. She said to me afterwards that their language was so inclusive – using 'we rather than 'I'. They were very caring of each other. As they spoke they were naturally helping each other to make a point, building and clarifying, finishing the end of another's sentences. When I look at the video again that sense of community stands out, and I am also taken aback with their competence in manipulating physics concepts, their discussion of paradigms, self-reflectivity and articulateness. The interviewer wrote in her summary of the session (see Appendix 6):

> There was a strong collective identity to this group that seemed to centre around their learning of physics. They had enjoyed helping each other and taking responsibility for the achievement of the group. They really enjoyed sharing their information and expertise.

She asked the students *Did you feel part of a group?* "Amazingly so". "This is a tough course and we need each other's input." "There is a real team spirit." "We are so comfortable, we ask each other."

How effective were the group building exercises? They responded that they were quite surprised at the time by these activities because it wasn't physics, yet in retrospect they really valued it for breaking down barriers and getting them co-operating early on.

Students said how important it was to ensure that everyone understood… in helping others to understand, it helped them to understand.

They also saw themselves as *scientists,* not just as *learners*.

I wondered how I could make this sense of being part of a *scientific community* more explicit for the following year's class.

1999. A new year, a new class. It is the second lesson of physics. I say to the class "I would like to invite you to be part of a community of scientists."
"What is a community of scientists?" asks one student.
I have just spent the holidays really thinking about this; what scientists do, how they think and how they work together. I say something like this…

> "Basically there are teams of people collaborating on research projects, aiming to understand phenomena, coming up with new ideas or inventions, with purposes generally to help improve the world. They have dialogues with colleagues to tease out their understandings, sharing their information on internet and at conferences. They aim to build on what others have done and to explain their understandings in such a way that enables others to understand, inviting ongoing dialogue, new ideas and critique.
>
> "The value of what they are doing is judged by their peers – the ideas have worthiness if they promote discussions and research as well as being able to stand up to scientific critique. Scientists work as an organic system, each one contributing to the whole through networking which encourages the emergence of new perspectives and understandings.
>
> "Scientists are inquirers, questioners and critical thinkers. They are reflective and creative. They are driven by a passion for understanding the world and making it a better place. They have a sense of wonder and intrigue. They can also be activists, recommending action or change.
>
> "So what might it feel like to create such an environment in our classroom?
>
> "We will not be learning just facts, but investigating deeply the ideas of other scientists, critiquing them and coming up with our own ideas. We will be developing the skills of scientific discourse in order to help each other tease out the ideas. Each of us will take responsibility to ensure that everyone in the class understands and can participate in the discussion. We take responsibility for our own understanding – we will ask questions. We will be bringing our own big and little questions into our inquiry.
>
> "We will be able to do our own research into something that fascinates us and present it to the class. Our purpose is to help inform our class of latest ideas and stimulate class discussion. We will be working together on major issues, each finding out expert information and sharing this in symposiums. We will be involved

> in a class internet discussion list. We will be doing quite a bit of peer review and feedback as well as reflecting on the rigor of our own thinking…."

I now ask students to write down their big and little questions as well as a response to my invitation. What do students think about being invited to be a community of scientists?

> I think it is a good idea to act like real scientists and have big discussions. It allows me to see what other people in the class are thinking so that I can relate to them.
>
> Conversing seems like a good idea because everyone has such different perceptions of things and therefore by communicating we can give and receive ideas. It's also a much more interesting way of doing physics.
>
> It makes me feel more comfortable about discovering, about sharing my thoughts, means I don't cope with physics alone! Conversing helps my own thought processes and gets the cogs turning and changes incorrect views.
>
> I am thinking that these teaching methods are quite unorthodox, although I can see the implications of this type of approach. I've never thought of the class as a group of scientists, and the idea of the responsibility that comes along with that title. I think that this new title that you have given us is an attempt to raise spirits and have a new different perspective that should provoke new achievement.
>
> No other teacher has invited me to be part of something like this before. I am looking forward to finding out what it would be like.
>
> It's great that we are actually going to discuss what we are learning as we will learn it more thoroughly. I was surprised - it is not like any other class.
>
> The sharing of information, the questioning of life and our understanding of it, as members of a scientific community is a valid and worthwhile effort, from which will arise a great deal of hypothesizing and questioning to vitalise our stagnating minds.

Ironically, although this class did feel like a community of scientists, it didn't have the very close sense of community based on natural care that my previous classes had shared. I believe that was partly due to the fact that I found it very difficult to break up some of the cliques (I hadn't mixed up the groups as much as usual because students adamantly wanted to work with friends), there were a group of very immature boys in the class who had all come from an all boys high school (some of whom were quite egocentric) and there were 5 mature age students who came when they felt like it, making it hard for groups to have a sense of continuity and unity. (I was also quite ill during the year and wasn't able to make it to the end of the year, missing the last 7 weeks.)

Although the students had achieved a high level of scientific discourse and critical thinking … a scientific community … it didn't seem to be a community of the heart. That isn't to say that individuals within the class weren't caring… but that caring wasn't the glue that held the class together. Thinking and discourse was.

So what does a caring classroom feel like? I can tell you that when I stopped teaching because of illness the thing I most grieved for was the sense of community I had shared with my students.

A friend and I were musing over why we missed our classes so much and we said "We must need our kids to love us"… and then we decided that it wasn't so much needing the students to love *us*… it was about being in a place where love or care is present and flowing. And when there is a group of people as large as a class this is a very powerful feeling.

Being in a caring place I feel myself become permeable to others around me … there is an exchange of energy …an intimacy … love… this is a place where my heart is open, where I laugh and feel joyful. This is a place where I feel I am at home.

Here I am in relationship, connected. The relationship comes not just from my care and interest in the students – greeting them as they come into class and finding out how they are going, or helping them with issues, or finding out who they are (how they learn, their questions and passions) – it also comes from this **being with** them as we engage in this activity called physics. For them it is a place where they can be themselves and be vulnerable and they have put this self in my keeping. I hope I don't abuse their trust.

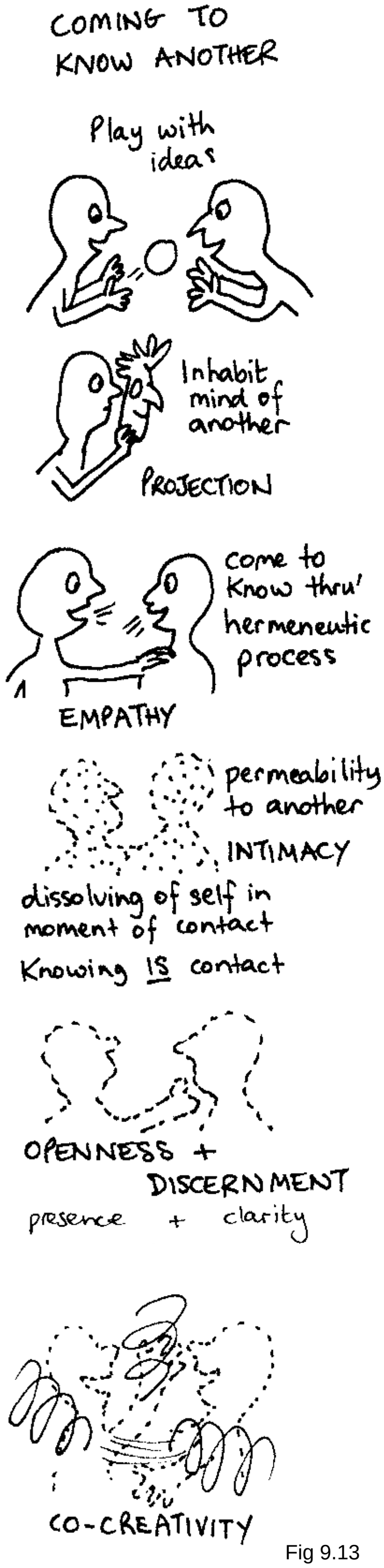

Fig 9.13

I believe that giving students the opportunity to move beyond critical discourse into co-creativity is where heart and mind integrate. The bridge is humor, trust and letting go the need to be right. When you trust others you can take risks and allow all parts of you to begin to participate. When you are just participating with your rational mind, there is a holding back from the 'other' and disconnection from the heart. Perhaps co-creativity is care in action. When heart is present soul is close behind … an expression of spirit in relationship… a calling forth of passion.

Steiner (according to Childs 1996) says that education should develop the abstract mind *after* students have developed the emotional and aesthetic self. Thus the will is based on both mind and heart and a person can act wisely, with ethical freedom and emancipation.

Is it the responsibility of science teaching to ensure development of heart and mind hand in hand, or is science just responsible for development of the mind… let someone else develop heart elsewhere?

> "The purpose of education is to develop *clear mind* and *warm heart*."
>
> Dalai Lama

And somewhere in all this community and discourse we need to allow space for individual reflection, connection to the inner self, connection to the present moment and connection to the Kosmos.

Conversation gives us the opportunity to test and build our understanding, but we also need opportunities to infuse this understanding with spirit or we are just batting the same ball around, albeit it might be getting bigger.

Indicators for effective discourse

So what might be indicators for effective scientific discourse that I now look for:

- Ability and commitment to create shared meaning – construct understandings, shared language, using humor and small talk, creating shared spaces, moving into perspectives of others, engaged in hermeneutic process
- Rigor in scientific process and thinking – moving around the inquiry cycle into different voices and modes of inquiry, applying critical thinking, iterativeness
- Tuning into the different stages of idea development and facilitating mindfully in that process, using openness to new ideas and criticality appropriately

- Being inclusive and caring of others – listening, empathy, giving time, recognizing and meeting the different needs of others
- Being self-reflective of the discourse process - meta-cognition, recognizes the limitations, can use 'blue hat' in discussions with others to name and challenge what is happening and move to alternative discourse methods.
- The product of the discourse – new ideas, new or deeper understandings, deeper relationships

Some of my students are more capable than others, some forget in the heat of the moment, but we are all learning. At least now we have some guidelines. I see a clear improvement in **the how** we discuss and as well as **the what** of discussion (quality of ideas) from the beginning of the year to the end. I notice the shy students becoming more confident as they participate with ease in discussions, and students becoming more able to challenge the mode of the discussion as well as the ideas.

Where is my notion of learning now?

1999. I seem now to be moving towards *social constructivist* notions of learning. Learning lies not just in students' experience or meaning they make for themselves, it is culturally situated in language and mediated by the feedback and interactions with others. I see my dialogical classroom also as an *ecological classroom*, using principles from Capra (1993) – interdependency, partnership, diversity, energy flow, co-evolution, ecological cycles, sustainability.

But how does this fit with my other notions of learning – learning seems to come direct from physical experience – it is embodied, or that learning is made in the head, or that learning might come from the soul?

Perhaps I can summarize my understanding of learning so far by mapping it on the quadrants.

Learning using The Eight Indigenous Perspectives

Individual

Inner (subjective) | Outer (objective)

I	IT
Inner: learning as personal meaning making, insight, inquiry **Outer:** Critique of one's meaning-making processes, understanding of one's own stage of awareness	**Inner:** learning as sensual, taken in from environment, feedback, know-how (action *is* understanding) **Outer:** making explicit that which is embodied.
WE	**ITS**
Inner: learning through discourse mediated by language, inhabiting space of other **Outer**: critical examination of how cultural conventions shape our understanding and interpretations	**Inner:** learning as part of a bigger self organizing system, community interactivity, natural adjustment to the environment **Outer:** critical evaluation of how one's environment, relationships and systems influence behaviours

Collective

Fig 9.14

Perhaps this helps demarcate as well as integrate the different learning theories. Perhaps *social constructivism* is more aligned with **WE** (inner), *critical constructivism* with outer aspects, *embodied learning* with **IT** (inner), *meaning making* with **I** and *ecological learning* with **ITS**.

Interlude 1: What do scientists think of the 'Aspects of Scientific Inquiry' map?

1999. I am working part-time at the university Physics Department, coordinating an action research project with five physics lecturers with the aim of improving first year physics teaching.

We have been spending some time unpacking what it means to be a scientist, to think scientifically and engage in scientific inquiry. I have been using the *Aspects of Scientific Inquiry* map as a heuristic device to help the lecturers tease out what it is they do as they engage in their own inquiry processes. They have mapped different inquiries they have done and compared the different routes that they each take and what territory they tend to cover. They have become intrigued in those aspects that they value in their own processes but which they haven't previously thought about as being part of the scientific method.

Aspects of Inquiry Scientific Inquiry | **A theoretical physicist's inquiry route**

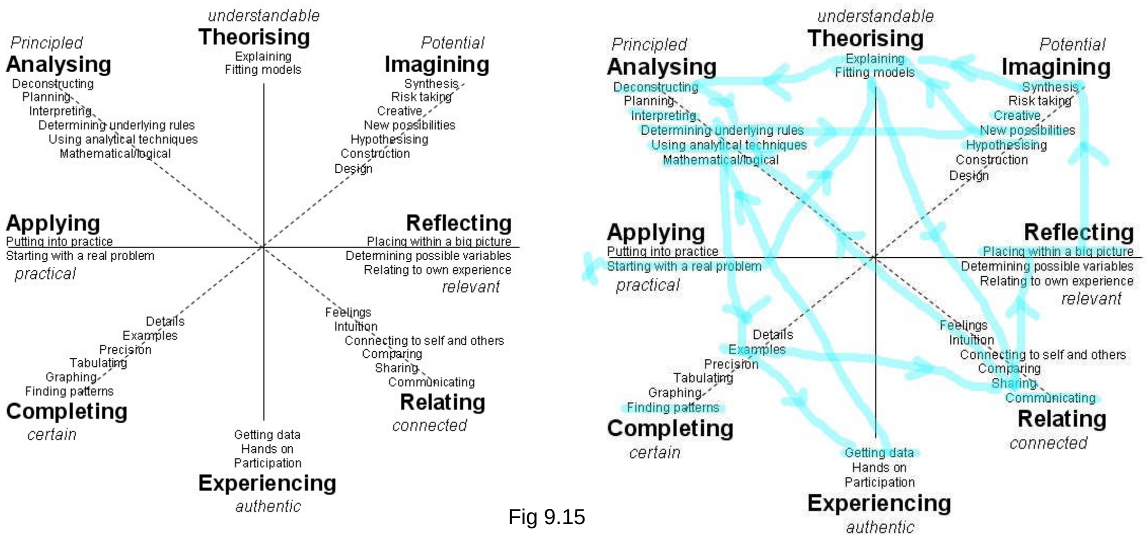

Fig 9.15

This has become a starting point for thinking about how to redesign lectures to enable more room for students to engage in inquiry as well as how laboratory experiments might be redesigned. Two lecturers, in particular, find the model very useful and organize a workshop where I can introduce it to their colleagues in the other science departments at the university. They hope this will stimulate their peers to reflect on what they value in science and how they might better articulate their values into their teaching.

So in June 1999 I am leading a seminar attended by 17 science lecturers (from biological, agricultural and physical sciences as well as mathematics). They are sitting a little uncomfortably in a semi-circle in a tutorial room. As they come in I have to work hard to stop them sitting at the back, inviting them into this circle.

I start off by asking the group to *Write down three words to describe how you see science.* As the scientists share their words with the group I write the words up on the board putting them mentally on the inquiry model.

There are the usual words you might expect for science – experimenting, observing, categorizing, precision, hypothesizing, theories, analysis, modeling, logic - and also some you might not expect – inventing, imagining. Then one biologist says with great passion: "I wonder, I WONDER, **I WONDER**!!!" We look at him amazed and there are smiles around the room and suddenly people are beginning to talk freely. It is as if he has reached down into our souls and reminded us about the passion of science. I feel like we have entered another space now where we can perhaps talk a little differently about science.

I now draw the inquiry model over the scientists' words and explain the basis of the model while fielding questions. It is clear when I do this that the scientists have left out a major section when coming up with words to describe science. And this is when the discussion really begins about what science is.

Now, earlier this year, I had done this exercise for a group of 20 Dip. Ed. students who were all science graduates. It was part of a workshop I was giving on constructivist and holistic teaching practices in science. Below I show the how the different groups saw science:

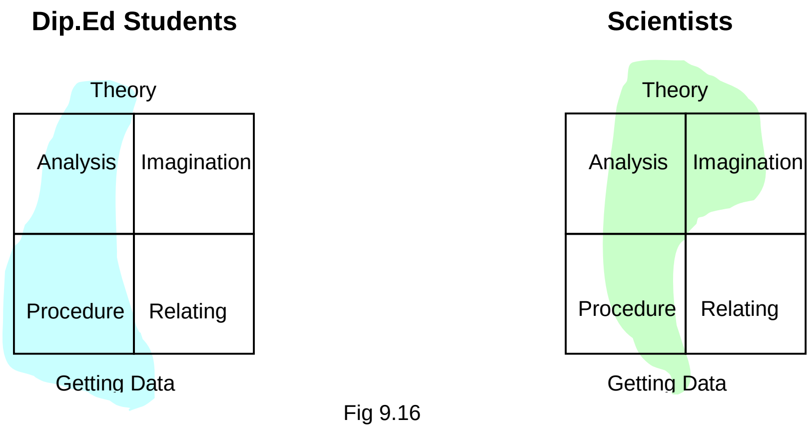

Fig 9.16

You will notice the difference between the groups. The scientists did not in this exercise give any words that could be put in the **relating/sharing** category. When they saw what they had said compared to the inquiry model they started discussing why they had missed this section, most saying how important dialogue was in their work as a scientist - from corridor conversations, research group meetings, to email with overseas research groups in their area, to conferences, to peer review. One biologist said that she uses group sharing sessions as an essential part of her mentoring role with her post-graduate students, but not with undergraduates and now she wonders why she only starts after they graduate.

When I showed the science lecturers the results of their past science students (the Dip. Ed students) most were quite shocked that the students should have such a narrow view of science. Where could such views come from? So they started discussing how their teaching methods might have inadvertently given that impression. Could it help to make explicit what we value in science and then ensure it is represented in our courses? This is the process that the physics lecturers believed was very useful as part of our collaborative action research project in physics.

I then asked the scientists to think of something they were researching and to map their inquiry route on the inquiry map. In most cases the scientists were visiting most of the aspects on the chart iteratively – their maps were covered with long curves going back and forth. We had quite a discussion comparing each other's maps which lead us to wondering if the discipline you were in had more emphasis on particular aspects than others, causing you to spend more time in different inquiry modes.

So sometimes a biologist might spend more time at observing, collecting data and then categorizing, whereas a physicist might spend more time using principles to solve problems or make predictions which they could test. Since scientists were working in research teams they might focus on particular areas while their colleagues on others. An example might be the human genome project where there are scientists working on measuring the characteristics of genes, others creating maps of the data and others creating the underlying structures for the maps.

The *body of knowledge* in a discipline is also perceived differently – to a physicist the body of knowledge might be a set of universal laws and the mathematical methods you apply to developing and using them. To a botanist it might be a body of information about nature.

So a first year physics student might sit in a lecture and learn a physics law, examples of how it is used and be expected to solve problems using it, while a botany student will sit in a dark lecture theatre watching a slide show of various types of plants and their characteristics and be expected to be able to use the language appropriately in seeing differences and similarities.

Now despite these differences, one thing in particular that the scientists seemed to agree about was the importance of **imagination and creativity** which they saw as being essential in helping make the insights necessary to create new science. Perhaps these scientists saw a key aspect of their role as scientists as *creators* of new ways of being able to understand the world? Many of the scientists said that the driving motivator for their research was a sense of wonder, curiosity and awe about the world. Should this be on the map or is it what drives our movement around it?

It was a concern to the scientist group that the Dip Ed students had missed imagination and creativity from their map. I told them about the students' responses - how one person disagreed quite angrily with my model - "*Science does not cover those aspects… it is the scientific method and that is logical and needs evidence. Imagination is not science!*" But other Dip Ed students were interested in what imagination might look like in a science classroom. Was it about fantasy or was there a scientific way of imagining?

So now the scientists begin to discuss how they could build their students' capacity for scientific imagination and creativity in the undergraduate courses. How could they make it explicit in their teaching? What is the difference between imagination in science and other disciplines?

Now it is time to conclude the workshop. I ask the lecturers to each share what they have got out of our discussion, what they might take and use, and what questions they still have, going around our semi-circle.

Responses are varied: for some it has challenged them to think differently and question what they were doing, others feel they still have lots of questions, some are still undecided about what they could do in their own practice, some feel it is a bit too hard, and one says he is unconvinced.

Then what happens next is interesting. One lecturer says that this is the first time in such a peer group that she had felt that everyone's opinions were valued, whether they fit into the majority view or not – just sitting in a semi-circle, rather in rows, made an enormous difference and changed the nature of the conversation. "It is much more personal. I feel I actually got to know people. I like the fact that we were given the opportunity to say what we think about it. That we don't have to agree." She continues to say that it is interesting to leave a meeting knowing that everyone was taking something different from it, or still had concerns – usually the majority made a decision - then the others either left feeling unheard, or pretended to consent while going off and sticking to their own agenda. "This is a lot more honest."

Her comments then spur a conversation about the processes I used in the workshop to support an open dialogue about teaching practice – the lecturers discuss what they each value about the actual process and how they might like to use aspects of it in other meetings.

Sometimes the simplest things – like sitting so that we face each other, including everyone in the group, giving people turns - make a big difference to the sort of conversation that results. But was there more to it than that?

From a spiral dynamic point of view (Beck and Cowan 1996), was I creating dialogue within a *green meme* postmodern culture (aiming for deep understanding of issues and each other, care, acknowledging all perspectives, allowing for plurality of outcomes, looking for shared meaning and consensus, challenging marginalizing structures), while the usual agenda based meetings were situated within an *orange meme culture* (majority view, goal and outcomes orientated, debate or devil's advocacy, structured for efficiency)?

Interlude 2: Creativity and Imagination in Science

How important is it that we explicitly teach imagination and creativity in science? How can we help students become scientific innovators?

What activities might stimulate creativity and innovation? Are there different types or levels of creativity?

Carlisle Bergquist (2005) has synthesized the research into creativity by saying that we can consider it as four stages (left hand column in table below). In the right hand column I have suggested possible pedagogies or tools which might assist in developing creativity.

Stages of Creativity	**Pedagogies and Tools for stimulating creativity**
Necessity – a natural learning process of the child – they are not aware they are doing it and it occurs as a natural part of the **make-meaning** process…. Creating new understandings – often as a response to dealing with difference or anomalies.	o Looking for patterns and connections o Dealing with difference, paradox and anomalies, disconfirming evidence o Using a range of experiences from different dimensions of being (imagination, visual, kinesthetic, rational, role play) with connections as well as dissonances (Bateson's interactivity of learning technique)
Analytical – self aware and conscious of the process of creativity. Students are actively and consciously creating products, understandings. Creativity can be developed by processes, ways of thinking and seeing, and metacognitive tools.	o Challenges to solve, designs o Using heuristic devices like De Bono's Scamper, 6 Hats, PMI o Setting up role plays o Using humour, imagination and speculation o Visualizations (thought experiments, putting self into situation) o Co-creative discourse
Synthesizing-innovation – individual opens up to the process and allows.	o Living the problem o Incubation time o Meditation o Complexity o Passionate attunement
Connection with larger reality – transformed consciousness	o Meditation o Personal growth

Fig 9.17

Interlude 3: Why is it so difficult to create critical thinking and discourse in first year university physics classes?

1999. I am standing at the back of a first year science lab of Applied Physics. There are about 32 students, one lecturer running the lab, one assistant and two others from our project observing along with me. The students are doing an electricity lab – series and parallel circuits and the lecturer has just explained the first experiment. I watch and listen as the students struggle to make sense of their diagrams, instructions and lab equipment asking each other procedural level questions "Where does that go?", "How do we connect that?", "What does this do?". There are hands up around the room and I listen in as the observers from around the wall get drawn in, giving a helping hand.

I listen to what the observer/lecturers say and do as they help the students. One observer, when asked about how the circuit goes together, just puts it together for the group. Another explains what he is doing as he does it. "You put this here, connect this, and then you can turn it on." The students are quiet watching.

Why are we here observing? We are supposed to be looking at ways of modifying the course to help students develop critical thinking and to engage in scientific discourse. I am here to listen into student-student and student-lecturer conversation and feed this back to the lecturers so we can diagnose what is happening. I have heard lecturers engaged in iterative and rigorous conversations about their own science amongst their peers, so they themselves are competent in critical thinking and scientific discourse. They have the intention of engaging in more dialogue with the students, yet it is not happening. Why not?

The scientific discourse in the room currently seems very low level and doesn't come close to my indicators for effective scientific and inclusive dialogue. I wonder why it is so different to my own students who in a similar situation would be discussing issues with the procedures, or circuit principles or the nature of electricity. Why isn't this occurring here? Is it the lecturers, the students, the environment, the expectations, the lack of questions to probe understanding? I have heard these students discussing before – they can do it – but it was as result of a carefully planned open ended question. Do they need something problematic and intriguing to catch their interest?

We move onto the next experiment which involves a parallel circuit and there are more hands up than before seeking assistance. Why can't the students work out how to construct the circuit for themselves?

All the lecturers/observers are busy and one group of students see me against the wall. They call me over and ask for some help. I am not supposed to be doing this but I can see the other lecturers are run off their feet with questions.

"I just don't get it," says a student with frustration.
"So how are you thinking about this? What are you seeing when you look at the circuit diagram?" I ask, without thinking and as result start a conversation. I discover that one student doesn't really get the idea of the circuit diagram. So here am I constructing her understanding… asking her to think how the diagram corresponds to the physical components… asking her how she imagines an electron might move around the circuit. And I soon discover that she has the notion that an electron will move around a circuit even when the switch is off. She explains how when the switch is opened, the electron continues to move around to where the switch is, then finds it can't get across and then the current stops. I ask her where she got this idea from and she explains to me about a role play she did in Year 10 of being an electron.

I unpack this further and in doing so discover I have an audience of five other students who all start asking me questions about electricity, how electrons move, what happens when they reach the parallel part of the circuit, why an electron might choose one path over another. Each tells me about their own prior learning experiences in electricity and we end up having a very interesting discussion coming up with the problematic nature of trying to model what is going on in a circuit by thinking of it as moving electrons. They are intrigued about the deeper issues of electricity and wish to understand the hidden meaning of circuit diagrams.

I look up and realize that the lecturer running the session is waiting to go onto the next experiment and we are too noisy. Oops.

I step back against the wall again and ponder what just happened. Was it the question I asked the girl *"How are you thinking about this?"* which was the key? Why didn't the other lecturers in the room question the students more deeply about their understanding? Didn't they see that the difficulty with setting up the equipment was a possible indicator of issues with understanding the concepts?

After the lab I talk to one of the observers (a post grad student) who had gone in and 'properly' set up students' circuits. I told him my experiences with the students I had talked to… how some found it quite difficult working out how to translate from the diagram to a real circuit and how they were interested in how the circuit operated in terms of what happened to the electrons. He looked at me quite surprised. He said it never occurred to him to question why the students were having difficulty putting the circuits together, that if you show them enough times they get the hang of it. That that was the way he learnt how to do circuits.

We then ended up discussing how we made sense of different types of circuit diagrams. I confessed to him that as soon as a circuit has a capacitor, inductor or diode in it that I just can't imagine how it might work. He says "Why should you? I would never try to work out what is happening… you just learn what certain types of circuits do."

I wonder then why do I need to have a conceptual understanding of what is going on? Do I expect more than what is feasible? Is it because I am a female and need to have a more connected understanding? But this seems to be what the students are wanting as well, even the boys I spoke to.

I then go and talk to the lecturer in charge, letting him know that a number of his students have major 'misconceptions' about electricity. We begin to discuss these and then get into a nitty gritty discussion of how electricity really works. The conversation lasts for over an hour and involves lots of diagrams, examples and thought experiments. I am thinking that perhaps this conversation will be very helpful for the lecturer in orienting him towards the problematic nature of electricity so that he can then teach it in a more inquiring way.

But he throws his hands up in the air and admits defeat "I have never questioned electricity before, just used the equations to work it out. It made perfect sense to me that way. Now I really don't know what to think. Sue, you have confused me and I don't like it. I would need to talk to someone who really understood electricity before I would feel even comfortable talking about these things with the students."

I now wonder what habits of mind the physics lecturers in our action research project have about 'physics knowledge'. All of them have told me about the tentative nature of their own research, saying that current science is contingent and based on continual revision and iteration. Yet in contrast, some are quite adamant that the foundational knowledge of physics is pretty certain. I wonder then whether they have an attitude about this 'old' knowledge (which makes up the undergraduate courses) which makes it difficult to bring a sense of inquiry into it. How much have they leapfrogged from this knowledge into their own research, how much of their use of it has been habit, how much is unquestioned repetition of how they were taught it? How much of this certainty is due to the fact that they think of it in terms of internally consistent mathematical equations rather than concepts? How do they think of physics and how distant is this from how their students think?

What might it mean to conceive such knowledge in new ways and bring a speculative eye to it?

I also wonder how much these attitudes about physics knowledge then sets up an environment where lecturers value their 'authority to know' as the currency of student respect for them. So being speculative or uncertain about concepts might challenge this perceived respect. Setting up more inquiry based discourse might therefore mean trying on new roles which can be a vulnerable process.

I find myself trying to diagnose the lecturers as if they have an illness. What might be the specific barriers to helping each of them see into students' minds and engage in successful discourse with them? How can they reconceptualise the physics they are wanting to teach?

Yes, I begin to realize, that seeking to improve the quality and opportunity for scientific discourse in university science is problematic; not a simple matter of creating an intention, nor developing pedagogical strategies. It is also dependent on each lecturer's habits of mind each of which seem to be creating different barriers. And these are much more difficult to shift despite a keenness by the participants to embrace inquiry based teaching.

I wonder what habits of mind I am developing in this process which also gives me blind spots. What assumptions am I making about students' learning and lecturer abilities as a result of buying into my models too much? Am I bringing enough of a speculative eye to what I think I am perceiving? How important is scientific discourse really? What paradigms and values underpin my own assumptions about what science should be like?

Am I valuing too much the *green* meme over other memes? What might integral scientific discourse be like?

Interlude 4 : Sue talks to Travis about group work and Travis writes in his journal

1999. It is the beginning of the year. Travis is one of seven boys I have this year from a boys' only high school, most of whom seem oblivious to the needs of others in the class. In class discussions Travis will dominate over others who might have their hands up, jumping in, following on his own track despite my efforts to share the conversation around and open it up. He tends to jump on people who are tentative. One girl has already talked to me about how it is impossible to have a good conversation in their small group; Travis is intimidating, gets locked into his own opinions and won't consider those of other people and certainly doesn't help others to articulate their ideas.

I decide to run a session for the class where we look at the different stages of dialogue and practice them. I assign the seven boys as leaders of their groups asking them to be facilitators of discussion… how to help others articulate their ideas… to ensure that criticism isn't brought in too early… to aim for opening up possibilities and understanding.

Travis thinks it is a waste of time and doesn't really participate in the way I have designed. I decide to talk to him after the class. How can I help him see that other people have a lot to offer and that when we help others explain and understand it also helps our own learning…. thus when we aim to ensure the understanding of the whole group we end up with a better outcome for everyone. Will this sell it to him, I wonder?

Travis's journal entry

Well I had a talk with you on Friday, Sue, and quite frankly you are wrong. If you think someone, anyone enters a classroom to sacrifice his/her learning in order to help others, then you are off with the fairies again. No-one enters a classroom aiming to get 5 points and 20 for his mates.

You tell me that I talk too much, so what? That's the way I learn. You say I ask too many questions, since when was a question a bad question? Sue, you need to realize any question is a good question. You say I am interrogating the shy students, that's not my problem, that's their problem, I can't help it they aren't strong people, they need to come out of their shells and not through the sacrifice of some other student's learning.

You've given me plenty of 'suggestions', well here are a few for you, Sue: get out of this tree hugging hippy bullshit and teach physics, it's quite clear your method is not working. If you think it is working by majority rules, well that's not the way a classroom should be run. EVERYONE should be happy, not 30%, 40% or 99%, EVERYONE. Everyone in that classroom would have done Maths Stage 2, or is co-studying it. We've all got good heads on our shoulders. Can you teach it as a maths lesson, or maths based lesson? It's got to be better than this!!! IT IS UP TO YOU TO MAKE US HAPPY.

I don't particularly like being a guinea pig for your 'mind boggling' bullshit and I could name at least 3 others who hate your teaching methods also Sue. I'm not saying this to hack into you, I'm saying this because I am worried about my learning, and about others who are just as much pissed off as I am.

You shouldn't be talking to me asking for quietness, you should be talking to others asking for loudness!

Yours pissed off, Travis.

Epistemological Pause

July 2006

A few confessions…

I have come back to this chapter now, after reworking Parts 2 and 3, and putting in my art work and now something really hits me. Has an underlying issue of mine been the feminising of science as well as the spiritualising of it?

Yes, you will notice that all my art work uses the female form; some in a non-gendered way, representing the spirit in all of us, but some pieces actually reflect critical feminist perspectives. I have only been articulating these perspectives in the last few years, yet this journey of integrating the feminine within myself began in 1997. Perhaps this was a counter-response to the male dominated field I was in or perhaps it is part of my transformation to more post-modernist perspectives arising out of my engagement with my research.

So has this emerging feminine awareness informed my teaching experimentation? In my search for integral and holistic perspectives am I valuing more the feminine aspects than the masculine? Does this alienate the boys in my class? What approaches are appropriate for their development? Or perhaps I am trying to counter-balance the masculine tendency of the physical sciences?

And what is this 'masculine tendency'? Is it a way of thinking, doing and being? Is *the masculine* in the physical sciences more associated with modernist, propositional, objective thinking whereas *the feminine* seems to draw more from post-modernist perspectives of relativism, subjectivity, complexity and care? What might post-modernist masculine perspectives look like and feel like? What might a balanced feminine and masculine science look like?

As I strive for integral perspectives I feel the tension between my well developed modernist self and my post-modern self. In my writing it is so easy for me to fall back into propositional ways of talking; particularly in thinking about something that happened long ago in the past – it is too easy to assign cause and effect and make judgements about what students have learnt and gained… something which in assessing students I am still required to do.

My headspace in the past was a mixture of certainty and doubt as I developed my living educational theories - putting them to the test, feeling I had understood something and then being perturbed and needing to change my own frame of references. What do I remember about the past? The moments of certainty? The situations where my thinking was perturbed? I found in writing this chapter initially I tuned more into the periods of certainty than doubt and this gave my writing a very modernist tone.

So now in writing from an auto-ethnographical perspective I need to bring in a post-modern awareness – looking deeper into things, expecting complexity and multiple possibilities, expecting rich layers. I need to fill myself with doubt, rather than certainty about what I think I have learnt from the past. It therefore helps to use anecdotes which are problematic and open themselves to multiple interpretations rather than only those which serve as exemplars or confirming evidence.

I find writing in dialogue is helpful sometimes in moving me from a modernist headspace to a postmodernist one. Dialogue enables my contradictory voices to play out in non-linear ways and I can begin to see the greater complexity. As part of the iterative process of writing this chapter I wrote one section as a dialogue which I subsequently replaced with a monologue, which leapfrogged in unpacking layers of meaning.

So in this chapter there are examples of both modernist and postmodernist writing headspaces. I have decided to leave these grating/clashing modes of writing deliberately because this is a key chapter in which I am struggling to find my way into a more post-modern science. And that process is problematic as I find myself drawn back into ways of modernist thinking. So my writing reflects that tension in the past as well as my tensions now in thinking about science and transformation of others.

But as someone searching for an integral solution I see that modernism and postmodernism each have a role to play. I do not think I have found an integral solution in this chapter, rather I have created a tension that might enable us to live our way into a solution.

As I write this chapter I see how much my own learning and ways of explaining my learning are based on *women's ways of knowing* – needing to explain processes rather than just endpoints; helping the reader get inside my headspaces and heart spaces, creating a narrative sense of self. Is the choice of my research methodology based on my gender? And how might someone of another gender read and respond to my approach?

In Integral Theory there are five key aspects – types, states, development lines, levels, quadrants. Types include gender, personality types and learning styles. So gender is an important component of the Integral map… and one now that I have to make explicit and acknowledge.

Yes, my gender is shaping my perceptions of what I see.

Before, I prided myself on my non-gendered approach to the world. HA!

Disclosure:

Crouching Cat – Hidden Leopard

My name is Jane.

Perhaps you think you know me.

In the 1930's I swung on long vines from tree to tree, clinging rapturously to that hero of the jungle, Tarzan.

But I cling to no man no more. And the jungle has changed. It is now glossy boardroom tables and the cut-throat world of corporate finance. You know, the places where decisions are made that shape the world.

You thought I was a pussycat, but I am a leopard to your lion.

Unlike you, I don't go for the jugular and climb to the top over dead bodies. I *seem* to play by your rules, but in fact I am trying to change them. Do you notice how limiting your rules are? How only certain outcomes are possible?

To you I might be chasing butterflies, getting no where. But in fact, in my very act of searching for new ways, the way you see the world transforms.

I am a change agent. The joker in the pack.

See my smile. And smile with me.