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Maturana's Biology and Some Possible Implications for Education

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INTRODUCTION

Maturana is a biologist. He makes it very clear that he speaks and writes only as a biologist. Others may apply his work to other spheres; however he himself does not.

This paper is based on notes taken during a three day lecture given by Humberto Maturana in St Kilda, Victoria, August 7th - 9th, 1993. It was obvious from the participants that many non-biologists have found Maturana's work to be influential in their thinking. The audience included immunologists, family therapists, academics, architects, agriculturalists and information technologists.

Apart from the lecture notes I have included commentary on Maturana's work from other sources. I have also added what I think are similar ideas coming from other fields of study.

What follows is an attempt to present some of Maturana's ideas and to suggest some of the implications of his biological theories for education.

THE NATURE OF REALITY

Maturana begins with a discussion of reality. He does this because the way in which reality is understood is the premise on which everything else is built. He states that traditionally western science has defined and explained an absolute reality, a reality that exists independent of people.

While traditional western science (eg positivism, post-positivism), he says, is objective and seeks to discover the truth about a dependable reality, Maturana suggests that we put objectivity in parentheses which indicates an awareness of many realities, and embodies the idea that we often cannot distinguish between perception and illusion. (He says that 'an illusion is an experience valid in one domain but listened to in another').

Mingers (1990) takes exception to Maturana's view of western science. Within the field of philosophy of science there is a wide range of positions and Maturana's view of western science as 'simple-minded objectivism', or a 'naive realist or common-sense view' he says, would no longer be in line with much of western scientific thought (Mingers, 1990: 573- 584).

Mingers outlines the major philosophical positions of Empiricism, Idealism and Realism, as a means of placing Maturana's scientific philosophy within a larger framework, (see Appendix 1 for a brief statement on each position). He argues that the whole thrust of Maturana's work places it in the Idealist tradition (and within that the constructivist). However he goes on to describe what he sees as inconsistencies in Maturana's methodology and concludes that his work probably has more in common with Critical Realism or Transcendentalism than Constructivism.

Other writers, however, have put Maturana's philosophical position at the opposite end of the scale to Transcendentalism (Kenny and Gardner, 1988), and in their view there is no way that Maturana's statements about the nature of reality could be confused with the Realist position.

However this is presumably of no concern to Maturana because, as he says, he is not a philosopher, his position comes from his research in the field of biology, and others may make of it what they choose.

Mingers recognises this when he acknowledges Maturana's enormously important contribution to scientific thought, in particular the way in which he shows, 'in a clear and consistent way how even our most self-conscious philosophy emerges from the roots of our biological origins.'

Explanations

Having established his view of reality Maturana turns to the question of explanations of experience. He asks the question 'How do we know what we know?' We cannot rely on reason because we can use reason to validate an illusion. We can only use experience to validate explanations about experience. The observer (we are all observers) he says, validates the explanation by what he or she *does*.

To demonstrate the power of explanations, Maturana says:

'We live in a changing present, the past is conceived through the coherences of the present. We can't change the experience but we can change the explanation. Change the explanation and your life changes.'

Explanations are not necessary for living but if you accept them your life changes. Explanations create a community.

As an example Maturana points out that many therapists work towards helping people to change the explanations of the past in order to make changes to their present lives. That is, they validate the explanation of past events by what they *do* in the present. Reality is not something that is 'out there' but something that we distinguish (identify) as happening to us in the *present*; we literally create the world by living in it.

As for the future, in strategic planning for example (ie explanations of the future) we create a changing present which *brings forth* a particular future. We cannot know what the future holds but we can know that everything we do and say contributes to it. 'This awesome responsibility is what we regard as the biological basis of our human ethics.' (Fell & Russell, 1993:35).

The role of the observer

Maturana emphasises that 'everything said is said by someone'. That is, the scientist's view is proposed by the scientist, the artist's by the artist. Each is a way of explaining the world, each refers to experiences in order to validate experiences, each 'is real'. In this view existence arises in what the observer does, rather than as something independent of what the observer does. The role of the observer is central to Maturana's explanations; all explanations are filtered through an observer. There are as many realities as there are explanations that an observer can bring to a phenomena out of her or his praxis of living.

Domains of explanations

However all observers explain the world out of a *domain* of explanations (science, Christianity, music, a particular social domain like a club, or a cultural domain). These explanations stand as long as they are accepted by the

observer (who could be oneself) and there are different criteria of acceptability in the different domains of explanations (eg science, art, philosophy). The different realities are *domains* of reality, not relative realities relative to each other or to 'real' reality.

This means that the observer is aware that the validity s/he claims for an explanation operates in a domain, and that there are other explanations possible in other domains, (this is what distinguishes Maturana's view from solipsism in which the self is the only knowable or the only existent thing). In Maturana's words, 'Explanations create a community and generate, or *bring forth*, the world'.

Logic is the one thing common to all domains. It must apply to the explanation and that which is explained.

There is, then, a universal logic valid for all phenomenological domains ... and the validity of our arguments, as the validity of any rational argument or concrete phenomenological realization rests on its validity ... To the extent that we have been successful (free from logical and experiential contradictions), we can conclude that ... the logic we have applied in our descriptions is intrinsically valid.' (Maturana and Varela, 1980: 121).

Bringing forth

Where does the 'bringing forth' paradigm fit into scientific philosophy? According to Kenny and Gardner (1988) it is quite unlike transcendentalism, which seeks a direct perception of reality which presumably exists 'out there' to be experienced, and in which the principles of reality are to be found by studying the processes of thought.

It is also different from, although much closer to, the radical constructivist view which, "does not deny an ontological 'reality' - it merely denies the human experiencer the possibility of acquiring a True representation of it" (von Glasersfeld, 1988:86). While, in radical constructivism, there is considered to be a 'real' world we can only ever discover what the world is *not*, as and when we find that our beliefs about the world no longer 'fit' our experiences.

Guba (1990) gives a concise explanation of the current paradigm dialogue (positivism, post-positivism, critical theory (ideology) and constructivism) and says that we are 'nationally and internationally, engaged in a major debate about which of these is to be preferred' but:

It is my own position that a struggle for primacy is irrelevant. As a constructivist I can confidently assert that none of these four is the paradigm of choice. Each is an alternative that deserves, on its merits ......to be considered. The dialog is not to determine which paradigm is, finally, to win out. Rather, it is to take us to another level at which all of these paradigms will be replaced by yet another paradigm whose outlines we can see now but

dimly, if at all. That new paradigm will not be a closer approximation to the truth; it will simply be more informed and sophisticated than those we are now entertaining' (Guba, 1990: 27).

Maturana's 'Bringing Forth' paradigm of creating the world as we live in it, or 'laying down a path in walking' (Varela, 1987:48), is a new paradigm and as such has various consequences.

Some implications of Maturana's position

There are several consequences of objectivity in parentheses, one is the kinds of questions that can be asked. If we believe there is an independent reality, we can ask such questions as 'What is knowledge?' or 'What is language?' because these questions presuppose the existence of 'knowledge' or 'language' as 'things' outside of people. Maturana however, asks instead, 'How do we know what we know?' or, 'What do we do when we language?' For Maturana knowledge is not an entity but is about *doing* interpersonal relationships.

Another consequence is the disposition to reflect. The path of objective reality, does not require that we reflect because it reveals the truth of a fixed reality, and being objective in operation, it is considered provable.

'objectivity is a subject's delusion that observing can be done without him. Invoking objectivity is abrogating responsibility; hence its popularity.' (Heinz von Foerster, in Fell & Russell, 1993:15)

Maturana says that a consequence of accepting the second path - objectivity in parentheses - is the disposition to reflect, which brings with it responsibility and also through reflection, the ability to break traditions, taken-for-granted truths, and cultural expectations. We are invited to reflect and disposed to reflect because of the realisation that there are other, equally valid and sustainable views of reality. Reflection occurs when we are willing to accept that we might not have the truth. In reflecting we take responsibility.

This applies to both the constructivist and 'bringing forth' paradigms, although there is a difference in the way in which knowledge is construed. In the theory of radical constructivism 'knowledge' is seen in terms of the system (ie the living organism) 'fitting the constraints' of its environment . Whereas in Maturana's view there is no need to propose mental models to represent reality, for him knowledge is about 'doing interpersonal relationships', this he refers to as *structural coupling* which he and Varela explain as:

'a history of recurrent interactions leading to the structural congruence between two (or more) systems.' (1987:75).

Some implications for education

Much of our curriculum depends on the presentation of predominantly western cultural knowledge as objective reality, and even within that body of

knowledge different groups represent as facts a variety of different constructs designed to answer particular questions. Take a simple example: the method taught in NSW schools for rounding numbers up or down, is not used in several other states, yet is probably presumed by most students and teachers in NSW to be 'the way numbers are rounded' (Bruniges, 1993). The realisation that this is not a universal truth can serve to illustrate that there are other ways of doing things and other truths.

In Maturana's view other domains of explanations and the bodies of knowledge belonging to other social and cultural groups are equally valid. To some extent this already is tacitly acknowledged in schools where religious knowledge exists along side scientific knowledge.

This is not to suggest a need for curriculum change. A curriculum evolves as a result of a society's cultural, social and political forces, and exists as an expression of that which the society values at any particular time. What is being suggested is that teachers recognise the validity of other domains of explanations, and seek to understand their students' realities. This means, for example, attempting to make sense of students' unexpected answers to questions or responses to statements by asking 'in what domain is this statement valid?' realising that:

- people operate in different domains, and
- answers/statements are not random.

This might well entail researching the cultural and social background of students, and becoming more aware of their different histories. The corollary of this would be that teachers would also need to be aware that they themselves operate out of a particular domain (or a number of domains in different contexts) and that these have consequences for decisions made in the classroom.

The second major implication for teachers of the above aspects of Maturana's work is the idea of reflection and responsibility embedded in the view that there are multiple realities. If teachers accept that people operate out of different realities they will be committed to reflect on classroom practice in these terms. Not only that, but they will invite students to similarly reflect.

In participating in reflection in this way it will be possible for teacher and students to both create a classroom domain, and explain (and perhaps challenge) 'from the inside' the traditions and cultural expectations of different groups in society represented by members of the class, (eg males/females; low socio-economic groups; students from language backgrounds other than English etc). With the disposition to reflect comes the ability to move away from traditions.

This emphasis on reflection and responsibility can also serve to reinforce theories of good professional development which make reflection a crucial part of the process, and which assign responsibility for the learning to the learner.

LIVING SYSTEMS

All living systems are interconnected, not because they are in touch with each other but because they are part of a history. If you change something changes will take place elsewhere, (eg. the 'butterfly effect').

Maturana asks: 'What makes a living system a living system?'

He explains: all organisms consist of one or more cells and all cells arise from pre-existing cells. The cell membrane distinguishes the cell from its environment, and it is across this boundary that the interactions occur which are the process of life. The cell secretes molecules into its surrounding medium and processes incoming molecules.

Although living systems are *closed networks* of molecular productions, they are open to the flow of molecules. The living system is the dynamics of the molecules, not the molecules themselves. By way of explanation Maturana uses the illustration of a tornado: it is the dynamics of the particles in the tornado, not an entity, that is called 'tornado'. Particles get swept up into it and then are dropped, but the tornado goes on.

Living systems are networks of molecules, in which the molecules they produce participate in the production of the molecules that produce them. A living system generates and specifies its own organisation through its production of its own components. Maturana and Varela called this autopoiesis (1987).

'Autopoiesis means that the organism maintains itself as a unity, not by its parts per se, but by virtue of the relationship among its parts.' (Fell & Russell, 1993: 26)

A living system is *autonomous*, perturbed by events in the surrounding medium and compensating for them with changes to its structure. Autonomy in this context arises from the living system's organisation as a self-producing system.

'Autonomy means that the organism subordinates all changes in the environment to the maintenance of its organisation no matter how its structure may have to change to do this. '(Fell & Russell, 1993:27 - 29). 'The autopoietic process works to keep the organisation constant, not the structure.' (Fell & Russell, 1993:62).

A living system lives as long as it conserves autopoiesis.

Living is a spontaneous matter - it happens to us. Whatever happens occurs spontaneously according to the conditions applying at the time. Maturana does not view this as cause and effect, but as the relationship between two phenomena. The observer in retrospect calls it cause and effect, however the *structure* of a phenomenon determines how it responds to any change in the

environment. Modify the conditions and change occurs spontaneously. For example a piece of bacon in a pan reacts to heat in the way that it does because of its own structure; given a different structure it would react differently. The structural changes that occur are the changes that the structure allows.

This structure determinism is the opposite of instructional interaction (ie the imparting of information) (Kenny and Gardner, 1988:12). For Maturana information does not exist and therefore there can be no instructional interaction. Von Glasersfeld's view, as a radical constructivist, is that "'Knowledge' cannot be a commodity that is found ready-made but must be the result of a cognizing subject's construction" (1984b). Problems arise through the belief that people are instructable, (Kenny and Gardner, 1988:12) and a great deal of time and money is spent every year by education systems attempting to instruct.

Fell and Russell explain the view of cause and effect expressed by Maturana, (1993:33). Causality implies an explanation which looks backwards to a determining event, after the event, from an observer's perspective. Maturana says that nothing occurs which is not possible in the existing structure however any event is just one possibility made concrete which in turn opens up other possibilities. Instead of one arrow pointing backwards (ie 'effect' looking for a 'cause'), it is like many arrows pointing forwards. These decisions are made moment by moment, not arbitrarily but according to the 'mutually triggered, mutually selected state of our interactions at any point in time.'

Some educational implications

This view implies that we cannot directly 'cause' people to learn. We cannot pour in information. But we can try to create conditions in which students can make connections with their own personal histories (their structure).

To do this we would need to:

- know ourselves, recognise, at least in broad terms, our own personal histories of interactions in order to understand why we act in particular ways in particular contexts, (and in what domains we are operating)
- know our students, attempt to understand their histories of interactions
- be willing to learn from students' unexpected connections
- recognise that students' classroom interactions arise out of their histories of interactions, and cannot, *at that moment of interaction*, be different
- recognise that we are all part of each other's environment
- recognise that every individual will be operating in a different environment (ie the environment of each person will include different people and will be constructed through a different 'interface', a different connection with the medium which will arise out of a different history of structural changes)

- acknowledge that people, as autonomous living systems, must also be seen as autonomous learners.

Structure and organisation

If a University celebrates its 125th birthday what is it celebrating? What has been conserved? What has changed? The answer has to do with organisation and structure.

To explain the difference between organisation and structure, Maturana uses the example of his small son who one day, with the help of a saw, took a slice of wood from Maturana's desk. This, Maturana explained to his son, was a structural change with conservation of organisation, (ie it was still a viable desk). Some time later the child took an axe to the desk so that it no longer could be used as a desk. This, said Maturana, was a loss of organisation.

The structure can change all the time within an organism, but when the organisation changes then the living organism dies.

Reproduction and lineage

If organisation is conserved when a split occurs then a lineage is formed. Lineage is a succession of individuals generated through reproduction in a manner that conserves organisation generation after generation. The thing that is being conserved over generations is autopoiesis. But the living organism will have a history of *structural change* as a result of interactions in a medium, (ie the structure is changed but the organisation remains the same).

The structure of a system and of the medium, change congruently, they trigger in each other structural changes. The system and the medium in which the organisation is realised change together, congruently. If they don't change congruently the system dies. Congruence with the medium is said by an observer to be adaptation.

At any point in time our structural coupling is determined (or constrained) by our original structure and our history of previous coupling. Who we are at this instant and the medium we find ourselves in mutually specify each other so that each contributes to creating the world of the next instant, and so on, creating the world by living in it.

Ontogeny

The individual history of interactions of a living system is its ontogeny. Ontogeny is the history of structural changes under conservation of organisation and adaptation. The organisation is conserved but the structure changes. For example the baby grows to be an adult, and Maturana asks 'What is it that my mother still calls Humberto?' The organisation has been conserved but the structure has changed.

We, like all living systems, are structurally determined systems. But the medium is also a structurally determined system. Recurrent interactions of both living system and medium will result in structural changes in both system and medium. What is true for the single cell is true for the multi-cellular unity. This Maturana calls co-ontogenic structural drift. Living systems 'slide' in the medium in the path in which their organisation and adaptation are conserved, like a surfer sliding along a wave. The 'structure of the system determines its interactions by specifying which configurations of the environment can trigger structural changes in it.' (Maturana & Varela, 1987:135).

When two living systems begin to act concurrently they will change congruently or they will separate, or disintegrate, or one or other will disintegrate. Changes in 'a' and 'b' will happen, 'a' encounters 'b' and triggers a structural change determined by the structure of 'b'. What 'b' accepts as an encounter depends on the structure of 'b'. The context plus 'a' are the medium of 'b'; the context plus 'b' are the medium of 'a'.

'An organism exists only in its connection with its medium and that connection is actually its history of interaction.' (Fell & Russell, 1993:29).

Whenever two of more people interact recurrently they change congruently or they separate. Behaviour is what happens in the interaction between an organisation and a medium. Behaviour is not constituted by the organism or the medium but it is the dynamics of interaction (ie behaviour is always in a particular context). For example, moving the legs is not always walking, walking is moving the legs in relation to the ground. As Fell and Russell say, 'This means that everything we have ever done together in this world could be a part of who we are and what we do today.' ' We cannot know what the future holds, but we can know that everything we do (or say) contributes significantly to it.' (Fell & Russell, 1993:35).

Kandel and Hawkins, (1992:60), from a neurobiological perspective, discuss a similar view point:

'Cortical maps are subject to constant modification based on use of the sensory pathways. Since all of us are brought up in somewhat different environments, are exposed to different combinations of stimuli and are likely to exercise our sensory and motor skills in different ways, the architecture of each of our brains will be modified in slightly different ways. This distinctive modification of brain architecture, along with a unique genetic makeup, contributes to the biological basis for the expression of individuality.'

Fischbach also displays a similar view when he says that 'the machinery of the brain is constructed and maintained jointly by genes and by experience', (1992:24).

Possible educational implications

People (teachers and students), have only whatever they were born with and their own personal histories (ontogeny) to bring to the classroom. It is this that determines how they operate in the classroom environment, and how they make sense of the world. Where personal histories are very different, behaviour, which is the dynamics of interaction in the classroom, might well be unexpected on both sides, because it will arise in different domains. The teacher might be responding from one domain, because of her/his ontogeny and the student from another because of a very different history of structural change.

In acting concurrently either they change congruently (eg negotiate the curriculum), or they separate (which is difficult in the classroom), or one or the other will disintegrate! Maturana says that if two people are operating out of different and seemingly irreconcilable domains then both can move to a different domain which includes the other two. For example people from two different cultural backgrounds can find congruence in a third 'culture' jointly constructed, (eg they build a classroom 'culture').

A further implication of this is that there will be as many classes as their are people in the class, because each will be in the class according to his or her own ontogeny And every person's view of the class is equally real. The teacher therefore will need to be aware that s/he is dealing with 31 different and legitimate views of the class, and that his/her own view is only one of them.

Maturana's theory of structural coupling provides the biological basis for the ethics of teaching. If we literally create the world moment by moment by living in it and everything we say and do contributes to the creation of the next stage of this world (and to the actual *being* of the people in it) we have an obligation to consciously create a morally responsible classroom. It will literally become a part of those who live in it.

COGNITION AND KNOWLEDGE

Cognition in Maturana's terms is not a special property of higher nervous systems but takes place with or without a nervous system. He says that living systems are cognitive systems and living, as a process, is a process of cognition. It is 'the sum of all interactions of the living organism in its operational domain'. 'The validation of knowledge is the maintenance of successful autopoiesis. False knowledge will lead to the destruction of the autopoietic process.' (Mingers, 1990:572).

To illustrate this Maturana uses the example of the amoeba engulfing a protozoan. The amoeba is able to do this by *'maintaining an internal correlation between its sensory and motor surfaces.'* (Fell & Russell, 1993; 63). Maturana says that in more complex organisms the process of sensorimotor coordination is much the same. This is quite different from the idea of a message or instruction that is being acted upon, it is instead an internal correlation that is being maintained. Piaget's view on the nature of

knowledge is similar, he says it is 'adaptive insofar as it enables us to *control* experiences and to maintain our equilibrium,' (von Glasersfeld, 1992:24).

The nervous system is a closed network of interacting neurons. Changes to the relative neuronal activity in the nervous system always lead to other changes of relative neuronal activity within it. There can be no inputs to or outputs from the nervous system, nor does the nervous system 'process information'. Learning cannot be in terms of the acquisition of a representation of the environment because all that the nervous system does is generate internal correlations (co-relations), it cannot encode or decode messages.

'Because a living unity is operationally closed, it follows that any outside action upon a living system can only be a non-specific sort of trigger - it cannot specify any particular response - that response being entirely determined by the structure (the internal coherence) at that particular time.' (Fell & Russell, 1993:28).

Thus cognition cannot be viewed as information processing. Biologically it is about internal coherence rather than internal representation of something. Information is a matter of internal construction rather than external instruction.

The living system viewed from the inside is one domain and the environment viewed from the outside by an observer is another, different domain. The observer puts these together and establishes correspondences between them. Maturana and Varela use the analogy of a submarine driver, who is congratulated on a perfect manoeuvre, he is confused by the congratulations in avoiding reefs etc, all he did was read certain dials and maintain correlations between indicators within the limits of the equipment. The dynamics of the operation of the submarine with its driver, who knows nothing of reefs and beaches, does not occur with representations of the outside world. Beaches and reefs 'are valid only for an outside observer, not for the submarine or for the navigator who functions as a component of it', (Maturana & Varela, 1987:137).

The submarine is the living system from the inside. We, as living systems, do not operate with representations of the environment (like reefs and beaches), we do not take in information as pictures of the world around us, we operate autonomously (like the submarine navigator) maintaining internal correlations according to indicators within the limits of our structure. The observer interprets our operations in the environment as particular responses to aspects of the environment (avoiding reefs etc). The observer calls this 'behaviour', but from the inside it is merely internal structural changes.

This is the same for any living system, with or without a nervous system. However the nervous system expands the realm of possible behaviours by coupling the sensory and motor surfaces through a network of millions (or in the case of humans, tens of billions) of neurons.

'behaviour is a description an observer makes of the changes of state in a system with respect to an environment with which that system interacts....the

nervous system does not invent behaviour, but expands it dramatically.'
(Maturana & Varela, 1987:163).

Maturana says that the nervous system operates as a closed autonomous system. The nervous system cannot then 'pick up information' from the environment and 'process' it providing a 'representation' in our minds. Varela (quoted in Fell & Russell, 1993:65) says that the nervous system is a closed network without inputs or outputs , 'that its cognitive operation reflects only its organisation and that information is imposed on the environment, not picked up from it.'

Damasio and Damasio (1992) in their article on the brain and language state their belief that, 'there are no permanently held "pictorial" representations of objects or persons as was traditionally thought. Instead the brain holds, in effect, a record of the neural activity that takes place in the sensory and motor cortices during interaction with a given object.' (p65).

Lloyd Fell, in his research into the effect of stress on feedlot cattle, realised that being stressed was related to the way the animal perceived the object/condition rather than a property of the object/condition itself. (Fell, 1993). Fell called this the animal's way of knowing, its way of operating in the world, its cognition. 'It's an active process of self-determination which is achieved by this way of operating in the world - not by receiving and processing information.' This way of operating in the world depends on the structure of the animal as it seeks to maintain internal coherences, for example, 'light falling on the retina is a trigger, not a bit of information - it doesn't determine anything about the subsequent activity in the optic nerve.' (Fell, 1993:4). Cognition is biologically constitutive. It arises in our living together. In conversation each forms her/his own meaning and therefore knowledge. There cannot therefore be such a thing as information transfer.

Within the nervous system any activity leads to another activity because its operation is circular, and every process of cognition is based on the operational closure of its nervous system, 'hence it follows that all knowing is doing as sensory-effector correlations in the realms of structural coupling in which the nervous system exists.' (Maturana & Varela, 1987:166).

In the objectivity in parentheses paradigm Maturana asks, 'From where, and how does the phenomena of knowledge arise?' Knowledge, according to Maturana, is not about any thing but is about doing interpersonal relationships. Knowledge does not reside in books or people but arises in our actions and can only be assessed that way.

Piaget, who was originally a zoologist, and Maturana, the biologist, are both concerned with questions about knowledge. Piaget sees knowledge as having an adaptive function and not a representational one, (von Glasersfeld, 1992). He describes knowledge as the cancelling out of disturbances to the system and thus maintaining the organism's equilibrium. Piaget, like Maturana, stresses that knowledge does not arrive ready made from the outside, it is not a matter of receiving impressions, but must be constructed over time

(Donaldson, 1987:140). Maturana sees knowledge as effective action in maintaining the equilibrium of the living organism. For both Piaget and Maturana knowledge is *doing*.

Some possible implications for education

The classroom context (which includes spoken and written language) will have as many meanings as there are individuals and these meanings will be as varied as the individuals themselves. Individuals in the context (each a part of the other's context) will trigger in each other structural changes through their history of recurrent interactions (structural coupling). These changes will constitute knowledge. A classroom therefore will function best if the interpersonal nature of knowledge is understood and all participants are invited to be a part of the classroom community.

If explanations create this community and knowledge arises through *doing* interpersonal relationships (eg maintaining relationships within a community), then explanations are a part of knowledge building. A classroom will be a learning classroom when explanations include all participants, are constantly under revision and are seen as a crucial element of classroom life. This has implications for who sets the goals (explanations about the future) and how they are set and needs to be considered in discussing student outcomes.

Moreover if knowledge is about 'doing interpersonal relationships' then perhaps the nature of relationships should be the driving force in the classroom rather than particular educational theories and strategies. Perhaps the unifying question that should be asked is, 'How will this theory/strategy allow me to relate to students, and students to each other?' rather than, for example in the current literacy debate, asking, 'Which theory do I choose?', 'What theory underpins the strategy?', or 'Can I use strategies arising out of different theoretical positions?'

On a somewhat different aspect of education, if living as a process is a process of cognition, then knowledge, as the sum of all interactions of a living system in its operational domain (in this case, students interacting in classrooms) is spontaneous. If we learn moment by moment spontaneously according to our structure and the context, then we cannot help but learn and our learning cannot be other than what it is at any particular instant in time. This renders praise and blame irrelevant to an individual's learning (except that it would serve to change the context!) and has implications for the competitive nature of much of our education system. It would make more sense to simply know that students will learn and concentrate our energies on creating the context in which school learning can best occur.

CONCLUSION

These implications for education are extremely tentative. In struggling with these ideas I have constantly come up against bigger questions like the meaning of 'choice' (or 'free choice') and the nature of making decisions. Also

I have dealt only with the teacher in the classroom, but recognise that exactly the same is true for the teacher operating in the school context and the school within the system and so on. There is much more thinking to be done. This paper is just one possibility made concrete, but, hopefully, it will serve to open up others.

Appendix 1

A Brief statement describing the main thrust of each of the Empiricist, Idealist and Realist schools of thought, adapted from Mingers, 1990, pp 573- 584.

- *Empiricism* states that valid knowledge must be based on our observations and experiences, rather than 'abstract rational or introspective ideas (rationalism and idealism) or .... unobservable causes or theoretical entities (realism)';
- *Phenomenalists* believe that phenomena are the only objects of knowledge, the only realities;
- *Positivism* is concerned with positive facts and excludes speculation on causes or origins;
- *Idealism* has challenged the empiricists to take account of the observer, our active construction of perceptions of the world, and the role of the scientific community in scientific developments; and within this -
- *Conventionalism*, states that choice of scientific theory is to some extent subjective and conventional;
- *Pragmatism* views science as a practical activity, useful in solving problems, within which truth depends on the usefulness of statements to solve problems at the time (Dewey belonged to this school of thought);
- *Instrumentalism* states that scientific theories are seen as predictive devices, instruments to improve our manipulative power over the world;
- *Constructivism*, regards our theories and experiences as our own constructs, as individuals or communities, (Piaget wrote of the construction of reality and belonged to this school of thought);
- *Realism*, states that there is an objective world which we experience directly, and our statements are true or false by virtue of their corresponding to the real world; during the eighties transcendental or critical realism developed which proposes that a real world does exist, some of which may be unobservable, but which does have causal properties. Science cannot be seen as 'creating true theories, but proposing and identifying potential causal objects, the descriptions of which are at least approximately true.' (Mingers p 575).

References

Bruniges, M. (1993). Report to the Assessment, Evaluation & Reporting sub-group meeting, Certificate of Teaching and Learning, NSW Dept of School Education, Leichhardt, 19th Oct. Report on *Outcomes* from experience on the National Mathematics Profiles Committee.

Damasio, A. & Damasio, H. (1992) Brain and Language. *Scientific American*, September, 1992, pp63-71.

Donaldson, Margaret (1987) Children's Minds. Fontana Press, UK

Fell, Lloyd & Russell, David, (1993). Co-Drifting: The Biology of Living Together. Unfinished Manuscript, Drs Fell, Russell & Associates.

Fell, Lloyd, (1993). Epistemology and Feedlot Cattle, paper based on seminars given by Lloyd Fell at the Elizabeth Macarthur Agricultural Institute, Camden, NSW.

Fischbach, G.D. (1992) Mind and Brain. *Scientific American*, September, 1992, pp24-33.

Guba, Egon G. (Ed) (1990) The Paradigm Dialog. Sage Publications, California.

Kandel, E.R. & Hawkins, R. D. (1992) The Biological Basis of Learning and Individuality. *Scientific American*, September, 1992, pp52-61.

Kenny, V. & Gardner, G. (1988). Constructions of Self-Organising Systems. *The Irish Journal of Psychology*, 1988, 9, 1, pp1 - 24.

Maturana, H. R. & Varela, F. J. (1980). Autopoiesis and Cognition The Realization of Living, Reidel, Dordrecht. In Mingers, J. (1990). The Philosophical Implications of Maturana's Cognitive Theories. *Systems Practice*, 3, 6, 1990.

Maturana, H. R. & Varela, F. J. (1987). The Tree on Knowledge: The Biological Roots of Human Understanding. New Science Library, Shambhala, London.

Mingers, J. (1990). The Philosophical Implications of Maturana's Cognitive Theories. *Systems Practice*, 3, 6, 1990.

Varela, Francisco (1987) Laying Down a Path in Walking. In Gaia: A Way of Knowing. W I Thompson (Ed) Lindisfarne Press, Barrington MA.

Von Glasersfeld, Ernst (1984b).Steps in the construction of 'others' and 'reality'. A study in self-regulation. Paper presented at the 7th European Meeting on Cybernetics and Systems Research, Vienna. In Kenny, V. & Gardner, G. (1988). Constructions of Self-Organising Systems. *The Irish Journal of Psychology*, 1988, 9, 1, pp1 - 24.

Von Glasersfeld, Ernst (1988). The Reluctance to Change a Way of Thinking. *The Irish Journal of Psychology*, 1988, 9, 1, pp 83-90.

Von Glasersfeld, Ernst (1992). Why I Consider Myself a Cybernetician. *Cybernetics and Human Knowing*, Vol. 1, No. 1, 1992.