

## Chapter 6

### The Meaningful Classroom - 1992 – 1998

#### Questions:

*Who are my students?*

*How do they learn?*

*What activities can engage them and help them learn?*

*What activities can connect them to their deeper selves?*

*How does my view of what I am teaching effect the way I teach?*

#### The story so far:

I am teaching a content bound science course, whose objective is to get students ready for an exam of 'right answers'. I am very focussed on helping my students to learn science and am interested in strategies that can help me do it better. At the same time I am wondering how to infuse my class with soul and spirit. Also at the same time I am teaching other courses using enterprise and experiential pedagogies (which are based on students learning and growing through 'doing' authentic tasks such as creating a fashion show or a college magazine) and I am wondering in comparison how am fostering student development in my science classes.

Now I am introduced to Holistic Education. (see Fig 6.1) I wonder how I can use Holistic Education pedagogies to help students gain greater understanding and meaning of the science. How can I foster their curiosity? How can I help them experience the universe as a whole? How might I incorporate non-sequential/logical learning strategies? How am I assisting in their development as human beings? What does it mean to be a human being anyway? What am I already doing well and what do I need to explore. Where do I start?

# Holistic Education

**Holistic Education** is based on the assumption that the universe is an integrated whole in which everything is connected. This assumption of wholeness and unity challenges the mechanistic assumption that underpins most contemporary thinking and practice. The holistic paradigm counters the reductionistic approaches of the last 200 or 300 years that have led to a world view characterized by separation and fragmentation.

**Holistic Education** is concerned with the growth of every person's intellectual, emotional, social, physical, artistic, creative and spiritual potentials. It actively engages students in the teaching/learning process and encourages personal and collective discernment and responsibility.

**Holistic Education** is a quest for understanding and meaning. Its aim is to nurture healthy, whole, curious persons who can learn whatever they need to know in any new context. By introducing students to a holistic view of the planet, life on Earth, and the emerging world community, holistic strategies enable students to perceive and understand the various contexts that shape and give meaning to life.

**Holistic Education** recognizes the innate potential of every student for intelligent, creative, systemic thinking. This includes "students-at-risk" most of whom have severe difficulties learning in a mechanistic, reductionistic paradigm which emphasizes linear, sequential processes.

**Holistic Education** recognizes that all knowledge is created within a cultural context and that the 'facts' are seldom more than shared points of view. It encourages the transfer of learning across academic disciplines. A holistic curriculum encourages learners to critically approach the cultural, moral and political contexts of their lives.

**Holistic Education** values spiritual knowledge (in a non-sectarian sense). Spirituality is a state of connectedness to all life, honoring diversity in unity. It is an experience of being, belonging and caring. It is sensitivity and compassion, joy and hope. It is the harmony between the inner life and the outer life. It is a sense of wonder and reverence for the mysteries of the universe and a feeling of purposefulness of life. It is the moving towards the highest aspirations of the human spirit.

Fig 6.1

## Learning styles and Multiple Intelligences

1992. I have become very interested in learning styles and multiple intelligences. These theories seem to say that we each learn in different ways, have different temperaments and different talents. A good teaching program should provide opportunities for students to learn through their preferred styles and demonstrate their learning across different intelligences. Poor performance by some students could be a result of teaching to their weaknesses rather than their strengths. Students who understand learning styles and the way they operate are likely to be more empowered learners who not only can learn through their strengths but understand how to build up their weaker areas.

The Holistic Education literature that I am reading is also supportive of pedagogies based on the multiple intelligences. They say that we are multi-dimensional beings who experience and learn via many different modes of being. Howard Gardner's multiple intelligences are seen as a subset of those ways of being, but are still valued as useful pedagogies in expanding our teaching practice. So will exploring these pedagogies help me in exploring what teaching for the whole person means?

So, what am I doing already? What does it mean to use other intelligences in teaching physics? What intelligences am I already using? Hmm... *Maths /logic* obviously. *Verbal/linguistic*. I am using *Visual/spatial* in some ways but could be doing more. I am doing *Interpersonal/social* – because we do a lot of group work where we discuss ideas.

Are there some intelligences I have been ignoring in the way I teach? What sort of learners are my students? What sort of teaching style do I have? What are my strengths? What have I been avoiding?

I give my students different learning style tests and discover that in each class there is a range of preferred learning styles and intelligences. Some students surprise me and I think “Aha, that makes sense, how can I do this in a better way for you?” There is some debate at the time amongst educators in

### Multiple Intelligences (Howard Gardner)

- Kinaesthetic
- Visual / spatial
- Verbal / linguistic
- Mathematical / logical
- Musical / rhythmic
- Interpersonal / social
- Intrapersonal
- Existential

### Kolb Learning Styles

- Reflective
- Theorising
- Pragmatic
- Experiential

### Julia Atkin Learning Styles

- Detailed
- Logical
- Integrative
- Feeling / Intuitive

Kinaesthetic – Audio - Visual

Fig 6.2

Australia on whether we should be making individual programs to suit each student's needs (with the danger of entrenching them into a particular learning style) or whether the key lesson from this research is to remind we teachers to vary our teaching. I decide to vary my teaching, starting my topics in different ways... sometimes with theory or case studies, with an experience or something reflective. I am very interested in the McCarthy 4Mat model which takes the Kolb model further by suggesting we need to move through all styles as part of any learning experience so I look at marrying that to the inquiry process of science.

I too take the learning style and multiple intelligence tests and find to no surprise that I am a strong visual, kinaesthetic and experiential learner; yet also rate strongly across the board in terms of the multiple-intelligences. An all round person. So why haven't I been doing **it all** then? There are a number of reasons for this. It is one thing to do it yourself; another to reflect upon it and pull from it aspects that might be useful for others. Then there is a limit to what I have been exposed to in the first place. What a bummer if you are born with the talent to be a champion skier but live in a desert!

So what can help me then to get started? I find books like Lazear's (1991) *Seven ways of knowing*, Gibb's (1994) *Tribes* and books on accelerated learning (MacGregor 1994) give practical examples of how multiple intelligences can be articulated into classroom practice. I introduce music into my classes, concept mapping, multiple coloured pens,

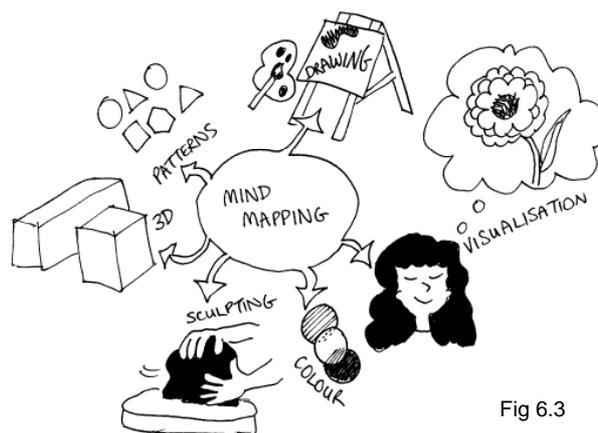


Fig 6.3

experiment with role plays and workstations, include guided visualizations, run 'fishbowls', 'jigsaws', create case studies and I am more aware of how I am using group work.

My College colleagues and I experiment in our meetings with different approaches in order to expose ourselves to new ways of experiencing and learning, and gradually build up confidence and skill in running such classes. I am lucky to be in an Australian lighthouse school which is only three years old. It is constantly re-visioning itself; we are engaged in thoughtful pedagogical discussions and keen to try new experiences.

This is a time of explosion of energy and creativity – both in the College environment and in my classes. I am very focused on **the how** to do it. I pour over examples from other teachers around the world on how they have used different activities in their classes (e.g. Flake

(1993), *Encounter* magazine) and my students are bombarded. Never a dull moment. Moving from desks to the front space of the class to engage in Mexican waves to demonstrate transverse waves; to slumping down on desks, eyes closed, embarking on a virtual trip to the moon and back; to working on physics problems while listening to the music of *Enya*; to taking on roles of scientists and debating from their point of view; to sitting in a circle listening to a children's story on the cosmos; to moving out onto the grass area doing silly walks and bumping into each other at different speeds to experience momentum collisions for ourselves.

My classes are energized, lively, engaging and **I think** the students are learning. There is some evidence to support my view as exam results are improving and students are telling me that they understand things well. For example, one ex-student came back the following year to thank me "You know Sue no-one in my engineering class at uni actually understands momentum. I felt streets ahead of them because of what we did." And I thought "Well that's pretty amazing, because I don't really understand momentum myself!" But he made me intrigued. What activities helped him and why?

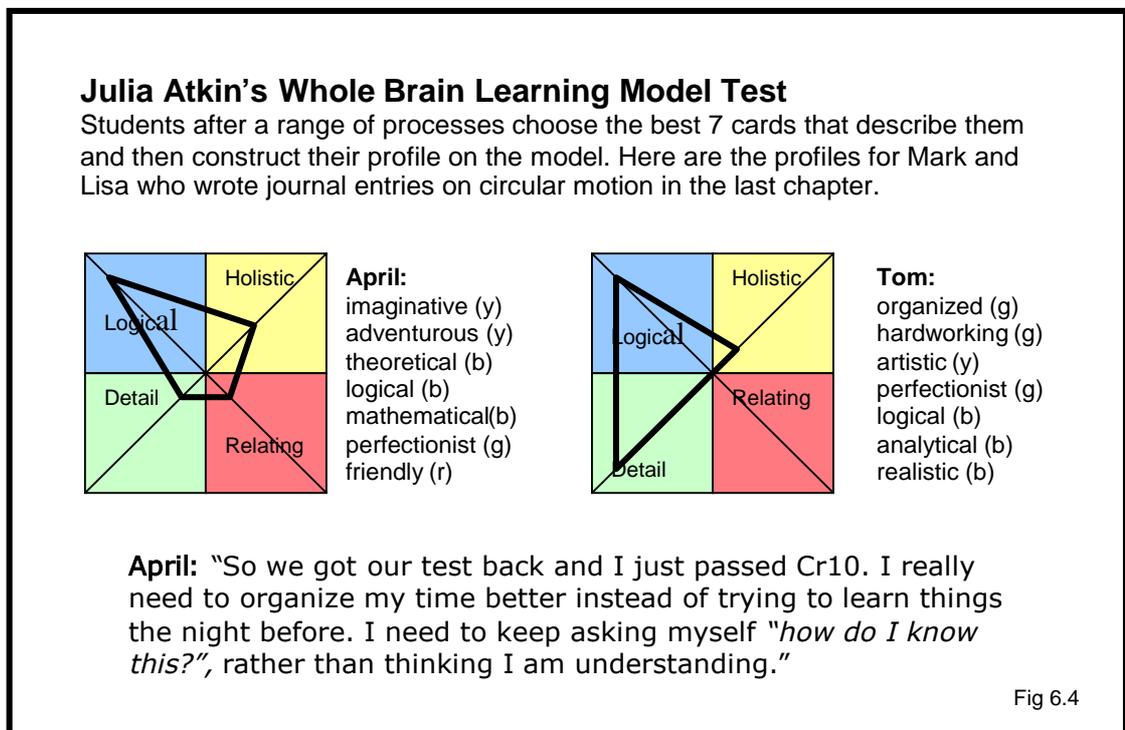
So now that I have begun to master **the how**, I can begin to focus on other aspects of this pedagogy; I begin to be more observant and seeking of feedback of my students. I develop many self and peer assessment forms for my students to reflect on their own performance and how they learn and whether they felt that the activity was effective for them and why. Initially my questions on these sheets are pragmatic and unpack the learning only to the extent that I have unpacked it and understood it.

As I get more comments from my students, I am able to reflect better on the learning that is happening and my questions become more insightful and probing. When I look back at a self reflection sheet I gave to students in 1994 to help them reflect on group work (designed like a quiz from *Dolly* magazine (an Australian magazine for young girls) where you could score yourself and your partner) I smile at the indicators I used for good group work. I realize how far I have come in my understanding of group dynamics and personal interactions, moving from pragmatic *orange meme* notions of group work to pluralistic *green meme* ones.

However, such a sheet made a big impact on many students at the time, some saying how they had never really thought what goes on in a group before. It seemed to help them be more aware of what they were doing that was helpful or hindering to group processes and to set higher expectations of what could come out of group processes. It seemed that students started to value the process of reflecting on their learning; they were beginning to understand

themselves better, take control of their learning and could be strategic in how they learnt for exams, at home and within the class. One year, I give the Kolb test (and its accompanying recommendations for strategic study) much later in the year than usual and some students were quite cross with me, saying “We should have had this a lot earlier... it would have helped us.”

What do these tests look like? They are maps students can make to see how balanced they are across different learning styles. I have included the results of the two students whose journal entries I used in the previous chapter – April and Tom. You can perhaps see how their learning styles reflect their style of writing and thinking:



During this time I am still very much struggling to nail what learning is, and what good learning looks like (which isn’t to say I can claim to know what it is now!) Gradually I began to distinguish between *energized participants* and *engaged learners*. I became more observant of behaviours and other clues students were giving me to help me understand the effectiveness of how they were learning, thus helping me to modify my approaches. For example, I realized that running a role play for students (e.g. where they are accelerated like an electron) might appear to engage students but unless we unpacked it and had a meta-conversation about it, it could lead to students being uncertain about what they were supposed to pick up from it. It could even inadvertently create ‘misconceptions’.

I began to see learning as students not just learning *about the concepts* and learning *about the nature of science* but also students learning *about how they learn*. So when I ask the question on their reflection sheets “*What have you learnt?*” I now see students making comments at all these levels. I began to see that a particular task could have many different learning purposes.

Yes I am fully focussed on learning. Have I forgotten my other aim of development of the whole individual? It seems I am using multiple intelligences to serve the learning of physics, rather than physics to serve the development of the multiple intelligences? Or is it possible to do both?

### **The holographic classroom**

At the time I am also reading different books on *systems theory* and so now I wonder how I can pull together these diverse learning experiences in a systems way so that the students are able to make connections, not just have connected experiences. How can I move away from the bit by bit logical sequential development of physics ideas? And in doing so, might I make my teaching more inclusive for those students who are not so strong in the *Mathematical/logical* intelligence?

I am struck by the metaphor of the hologram (Talbot 1992) – If you break a hologram into bits, each bit still gives a picture of the whole, even though it may be fuzzy. I wonder how I can develop topics in this holographic way, rather than introducing ideas one after the other. I start introducing some topics with a range of workstations that enable students to move around the room experiencing different concepts that we are going to come up with later in the topic... so now rather than building concepts up *one on top of another* I expose students to them simultaneously. Later we would explore them in more depth in bits but do it knowing their context to the whole topic. So we see the whole picture first and the connections in between.

These holographic investigations are quick and playful and enable students to move back and forward as they explore different ideas, testing out emerging theories and seeing underlying connections with something else. The white board is a shared place to write down connecting ideas, general principles and questions. Initially deducing generalizing principles from a range of different phenomena without me making the connections is difficult for the students

but with practice they are better able to discern patterns for themselves. I realize that in our linear (though cyclic experiments) that students do not have the opportunity to develop this skill of pattern recognition – a key one for any scientist dealing with complexity.

We now use concept maps of our questions to derive our path that we want to explore through the topic... though this is still very much directed by me. Students say to me now they can see where they are going, what questions to ask that might be useful in teasing out a whole topic and are now better able to make links and connections between ideas.

I am now using concept maps as the main way I take notes at workshops or meetings or in my own self reflection. I see concept mapping as a valuable tool and explicitly teach it to my students. I am expecting to see connections and look for ways to make links between what I do. I now see a lot of synchronicity in my life and the invisible web I am in becomes slightly more transparent and I start looking for it. I am now bringing a different lens to what I am doing and different standards... looking for *cohesiveness* and *interactivity*.

I am really keen now to encourage **feedback** so students get feedback from me and feedback from each other as well as giving me feedback about the effectiveness of their learning. Students mark each others' tests and their midyear exam to give immediate feedback. Students can get immediate feedback through concrete experience as well as conversation. My assessment moves to a more iterative model where students have a chance to reflect on what they learnt and are able to say what they would do now if they had the chance. I realise that just asking the question "What would you change now?" takes them and me into a new level of understanding about their task. For example, a student might hand in a task which might be a **B** standard, but their reflection on what they would do to change it with the benefit of hindsight indicates an **A** level of thinking and discernment.

Yes, what would I change now in this writing that I am doing?

## **Seeing inside the physics**

I need to get back to role plays and visualisations because these now cause me to experience physics in a new way, challenging my perception that scientific inquiry is a rational process. Systems theory is already challenging whether it should be linear.

So here I am designing role plays and visualisations for students to explore science through their imagination and through their bodies, requiring them to move into new perspectives. In doing so I need to enter into the physics from an entirely different viewpoint to how I had been taught it at university - which was mainly through *Mathematical / logical* intelligence. I could give you the *equation* of the magnetic force, but couldn't really tell you what magnetic force *is* in order to help you get inside it. Now I am forced to do so and I am learning so much about physics.

I realize how much I don't understand and now some of the questions students had been previously asking me are beginning to make sense... I can begin to get in their heads and see from their perspectives much better. I realise how enculturated I am in seeing the world through a rational lens. How can I see it through other lenses?

I remember how I felt after coming back from five months in Finland where I got used to hearing people in the supermarket but never understanding

their conversations. The first time I went to a supermarket in Australia after returning was a real shock... the noise made sense and I could understand what I was hearing. I had forgotten that I could do this. It had been as if I had lost one of my senses. So now I wonder whether perhaps I haven't had the 'sensory' perception to hear my students. Perhaps I need to develop new ways of perceiving and new perspectives to understand them. And could these other ways of perceiving be a legitimate part of inquiry into physics and reality?

So as a result of using role plays, visualisation and stories I am gaining an intimacy with the ideas of physics that I never had before. I find myself awestruck... amazed by reality and our attempts to make sense of it. For example, one day I found myself suddenly struck by a formula that I was describing on the board – seeing Newton's *Law of Gravitation* not just as an equation for us to use in problem solving, but a major insight into reality. What is matter really? Why does it attract? Given that things with the same charge repel, why don't things with the same matter repel also? Is this anti-symmetry?

### Role Play in Physics

1. **using the body as a sensor** - where students physically experience things like jumping off tables and being really conscious of what it felt like at all stages... what does it feel like to move with a momentum of 130kg/m/s or to poke someone with a force of 20N?
2. **role play of a physical phenomenon** – where we simulate a scenario like the decay of an alpha particle in a nuclei where girls are protons and boys are neutrons
3. **taking on role of a person** – taking on the role of a particular scientist in a debate

Fig 6.5

$$F_G = Gm_1m_2 / r^2$$

$$F_E = kq_1q_2 / r^2$$

What is this attraction anyway... is it expressing the universal principal of love? And isn't it interesting that the equation for the attraction of matter is the same for the repulsion of charge? There is an anti-symmetry between electrostatic equations and gravitational equations. We had a fabulous discussion about this and it lingered on with some students, being expressed in their journal entries.

One boy, at the end of the year, when asked about how important maths was to physics answered by "If you can't do the maths you miss seeing the connections, the symmetry." Not, "Maths helps you solve problems in physics."

I remember suddenly looking at the **binding energy graph** which plots every atom against the energy needed to break the bonds between nucleons... to split the atoms... and suddenly wondering why it was that curved shape. If it had been slightly different then fusion and fission of elements would operate differently and we might not see the range of elements we have today. How were the elements produced anyway?... Fusion in the sun?

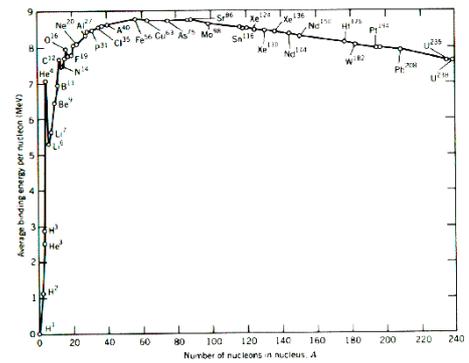


Fig 6.6

I then found out the elements in the latter part of the periodic table can only be constructed through the energy of a supernova, something I hadn't really known or registered before. Yes, I was made of star dust from the explosion of the star Tiamat. I am made from the cosmos.



Fig 6.7

I helped my students to see that they were too. Later I was to discover *The Universe Story* (Swimme and Berry 1992) which says how important it is to give students 'grand narratives' of themselves in the universe. Perhaps I was doing this.

I began to see that this universe we are in is really held together by a careful balance of the major forces... if the electrostatic force was greater than the nuclear force, the nucleus wouldn't be stable. I imagined a scientist trying to create our universe by trial and error... what sort of universe could be created if a particular universal constant was slightly bigger and smaller?

I asked my students to imagine that they were creating the universe and we were awed with the delicacy and complexity of forces that enabled it to exist. We laughed thinking about all the dud universes our scientist might have made first... what would happen if the gravitation force was too big? What might a universe be like in which the universal constants were actually variables? Yes we were using our imaginations, but now it seemed in a much more meaningful way ... and naturally conversations like this lead to questions about god, the big bang, creation versus evolution, entropy, the future of the universe, Stephen Hawking's universe, string theory, black holes.

Jostein Gaarder (1999) has a beautiful idea about the universe.

It has taken 15 billion years for the universe to evolve so it can see itself and applaud its own creation.

Yes we are the universe's eyes. And we are clapping.

Was I achieving another aim of Holistic Education ... stimulating in my students *a sense of wonder and reverence for the mysteries of the universe which moves them towards the highest aspirations of the human spirit?*

So now while on one hand I am seeing nature with wonder, on the other I begin to find myself critically thinking about the physics ideas which attempt to explain nature. Had I really understood them before? And now with this new expectation of cohesiveness and connectivity I begin to see a problem with the plausibility of ideas which I had previously taken for granted. My notions of what constitutes scientific plausibility now begins to expand beyond the criteria I had previously been applying (supported by evidence, logical, self-consistent)... I need more.

In realizing the benefits of *designing* such activities as visualisations and role plays in helping *me* to understand the physics, I now hand over to my students opportunities to design role plays and visualizations for themselves in order to test their understandings of ideas. This seems to take their learning to a whole new level. The conversations we have around the ideas seem far deeper than what I had experienced before. It seems that students really value these approaches to their learning. Now when I offer them opportunities to present group understandings in any way they want, some groups choose to take the class through a role play or alternative activity rather than just standing at the front of the class explaining something.

Tiffany writes:

I can now visualize a cathode ray tube and how it works, rather than take it for granted that this really does occur, thanks to Adam, Robin and Matthew. I realize that there are some people who never want to join in everything, but I think the majority want to. Maybe these people are very self-conscious and shy. I know I was but I feel that I have changed significantly. One good example is when we jumped off desks earlier this year. A few years ago and I would never have done that. It was fun though. Doing practical things like that is a way I learn rather well. Being able to experience what happens when an electron does this or something is really beneficial because then I can revisit that situation and remember it.

This is a very pragmatic reflection, yet further on in her journal is a poem about light (stimulated by a blindfolded walk we did – see Chapter 3) ... which indicates the sense of awe she has in the nature of light, but not the physics which describes it.

## Light

Light can create emotions...  
A warm bright yellow creates happiness,  
youthfulness.  
White light signifies purity, brilliance.  
Soft pink and yellow light is inviting,  
sensual, romantic.  
Black is depressive.

Light is not just light,  
with a velocity of  $3 \times 10^8$  m/s in a vacuum.  
Light, green light, is used by almost every plant  
for photosynthesis.  
Light promotes vitamin D formation.  
Light provides us with warmth,  
security and comfort.

I've just realized the healing power of light.  
Indigo for pain relief  
Sun gold for depression.

So the physics definition of light is missing  
just a few explanations  
of the mysterious abilities  
of Light.

## What am I seeing and learning?

Jack Miller (1996) suggests that pedagogies such as role play and visualization can help students connect in a greater way to the deeper self, to their body, to the world / cosmos and to their lives in general. Can I claim that my activities were doing this? I think so.

What was I seeing? A boy who told me about a trip in a bus where he felt the vibration under his bottom and tried to understand what was causing it, saying “Before I did physics it never occurred to me to use my body as a sensor.” Emily who ran out of the class in tears after role plays which constructed a perturbing notion of circular acceleration causing her to reflect deeply about where she was going in life (Chapter 2). The wondering and existential questions generated by students. Their greater physical and social intimacy with each other. Their passion and emotional investment. Their deep questions? Ex-students who after many years tell me of significant things from their class or even how something in class caused them to change their direction, their worldviews or their appreciation of life.

Were these indicators of body mindfulness? Of connection to the cosmos? Of connecting with deep issues of the self? Hmmm. I believed so. How do you measure such a thing? Some teachers talk about the light in students’ eyes, the brightness and energy they bring to what they are doing. Yes, I believe I saw these things.

But there were some students who didn’t participate well in alternative learning activities. Although I was giving students a range of everything, the very way I was doing it was fast paced with multiple activities in one lesson. Compare and contrast with a three hour ceramic class where you might sit quietly molding some clay, listening to music with desultory chatting to the people around you.

Space.

My physics classes weren’t for quiet and passive souls...

*Oops, sorry, I forgot that you might actually prefer some longer periods of extended peacefulness and space. I am giving you space in the think time and sleep time between classes... isn’t that enough?*

Now my take on multiple intelligences during the time I taught physics was really from two viewpoints – using them as a tool to help conceptual understanding of the physics and as a way of creating a more holistic and connected experience. A key aspect of multiple intelligences is the notion that they are developmental and can move through various stages. I was oblivious to these stages; I had honed into the word ‘growth’ and believed that I was helping the growth of these intelligences. Now with the hindsight of Integral Theory I realise I was engaged in the flourishing of some (e.g. kinaesthetic intelligence, artistic intelligence), and perhaps through asking students to reflect on own their learning I was helping them to advance through stages for others (e.g. interpersonal and intra-personal).

It wouldn’t have occurred to me that I might have a role in the *flourishing and the transformation* of every intelligence, nor what indicators of development I might look for and that there might be an art to such development. So although I expanded my teaching pedagogies beyond *Mathematical / logical* intelligence, really this was the only intelligence that I was explicitly looking at developing. Inadvertently I think I was developing social intelligence through the meta-cognition I was encouraging my students to bring to their group work, but this certainly wasn’t a valued part of the syllabus.

Should a subject teacher be concerned with development of a broader range of intelligences than is traditional? Should syllabi explicitly value the multiple intelligences? Or will this just remain a ‘take it or leave it’ pedagogical approach at the discretion of the teacher, rather than the main game of education, as is suggested in Integral Theory?

**So how is my view of science changing now?** On one hand I am engaged with it far more. I am being seduced by the deeper meaning I am gaining from exploring the concepts in these different ways. On the other hand I am beginning to question the plausibility of the concepts, which I have previously taken for granted. Rather than just standing back and criticising science from a different worldview standpoint as I have done in the past, I am now getting in, my feet wet and critically thinking about it from within it. But at the same time I am expanding my thinking of what those critical thinking tools might be. What is scientific inquiry now?

I really value this critical thinking and inquiry process that we are bringing to coming to know the physics. I feel this is a skill that students will have long after they forget the facts of physics. If this is the case then perhaps I should be thinking how I can use the physics’ *body of knowledge* as a vehicle for developing these *inquiry processes* and ways of thinking.

The facts serve the acquiring of processes, as well as the processes serving the acquiring of the facts.

I am also wishing that I can teach complexity and systems explicitly. I feel that this is a crucial part of any science course and should not be left to university study. Understanding feedback, I feel, would be such a useful tool to have to apply to one's own life, not just to science.

I also am now beginning to see the potential within the ideas of physics to inspire a sense of wonder and inspiration of this amazing universe in which we live. There has been a real shift in my perception because previously I just saw formulae as letters relating to constants and variables that we use to solve problems, not an insightful commentary on the inner workings of reality. To inspire wonder you really do have to see it yourself first. How can I be more mindful of the wonder around me?

My students' needs seemed to have changed also. Previously their need was to understand the physics. Now it seems that just like me they need for it to be plausible. And they also expect to be inspired by it.

It seems such a paradox or irony that these other ways of knowing and experiencing physics can be such a stimulus for greater *thinking* about it.

“An enchanted world is one that speaks to the soul, to the mysterious depths of the heart and imagination where we find value, love, and union with the world around us. As mystics of many religions have taught, that sense of rapturous union can give a sensation of fulfilment that makes life purposeful and vibrant.”

**Thomas Moore**

**Where is the soul in my teaching?** Is it in the deeper connections and experiences of my students? Is it in the WOW! (Wonder Of the World)? And does this WOW, help my students to feel more fulfilled and have a greater sense of meaning and purpose?

Have I moved beyond *Teaching for Understanding* to *Teaching for Meaning*? What else might be possible? What might it mean to *teach for wisdom*? Does wisdom require a sense of wise action? How are my students articulating their meaning into wise action? Are we developing a sense of heart and ethics... or just an aesthetic appreciation? Can an aesthetic appreciation of life encourage ethical behaviour? How are my students ethical agents in the use of science? How are they ethical agents in their relationships with each other? How am I giving them opportunities? Is it happening beyond the classroom? How are they wiser and how might I tell?

And where is the wholeness in all of this? Is it coming through with my modelling of my teaching practices in a systems and holographic way? Could students be having a whole experience, bringing their whole selves in this complex interactivity of different ways of knowing and being? Are they beginning to see the larger whole of reality and their place within it?

“Most of us have lost that sense of unity of biosphere and humanity which would bind and reassure us all with an affirmation of beauty. Most of us do not today believe that whatever the ups and down of detail within our limited experience, the larger whole is primarily beautiful.”

**Gregory Bateson**

### **And how am I thinking about spirituality now?**

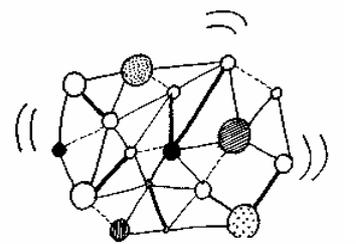
Despite the sense of soul present in my classes I feel that I am still not making spirituality explicit in my teaching. Even though I introduced my students to visualisations I am aware that these are just tastes of using the inner eye and in themselves are not a path to enlightenment.

I still think that ‘teaching spirituality’ is something you have to do outside normal curriculum which I continue to do as part of the enrichment program. But the name of the class has changed – now I call it *Dream Interpretation and Guided Visualisations*. Yes, isn’t it interesting how this has changed, just like my physics teaching into a more *process oriented approach*? In my enrichment class I am now developing the *tools of inner practice* and reflection, rather than exploring a *body of spiritual knowledge*. I am helping students to discover their inner voice and their inner purpose. How can I help my physics students discover their inner purposes?

Yet, if you had said to me at the time that my science experience was modifying my notion of spirituality I would have laughed. How might these two views continue to interact with each other?

What is also interesting is that in my visualisations in my enrichment course, the aim is to give space for the students to connect with deeper aspects of themselves, experiences which we then *explore through art and poetry* and then discuss and make meaning of in a very gentle and reflective way. Yet in my visualisations in physics I am taking students on a prescriptive journey... it is using the imagination to conduct a scientific thought experiment, not really allowing space for a deeper connection with reality. Afterwards we *brainstorm questions*. Still in the left hand side of the brain. Hmmm. Why haven’t I transferred my spiritual approach across? I seem still to be compartmentalising.

**And how do I understand learning now?** Is it something that happens in the head? If so, it is a lot more complex than I previously thought! Perhaps it is a system where parts are in a dynamic relationship with the whole, being constantly perturbed until another emergent whole is formed? Is it my job then to perturb my students to increased understanding?



What about the boy who could never start a problem because he said it was like having the whole world in his head and didn't know which bit was needed for a problem... as soon as he started to think of an answer he kept modifying it to try and include other perspectives. His answers were this



Fig 6.8

*and this... but that... and this...* he could never write succinctly in a scientific way. Is science thinking too simple? Is he in fact seeing things with greater understanding than most scientists, even though he cannot capture and snapshot that understanding?

I am beginning to pay more attention to how my students talk and write and what it might say about how they think. Have I been too dismissive of some of my students before? I had thought I was listening well before, but now there seems to be more to see.

How do *I* think? I feel like the boy with the world in his head when I am trying to make sense of this incredibly complex thing called learning! Would it help for me to start thinking about my thinking processes? .... how I come up with ideas and develop my thinking.... The way I like working with disparate threads and allow them to interact, rather than being focussed on one line of thought. How important this dialogical thinking is in helping me be creative and see things in new ways. How do my students like to work? Are they multi-taskers? Is this scientific inquiry cycle too linear and simplistic? Does it need to have more interactivity between the different aspects? Be in dialogue?

And even thinking of understanding and meaning as something you construct in your head is too limiting! Is meaning made with the whole body, mind, soul? That student who has zoomed on a skateboard for one hour claims to really know momentum. Does he really? What is this ineffable thing called learning? How useful then is constructivism (with the notion that we *build up* concepts) in helping us to understand how our students learn? Maybe *social constructivism*, which seems to acknowledge the social interactivity of learning, is a better model for helping me to think about learning? But how does that take into account *deep knowing*?

How does this theorising about learning help me to be a better teacher? Am I able to design more effective learning opportunities? Am I able to see and understand my students better? Or does this theorising put me in my head and out of the actual presence of my students? Oops. I have to remind myself to be present so I can really see them with my heart and not just my head.

Perhaps though, it is useful scaffolding which help me on my journey of understanding. I have to remember not to love this scaffolding and be prepared to let it go. Is there a way that all these different perspectives about learning could co-exist? Do I need to use trivial constructivism in some situations and other models in others? I just need to learn how to be more flexible and not seduced into one 'right' way. Phew. This is hard work... learning to helicopter and move around. I think it is a valuable skill though. Should I be helping my students to develop this as well? What might help them? Perhaps I need to talk to them about how they model their learning and thinking processes?

And let's be pragmatic now. **How has this benefited the students?** I am seeing outstanding exam results (much higher than state average) and an increasing number of my students want to continue on with physics at university (in one year students from my class represent 15% of the 1<sup>st</sup> Year university pure physics intake despite my class being only 1 of about 30 in the state).

Excuse me, what did I just say?... How has this benefited the students? I will ask this again and wonder what it might be like to answer it from a different perspective. What am I valuing above in the response I just gave?

**The exam results** – an artificial indicator of **ONE** of nine intelligences. What about the other intelligences... what has happened to them? Am I valuing the growth my students have experienced in their *whole being*? But that isn't measured, and if it isn't measured then is it valued?

**Pathways** – yes I am valuing that this course helps move students along a career path. What about one student who moves into the tourism sector who says to me "Every student should experience physics because it helps you to really see and appreciate the world you are living in. I wouldn't have missed this experience for the world!" And another who says that "The purpose of school should be to *instil wonder!* That is what is important!" Isn't that notion of

greater appreciation of their world an important thing to value.... Should it be a goal of our courses along with the pragmatic ones?

What other perspectives could I take here?

What am I still missing from this construction of my teaching of science?



*Remember what you are made of... stardust*

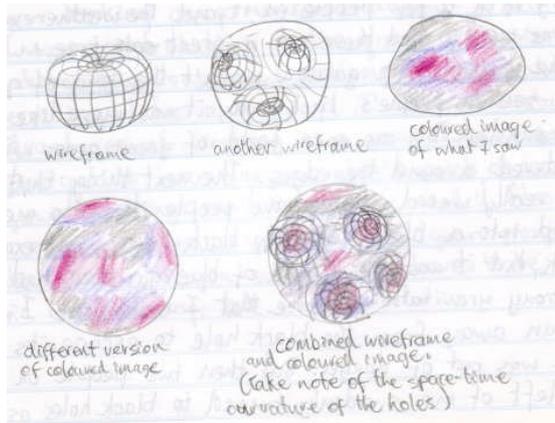
## **Interlude 1: An extract from a student's journal**

### **The universe dream**

This afternoon, after watching an episode from a video called *Stephen Hawking's Universe*, I decided to take an afternoon sleep since I was feeling tired from a busy morning. After falling asleep I had some weird dream about black holes and the creation of the universe. I think I will try to explain as best as I can of what I remember of the dream, even though it may seem very abstract.

To start off with, I was in some kind of garden party with a few people in it, and the weather was fine, it was sunny and there was a great oak tree in the centre of the garden. The garden wasn't the kind of garden you see in people's backyards, it was more like it was surrounded by an open field of green grass with forests scattered around the edges. The next thing that happened was really weird. One of the people close to me suddenly turned into a black hole. The black hole wasn't exactly black, but it was like a ball of blue gas that had such a strong gravitational force that I could feel. I managed to run away from the black hole to escape its gravity so I was out of danger. Eventually people on the right and left of me suddenly turned to black holes as well. They became orange and yellow coloured black holes and I found I was standing directly between them (by this part of the dream, I was no longer in the garden, but I was in outer space). While standing between the two black holes I could not feel any gravitational force from either of them. I assumed that they both exerted the same gravitational force on me, so the gravitational forces were annihilated (cancelled each other out) at the point in space at which I was standing.

Later, I did something weird. I grabbed both of the colour black holes with my hands (they were the size of basketballs to me) and pulled them together to form one big black hole. Now, the next part of the dream was completely out of this world. I saw that the newly merged black hole had formed some weird and wonderful spherical like shapes. These are hard to describe in words, so I will try to sketch them (think of these sketches as computer-generated images because that is quality of the image I saw in the dream.) The shapes keep changing.



After a while, I felt I was being sucked towards this anomaly as it had an extremely strong gravitational force. As I got closer to it, it seemed to shrink and become unstable and violent as it kept changing shapes. All of a sudden, it stopped pulling me in, and became a singularity (infinitely small.) Just a few seconds after it

shrunk, it suddenly made a huge gigantic explosion that made me recognise it as the 'big bang'. As it exploded, I could see visions of elementary particles flying past me (quarks, atoms, radiation, neutrinos). Then seconds later I saw the universe as we see it in the night sky today.

I think immediately after I saw the creation of the universe, I had some kind of uplifting feeling that made me think I had the ultimate answer to how universe was created. Immediately after that I think I must have woken up because the dream was a bit of a shock. Well, I spent most of dinner time trying to make sense of the dream and trying to convince myself to write this all down. At the moment I don't think I'll try to interpret the dream to any sort of meaning, because I am running short of homework time for other subjects. Anyway, this dream probably contains something very important which I shall find out later. For this is probably the way the world's greatest minds like Hawking and Einstein get their great ideas - through dreams.

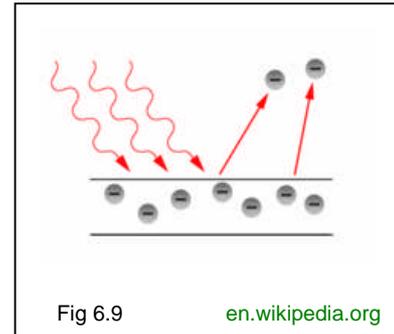
**Tom**

## Interlude 2 which features three voices, a role play and a photon played by Kathy

(and apologies if this is saying the same thing twice... but as a teacher I know how important it is to explore an idea in a different way. It enables us to get inside things more.)

### The disappearing photon

*I have just explained the photo-electric effect to the class with pictures and graphs on the board and now I have set up a role play where we can look at the photoelectric effect in action. I have a group of photons (girls), who each have different energies, waiting to strike the metal. The metal is composed of some 'free' electrons (boys) loosely held by some positive metallic ions (bigger boys).*



*Lauren is a low energy photon. She walks up to the metal but doesn't have enough energy to pull away an electron (Adam) and just leaves again.*

*Kathy is a high energy photon and bounces up to the metal and drags Adam away from his bonds and they both walk away from the metal.*

*"Hang on a minute," says Sam who is watching. "Kathy shouldn't exist anymore!"*

*"What do you mean, I shouldn't exist?" says Kathy, hands on hips.*

*"Well you had to give up **all** your energy to release Adam from the metal or **none at all** ... that is Einstein's rule."*

*"That's OK then," says Kathy, "so, I have given up all my energy... but I still exist!"*

*The rest of the class is listening intently...*

*"But aren't photons **only** energy and nothing more?" wonders Nick...*

*"Yes, if you gave up all your energy there would be nothing left... There is no shell or ghost of the photon... it completely ceases to exist," says Sam.*

*"I don't like that at all," says Kathy, "how can something just disappear?"*

*"Let's do it again", says Adam, "Come on Kathy."*

*So Kathy bounces in again and releases Adam from his metallic bond.*

*“So some of your energy goes into releasing me,” says Adam, “and the rest I get as kinetic energy and I can zoom out of here.” Which he does. “You see, the energy is transferred... it doesn’t disappear.”*

*Kathy is standing in the metal now, looking bereft. “But I, the photon, do disappear... POOOF!” she crouches down. “It can’t be much fun being a photon then.”*

*Students are now talking amongst themselves, some arguing. This has obviously struck a nerve. I pull them together and ask for comments and questions. Some want to see what happens if less energetic photons hit the metal and we try it out with some students taking the role of conductors and narrators. Some are still questioning what a photon really is and what energy really is. I didn’t expect such controversy when I set this up but I am an interested observer waiting for what happens next.*

*I am very interested in the fact that the role play has taken on a life of its own. It is like a play where a drama can be played out to give new meanings. I wonder how prescriptive I have been in setting them up previously which may have suppressed opportunity for emergence. I think about systems theory which I am currently reading and realise that role play can be like a system provided it is given enough opportunity for interaction, feedback and iteration. Perhaps this is where the part and the whole divide can be reconciled?*

*I wonder now about asking the students as revision to design their own role plays to look at key phenomena because I think the discussion that happens when we try to make the role play work really helps us to get into the concepts and understand them.*

*What surprises me most is the big idea which has emerged from this exercise... not the **quantisation of energy** (the foundation of quantum theory which this phenomenon is all about) but the **nature of energy** itself. We have been using the concept of energy all year but never really questioned it to this depth before...I guess we have taken it for granted. When you come to think about it, energy is pretty amazing. I think the students are beginning to be amazed as well, questioning their prior blithe acceptance and assumptions. Is this a sense of wonder?*

*The more I think about this disappearing photon, the more I wonder if we are seeing evidence of the ‘ true’ nature of reality... the notion of the Tao...the nature of reality is flow, change and impermeance. But how can physics say something about spiritual reality?*

*It seems I have three voices in my head, each with their point of view. What would happen if I give them free reign...*

*Science Head:* Well, I am not sure about the way Kathy anthropomorphised the photon. In fact I am concerned that the role play gives the wrong impression entirely about the nature of photons. And I am really concerned about the validity of role plays in exploring science ideas.

*Pedagogy Head:* But that is the beauty of this role play. The students already had different ideas about the nature of photons and the role play brought those out for examination and discussion. Also, some students 'knew' intellectually that the photon was just energy, but until they saw it played out this intellectual knowledge hadn't really connected at a deeper level.

*Science Head:* How do you know that it connected now?

*Pedagogy Head:* Well I know it is a big assumption but there is a change in the level of their conversation and their questions following the controversy. It seems that this phenomenon is a lot more meaningful to them. It started out as a mere physical mechanism of minimal innate interest, but now it has almost turned into a philosophic question.... *What is the nature of a photon?* And the fact that the photon is just energy is now problematic. What is energy anyway and how can it simply exist as a bundle or wave packet? What happens to light now? It has really opened up a can of worms... where we are getting to the heart of what things mean.

*Science Head:* Hmmmm. But those are the questions we just don't ask in science because they are unanswerable.

*Pedagogy Head:* But they are the interesting ones!

*Science Head:* Only if you are interested in philosophy and teach science **as** philosophy.

*Pedagogy Head:* Well I think perhaps that is what I am doing... teaching physics as philosophy, but I think I am also teaching it as physics.

*Science Head:* Well you need to make it very clear for the students that this bit is **proper** physics and this bit we are now deviating into is philosophy.

*Spirituality Head:* Perhaps we are also moving into the spiritual realm as well? Physics as spirituality? I recently heard John Gatto, at the Spirituality in Education Conference, talk about 'the sacred'. John felt that we should be encouraging students to experience the sacred in nature... to have a sacred experience... one of reverence and deep connection ...to appreciate that all of nature is sacred. Are they experiencing a kind of wonder here that is a sense of the sacred?

*Science Head:* But what is sacred here? You can't tell me that a photon is sacred? It doesn't have feelings! I think what we are seeing is intellectual curiosity or intellectual wonder... not sacred wonder or a deep connection.

*Spiritual Head:* What about Kathy's identification with the photon? Does Kathy's concern for its annihilation indicate a connection at that level?

*Science Head:* Or perhaps it is just because she was acting as the photon for a short period of time so she identified with it and thus projected her own self and feelings into it. She was afraid herself of being annihilated!

*Spirituality Head:* Or perhaps she had begun to *inhabit the space of the other* and as a result felt connected to the other... a breaking down of separation between self and other.

*Science Head:* I disagree... perhaps you might convince me if you could claim she had a gnosis experience of the photon, not that I believe in that.

*Spirituality Head:* But perhaps imagining yourself as the photon and putting yourself in its place is a first step in developing capacity for gnosis experience. Perhaps we could be encouraging students to exercise their spiritual muscles to help them develop another way of knowing and being which they can bring to inquiring into the world and their experience of it?

*Science Head:* If so, you need to help students distinguish between levels of such experience... what might be self projection and what might be true gnosis and how could they tell? Otherwise you are just encouraging self indulgence and a lack of objectivity. Science is about objectivity after all and surely in a science class they should be learning how to be scientific and objective.

*Pedagogy Head:* Yes that is an interesting point... in the teaching of science there is a confusion between what assists **learning about nature** and **learning about science** with what actually is the **scientific approach to investigating nature**. It would make good sense to put some scientific criteria on examining our personal experience which we have as learners. To make explicit for our students the different ways we come to know.... To ask what might be rigorous in terms of *philosophic inquiry* about a photon, *scientific inquiry* and *spiritual inquiry*.

*Science Head:* Yes, make explicit the different 'hat' they might be wearing at any one time.

*Spirituality Head:* I am wondering about insight now. Perhaps insight is *the space between* all those different inquiries. If you demarcate inquiry into small boxes you shut out the opportunity for insight coming from the interaction of multiple perspectives. Even Einstein said "*Imagination is more important than knowledge.*"

*Pedagogy Head:* So perhaps these pedagogical techniques for helping students come to an understanding of science could also be valuable tools for scientists who are exploring the natural world... stimulating insight?

*Spirituality Head:* Yes, because isn't **insight into nature** the actual aim of science?

*Science Head:* But done scientifically.

*Spirituality Head.* I was just remembering about the guided visualisation we did last term where students imagined they were an electron and then went on a journey through different devices and types of fields with different forces acting on them. Do you remember how Kathy said that she felt that as an electron she had no control, she was just at the whim of the environment around her? She said how disconcerting it was to experience that. She seemed to have had a big insight about the nature of an electron within electric and magnetic fields. It seemed to give her a whole new perspective about the workings of the subatomic world. Perhaps insight or new perspective taking are also steps to gnosis? Unpeeling the layers and seeing more clearly. Perhaps it is a continuous process of greater and deeper realization until one gets the point of gnosis... total realization, non-separation.

*Science Head:* Surely she was just using her imagination. And yes, like Einstein, I believe that imagination is an important tool for a scientist. It is important to be able to have a visual picture in your head about phenomena... and then modify this picture or do 'thought

experiments'. It would be very useful to encourage students to develop imagination of this sort, but also to look at what they are doing critically. What is an analogy and what is real?

*Spirituality Head:* Well I think it is interesting that in developing imagination for purely a scientific purpose it might also have the effect of developing a student's capacity to meditate or visualise for spiritual purposes... or even give them the tools to project themselves into the perspective of another person .... thus building their moral capacity. Perhaps imagination building is something that we should explicitly teach?

*Pedagogy Head:* Well I am interested in the fact that Kathy has invested herself in the process of learning and coming to know and the personalisation of it was a key factor in that. It reminds me of *women's ways of knowing* (Belenky et al. 1986) where women respond to learning experiences which are personal and empathic.... Called *connected knowing*.

Do you remember the class conversation we had after the electron visualisation where we discussed whether as humans we also were subject to invisible forces or fields we might not see? It was a very engaging dialogue and many students were very thoughtful. We teased out how much could be influencing us, touching on implicit worldviews and paradigms that we hold that could be colouring our interpretation of our reality. It interested me that a physical phenomenon could have parallels with or resonate with our own human experience. It certainly made me wonder how to make better links between physics phenomena and students' lives. I believe that as a result of making such connections students are not only much more engaged learners but also more self reflective, thus encouraging self development and even perhaps helping them to become more self-realized. It seemed that the boys were engaged in making the links between themselves and the physics as much as the girls.

*Science Head:* Hmmm. Interesting. Perhaps I have been too scientific.... I have found the stories in physics to be too distracting and not really relevant so I have deliberately taken them out and just constructed a course of facts and ideas. Perhaps I have used an anecdote about a scientist in places but more as a humorous aside.

*Pedagogy Head:* Yes, the facts by themselves can be interesting as we saw just with the nature of the photon, but just imparting the facts gives some false impressions about science and how it is constructed. Students could end up with the notion that science is all there already, a body of knowledge floating in space, with no history, no foundations, no controversy, no iterativeness, no dialogue between scientists, no paradigm shifts.

*Science Head:* Well the stories that I have read about science don't actually show those either.

*Pedagogy Head:* Well perhaps it is up to us to ask what are the characteristics of science, and what stories reveal these? What are the grand themes and who are the players?

*Spiritual Head:* Yes, I like the idea of stories. I think stories help us to reclaim our wholeness.

*Pedagogy Head:* Perhaps then activities like this role play... stories in action ... create wholeness within the actual lived experience of the actors.

Perhaps....

## Epistemological Pause:

May 2006

Whose voices are these? Yes, these are my voices. I am trying to capture different aspects of myself held in tension at a particular moment of time. It is a snapshot of a conversation between 'people' who are at a certain stage of understanding and in the process of evolving. If I was using a science self or spiritual self from my current standpoint it would sound very different.

Can you imagine your own contribution to the conversation and how it might change it?

Could I have written a conversation like this back at the time to represent the tensions I was feeling? Yes, but it is likely to be different to now. Now, I have the hindsight to separate out the perspectives and contrive them. I think they can be more playful in dialogue now. They might have throttled each other back then, ending the conversation prematurely. In fact, at one point of writing this I put myself in role too much in the spiritual head and *did* want to throttle the science head! I would have had to spill tomato sauce on the page.

But is this a useful device? What might it lead you to understand and what perspectives are missing? Is this what I want to be understood? Different voices enable possibilities rather than agreed meanings. Is this OK? Do I always need to make the links and draw inferences as a scientist would or can I be an artist and just put stuff out there and sit back and enjoy all the different reactions it promotes?

I realise that while I am a strong believer of creating situations which give students feedback, I have really not sought much feedback from my own writing. What impact might this piece have on a real scientist or a teacher?

I decide to email it to my friend, Dr Jaci Brown, a climate scientist and applied mathematician (who loves playing with mathematical models) who is currently working at Yale. I ask her what she thinks of it... how it makes her feel (like cross) and what it causes her to think about.

She emails it back with comments in red and explains:

Hi Sue,  
I read through the photon discussion. I didn't go back and change what I wrote – I just responded as I read. I'm at work reading it, so I really do have my scientist hat on! I'm not sure I got the whole spirituality argument but hey, that is why I'm a scientist and you're an educationalist! Anyway it should have some fodder for you to comment on in your thesis. Mostly I agree with your scientist, though I think she gets it a bit wrong sometimes. I have not tried to understand what you are saying – just given gut reactions to it and the first thing that comes into my head.

One of the best bits of my science degree was the science philosophy course I took. It made everything come together and have meaning.

I look at what she had done to my writing. She had added comments to the Science Head - expanding, agreeing or disagreeing with my stance.

"That is not what I meant you to do," I think! "I want to know what it made you think! Hmmmph, typical scientist approach, hmmmph. This is *my* Science Head not yours!"

But I look again and realize that Jaci is better reflecting who I was back then. She *is* my 'head'. I put all her suggestions in and they cause me to reflect further and add new insights. I then talk to her on the phone and tell her how useful it was. But did she gain anything else from it?

"Well Sue, as you know, I really just let all that spirituality stuff wash over me, so I don't think I really got what you wanted me to. But it did make me think..."

"Oh," I ask intrigued, "in what way?"

"Well, I'm having to take over from a lecturer next week in his grad class on Climate Change. I was feeling really pleased with myself because I had just spruced up all his slides (which were pretty bad), but after reading your piece I

really wondered what I else I could do. I had made them prettier and more understandable but they were still just formulae and graphs. It made me realize that I could be a lot more creative."

"Any ideas?"

"Yeah, I am thinking of linking this graph of El Nino effects over the last hundred years with the impact on Australian farmers, to get the students to see how a farmer on the land would feel and how it would effect his planning of crops and management of his finances. So we do more than just look at the maths of the models."

"Sounds great... maybe they could role play?"

"I don't think so Sue, this *is* Yale you know!"

But later she tells me she got a student to wear an Akubra hat and speak in an Australian accent, imagining himself from the perspective of a farmer and it went down really well. Later in the lecture when the grad students asked her what might be the future impact of El Nino on the world, she realized that she couldn't give them an answer and opened it up to the class for discussion which turned out to be really interesting and engaging; the students saying how much they got out of the lesson. The role play had actually generated another perspective beyond the mathematical meaning.

And the moral is....

Perhaps the value of writing (or even teaching) is not so much that it is understandable according to the aims of the author, but that it creates **praxis**... an urge to do something, an ability to see in new ways. And what an extra benefit that this *urge to do* might in its turn create in others an urge to think or do? Perhaps as author/teacher we need to let go of the need for the reader/student to make the meaning we want... it is not going to happen anyway... so let's not stress over it.... And just enjoy what emerges.

Now if I had written a dialogue between my different selves from my current standpoint, would I have engaged Jaci? She no doubt would think I am disappearing up my arse and would not be afraid of telling me. So these snapshots of dialogue do not have to represent 'best thinking' to create praxis. Even Richard Dawkin's dialogue with the Religious Fundamentalists created insight and praxis in me.

I remember having a dialogue with another physics teacher in a corridor while we were waiting to go into a workshop. I was telling him about what I had been reading about - holographic notions of sight- which suggests we might see in *interference patterns*, not as a slide show. It is our brain that constructs our slide show picture of reality. Perhaps true reality might just be interference patterns. What did he think? What was our current notion based on and could it be wrong? He was really intrigued and we ended up exploring it in some depth together.

I didn't realize that we had an audience. A year later another physics teacher told me he had eavesdropped on our conversation in total awe and had followed us surreptitiously down the corridor. He had never heard people discussing physics ideas in such a way and it had totally inspired him to think about physics in a new way. So perhaps there is advantage of listening into dialogue that can move you into new possibilities and perspective levels. Am I doing it with my students?

And how important is this breaking down into different aspects? To see things from different stances? Without this differentiation would we move to a new level of insight and integration?

Perhaps Bohm's (Talbot 1992) notion of the explicit and implicit order as a fundamental property of reality has some meaning here. He says that it is the constant dual reciprocal actions of making explicit and then integrating which creates the wholeness of reality. Differentiation is not an end point... it is a process... one part. Perhaps this is where science and the critical mind can excel.... helping to differentiate. But the problem is when science thinks it is the only epistemology that we can use to differentiate. Does it need to move out of the maths and put on the Akubra hat as well?

And what helps integration? Perhaps this is the being and living in the space in between.

Does science need to find partners then in the pursuit of the **whole** truth?

But I am thinking of science here as something separate from the human endeavour of doing science. Perhaps the integration of science lies in scientists like Jaci, who are open to other perspectives and prepared to live their way into them.