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Teacher torque: A research project investigating student cognitive engagement through observations of non-verbal responses to certain forms of classroom questions

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TEACHER TORQUE

A RESEARCH PROJECT INVESTIGATING STUDENT COGNITIVE ENGAGEMENT THROUGH OBSERVATIONS OF NON-VERBAL RESPONSES TO CERTAIN FORMS OF CLASSROOM QUESTIONS

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ABSTRACT

This research project investigates student cognitive engagement through observations of non-verbal responses to certain forms of classroom questions. The basic assumption of this thesis is that education is the intentional act of expanding or evolving each individual student's model of the world. This study explores the non-verbal responses that various forms of questions generate in order to assess the level of student thinking that occurs as a direct result of the question. It looks at responses to closed, open and schema accessing questions to discover the role that they play in the expansion of student schema. The expected readership of this thesis is teacher educators who will be able to use this information to train teachers to use questions for fulfilling their educational outcomes. It investigates the assumption that questions cause people to think, and shows that not all forms of questions consistently do this.

The link between questions and thinking was investigated by examination of brain research which shows that "...blood flow level reflects the level of neural activity (Goldberg, 2001, p49)" and Greenfield (2000, p23) who tells us "The harder working the brain region, the greater it's consumption [of brain nutrients] and the greater the blood flow to that site".

An external manifestation of the level of brain activity was sought by filming the non-verbal responses of a small group of students to their teachers' classroom questions. See pages 35-37 of the literature review where it reveals that eye movements are both caused and are caused by stimulation to specific brain areas, and that the activation of the brain could be clearly seen by teachers when they watched the eye movements of their students. The study showed that observation of more movements of the eyes meant activation of more areas of the brain.

Therefore the chain of events found in this study is: when students are focussing on the lesson they may choose to either discard or respond to questions. The level of cognition caused by response to the questions can be assessed by observation of eye movements (just as external

eye tracking can be observed when reading, so eye movements can be seen while people are tracking internally – that is thinking). Eye movements are indicative of brain activation such as memory and thinking so we can postulate that learning is the result of brain activity. Teachers can therefore assess the level of cognitive involvement occurring in response to the various forms of questions they ask by observing the eye movements of their students.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND TO THE STUDY.

> Research has shown that thinking influences behaviour. Our thinking process – how we think – affects our decisions, action and consequently the results we get. High performance results are governed by high performance thinking (Richards, 2003, p2).

I remember quite clearly the day I decided to connect with others in an artist's deep unconscious way by using language. My aunt was screaming at her son because he wouldn't do what she wanted. My father spoke very quietly to his sister, and the 'stolen' information I received changed my life. Very calmly my Father said: "I wonder how it would be if, instead of using force, you used the power of language to help him do what you are asking?" This was my first conscious exposure to the idea that language is a powerful influence on brain function and choices people make for their behaviour and actions.

My father lectured in public speaking; he trained others to use their own potential. He was also a cartoonist and a highly competent business person. He taught his children the power of words from an early age. Later, I too became a public speaker, qualified as a teacher, became a business owner/manager and trainer of adults. I use words not only to convey information, but to inspire, motivate, evolve, excite, energise, and open choices for my clients, empowering them to make their own patterns and links. In the language of brain science these patterns and links build neural networks which involve the linking of new inputs to existing schema and results in a new insight comprised of more than the sum of the parts. I learned the value of questions to help me educate others through trial and error over the last twenty five years. I wanted to know why some questions were very effective at encouraging thinking, some provoked less generative thinking and some provoked no response at all. This led to my studies into neurolinguistics and in 2000 I became an internationally accredited trainer and coach of Neuro Linguistic

Programming (NLP)[1]. Neurolinguistics is a technology of managing change and provides techniques for understanding human communication.

Many academics believe that NLP is a popular fad, not realizing that its foundations are in traditional academic disciplines. Some of the people whose work forms the basis of NLP are Fritz Perls, the father of gestalt therapy; Gregory Bateson, anthropologist (1972, p30); Maslow (1971) and Piaget (Phillips, 1975), both developmental psychologists; Noam Chomsky, linguist and social activist (Maher & Groves, 1996); Alfred Korzybski, father of general semantics (Korzybski, 1948); Milton Erickson, father of medical hypnosis (Battino & South, 1999); Virginia Satir, family therapist (S. Andreas, 1991); Carl Jung, psychotherapist and philosopher (Stevens, 1994); and many more. Since the 1970's NLP has continued to evolve through scientific research into the brain and behaviour. For instance, the neuroscientist, V.S. Ramachandran (2002) has discovered mirror neurons in the brain. Winston (2002, p290) tells us that mirror neurons cause people to engage, building rapport through matching each other. This matching includes posture (Pease, 1981; Pease & Garner, 1985) breathing, eye movements, predicates[2], tone and pitch. Matching underpins all neurolinguistic techniques for rapport, or empathy, and now thanks to Ramachandran we know it has a physical basis and is indeed the foundation of human communication.

Werner Heisenberg (cited in Fletcher, 1994, p20) says "Every tool carries with it the spirit by which it was created." The spirit which moved Bandler and Grinder (Bandler & Grinder, 1975b; 1976) when they developed a programme of techniques for neurolinguistics was a deep and hungry curiosity. They had an abiding fascination with how people change, how they do mental processing and the link and causal roots between language, meaning and action.

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1. Neurolinguistic Programming is: "The study of excellence, a model of how people structure their experience; the structure of subjective experience; how humans become *programmed* in their thinking – emoting and behaving in their very *neurology* by the various *languages* they use to process, code and retrieve information (Hall & Belnap, 1999, p307)". "A core contribution of NLP has been in defining the connection of behavioural cues and patterns to internal cognitive structures and unconscious processes(Dilts & Bonissone, 1993, p100)".

2 Predicates are sensory based words that indicate the sensory processing an individual is using to express meaning.

NLP has a constructivist framework and provides a set of cognitive tools that can help to organise or restructure our experiences and build our own representations of knowledge. It is the study of how people think, what drives them, how they organise and pattern themselves and how they construct and use their individual maps of reality to navigate their lives. The basis of NLP is the detailed modelling of exceptional skills and the transference of those skills to others. Over the last thirty years the skills involved in this particular type of observation (modelling) have been refined and developed into a study of human learning. In my practice where I coach, train and facilitate both business and personal development I have long been aware of the value of eye movements as an indicator of cognitive function. Practitioners of NLP use the NLP eye cues chart (see page 37) to work with an individual's learning and thinking styles. I noticed that the responses from my clients were often preceded by fast eye movements in many directions and that people who used more eye movements often replied more generatively, showing me that they were really thinking about the question in more than one way.

I now run a training and mind-coaching business. My clients are business people, educationalists, trainers, facilitators and individuals referred by local doctors. During a mind-coaching session clients are given cognitive tools to change previously formulated belief systems on which their decisions are based.

1.2 PURPOSE OF THE STUDY

> My questions opened up students' reality, but at the same time they expanded the boundaries that determine their current interpretive and perceptual horizons. In this sense, the questions guide or scaffold students because they always tested the outer edge of student's current reality (Roth, 2002, p77)

My purpose in doing this study is to explore the formation of questions in an attempt to use them more effectively to achieve learning outcomes. My expectation is that insights I have gained during this study will result in a questioning strategy for teachers which takes into account the fact that their words physically impact the neural networks of their student's brains

in ways they might not have considered to date. Learning how to see, in the moment, whether or not their questions are activating the neurology of their students can make life for teachers much easier, less stressful and more rewarding. By improving the focus and engagement of students, classroom behaviour should also improve, negating the need for frequent discipline. A correlation between the number of eye movements students display in response to various forms of questions and the numbers of brain areas that are activated when questions are asked could be an important feedback tool for teachers to know what level of engagement, attention and focus their students are displaying. This would give teachers immediate information to help them respond in the moment, instead of waiting for the results of a test. They could quickly respond to students who were off task or not engaged at the same level as their peers, or they could watch the students eyes to gauge how long to wait while students think, before moving on with the lesson.

Training to notice eye movements is not difficult, but requires motivation and practice to make it a conscious part of relating to people. It is something we all pick up as we learn to communicate as very small children and quickly becomes one of our unconscious skills. Training to bring these skills back into conscious awareness at a higher level gives us the option to develop and apply them at will. My training and experience in this area has been an important aspect of the analysis of the data for this study.

Professor of Linguistics at the University of California, Santa Cruz, Dr John Grinder used Noam Chomsky's transformational grammar[3] (Grinder & Elgin, 1973) and from it developed the first language model of neurolinguistics. He developed it in a way that was easy to teach – a model of effective questioning.

[3] Transformational grammar says the deep structure is the event and the surface structure is the linguistic representation of that event. The surface structure is derived from the actual event when the speaker transforms it by employing generalisations, deletions and distortions. The speaker's choice of what he wants to generalise, delete or distort is guided by his model of the world and the assumptions he draws from it [his cognitive map, or schema] (Grinder & Elgin, 1973).

A second NLP language model was based on the work of Dr Milton Erickson (Bandler & Grinder, 1975a; Grinder, DeLozier, & Bandler, 1977), the father of medical hypnosis. He worked with patients using a questioning style which was content free (didn't specify parameters). He was the first to learn how to directionalize the brain towards perceived choice. The important words here are 'perceived choice', because choice negates resistance, whether or not the choice is 'real' or perceived. An example of a perceived choice is the double bind: Do you want to brush your teeth or go to bed first? This sentence implies choice but is in fact an instruction to 'brush your teeth and go to bed'. Erickson employed softeners and reframes which diverted the thinking of the listener's structural brain processes towards the neocortex[4], where thinking occurs, instead of to the limiting emotional reactions which the amygdala[5] uses (survival instincts, uncontrolled emotive reactions unrelated to logic).

After learning these two models of questioning my work in the training of adults was markedly more effective. I became passionate about disseminating the models to people who are responsible for the evolution of thinking in our society – fellow teachers. I am grateful for the opportunity to undertake this research and hope that it will help the next generation to be brighter, smarter, more innovative and wiser in human relations than is currently the case.

This study has moved towards observing not the specific sensory cortices being accessed, as neurolinguistics does by noting the eye gaze direction, but the number of eye movements displayed in response to each of the five forms of questions found in the lesson. The reason for this is that student eye movements show how many brain areas students are accessing when undertaking a transderivational search. A transderivational search occurs when a person searches across (trans) all the sensory information from which they have derived meaning (derivations) thereby accessing their schema with the express purpose of making sense of new experiences.

[4] Neocortex – frontal area of the brain that is responsible for logical, sequential thought (Goldberg, 2001).
[5] Amygdala – two almond shaped organs in the reptilian section of the human brain. They are responsible for instinctual survival responses, like emotions and motivation (Shore, 1997, p71).

1.3 ASSUMPTIONS GUIDING THIS PAPER.

> "Unlike instinctual behaviour, learning, by definition is change. The organism encounters a situation for which it has no ready-made effective response. With repeated exposures to similar situations over time, appropriate response strategies emerge. The length of time, or the number of exposures required for the emergence of effective solutions, is vastly variable. The process is sometimes condensed in a single exposure (the so called Aha! reaction). But invariably, the transition is from an absence of effective behaviour to the emergence of effective behaviour. This process is called "learning" and the emergent (or taught) behaviour is called "learned behaviour." At an early stage of every learning process the organism is faced with "novelty," and the end stage of the learning process can be thought of as "routinisation" or "familiarity." The transition from novelty to routinisation is the universal cycle of our inner world. It is the rhythm of our mental processes unfolding on various time scales" (Goldberg, 2001, p44).

1. Not everyone thinks of learning in this way. I thought the above quote so completely summed up my own ideas of learning that it was adopted as my first assumption.

2. My second assumption is that each and every human being is unique and magnificent, externally and internally we differ, yet are remarkably similar. Each human has different facial features; they are all spaced in a common pattern on our faces. As time goes by, within the parameters of our genetics and the features we were born with, the lives we lead are 'written' on our faces, some of us develop 'smile lines' and some develop deep 'frown lines'. Some cheeks become sunken with poor muscle tone from infrequent use, and some develop cheeks which are firm with good muscle tone. It is not surprising therefore that our internal structure follows the same pattern. Our brains also change with our individual experiences. Most of us are born with the same brain features, in roughly the same places as everyone else. As we interpret and act on the inputs we receive from our environment the most frequently used parts of our brains grow strong, the less frequently used parts do not develop as strongly.

> Lots of positive experiences early on produce brains with more neuronal connections – more richly networked brains...the more you use it, the more it develops. On the other hand, if you don't use it, you lose it – the absence of activity tends to make neurons atrophy like wasted muscles (Gerhardt, 2004, p43).

3. The third assumption guiding this study is that environmental stimuli influence our brain's structure very fast as can be seen from the affects of neuroplasticity [6] . Fuster (2003, p116) tells us that neural networks are developed in response to both environmental (external) and internal mechanisms. The external environmental input is the subject of this study and that "...sensory stimuli and outputs from sensory processing areas are the most important". He goes on to explain that internal stimuli which expand the neural networks come from two sources: those sensory stimuli we process through our emotions; and secondly the information from previously constructed 'cognitive cortical networks'. Therefore both external and internal stimuli change the physical structure of our brains. The infant's developing model of the world gradually shapes not only its beliefs and values but also changes the physical structure of its brain. Susan Greenfield (2000) shows a remarkable set of brain scans on page 55 of her book *The brain story.* The first scan shows an infant's neural structure at birth, there are some interconnections and many 'holes'. The second shows a scan of the same infant at 3 months, there are more than double the number of neurons and many more interconnecting networks between them. The third scan, at fifteen months, shows huge expansion of neurons and the development of complex interconnections. The last scan, taken at two years, shows not only further neural network development, but also some areas where the networks have not connected, this last is due to lack of stimulation of those neurons. These photographs depict brain neuroplasticity in action.

4. The fourth and fifth assumptions can be considered together. They indicate that we all learn to read the faces, body language and emotional signals of others and base our communications upon these unconscious readings. 5. Empathy is essential to effective human relations. As infants develop it becomes necessary for them to learn to interpret the biological mechanisms of facial expression (Bates & Cleese, 2001, p80). Facial expressions very quickly indicate our emotions and communicate them to others. Instantaneous response to the facial expressions of others is imperative for survival. Bates and Cleese (2001, p70) tell us that reading the

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[6] Neuroplasticity – the ability of the environment to affect changes in the neural structure of the brain according to Hebbian rules which state that synapses are strengthened by 'transmission of impulses through them' (Fuster, 2003, p43)

expressions of others causes us to quickly feel what they do, "The empathy is real, biological and strong".

The musculature of faces are capable of making about seven thousand expressions (Bates & Cleese, 2001, p78), but few of us use more than a few hundred. Infants start to use their facial muscles to express themselves at a very early age (Bates & Cleese, 2001; Greenfield, 2000) infants experience sensations through visual, auditory and kinaesthetic stimuli even before birth (Greenfield, 2000, p54). Their senses provide the raw material with which they start to build their model of the world.

6. This leads to the sixth assumption, that sensory input is essential to the thinking and communication of all people. As children grow up they learn abstract thinking but their senses continue to provide essential information throughout their lives. Sensory input constitutes experience, first we use our senses to perceive the stimuli, then encode them into our memory (or not) using a sophisticated sensory filing system. It could be argued that when information is needed again it can be accessed through the same sensory channel through which it was encoded, because, as Fuster (2003, p111) writes, memory is "...fundamentally an *associative* function", while Beaver (1998, p11) tells us that the things we remember by encoding them through most of our senses are the easiest to access. Lunzer (1970, pp3-4) reaffirms that the sensory nerve endings are the brain's receptors of experience and that "...sensory impressions or sense data being the bricks out of which all forms of knowledge are built up". What we see, hear and feel constitute the ability of our brains to grow, to change and to make choices.

It is important to note that we all make different choices, and the decisions we make can in turn influence who we are, which then influences our other decisions. Greenfield (2000, p55) explains that the sensory bombardment that begins at birth causes the growth of neural networks at such a pace that the brain is four times larger in adults than in infants even though the number of neurons is almost the same, it is the connections that increase the brain size. This shows that

the growth of a child's model of the world (cognitive connections) directly influences the physical structure of the maturing brain.

7. Thus we build a model of the world which becomes the foundation of our mental and physical development, each connection we make adds to our brain mass. As we attempt to build the connections between what we perceive through our senses and our ever evolving model of the world we build cognitive 'maps', to help us make a model of reality. As children we often do not know what is real and what is imaginary. Many children have imaginary friends which are very real to them. "As human beings, we will never know exactly what reality is..." (Dilts, Hallbom, & Smith, 1990, p29). The temptation to act <u>as if</u> our model of the world <u>is</u> reality is discussed by Russell (1983, p114) when he describes the assumptions which guide the scientific process. The agreed 'reality' or 'conceptual framework' is an acceptance of a prescribed model of the world. In my practice I see that pain is caused by perceived limitations in an individual's model of the world. When greater choice is perceived people can evolve their thinking to cope with their problems in different ways.

8. The eighth assumption guiding this paper comes from the work of Golman on emotional intelligence (1996). The brain has the ability to process new inputs by either reacting emotionally or responding logically and thoughtfully. Brains cannot simultaneously react and respond, though my clinical practice has shown that the attentional focus can swing very fast from one to the other. It is useful, when transferring data between one person and another, for the teacher to be aware of which brain processes their communication is evoking.

Instinctual reactions are dramatic and speedy, pre-empting the possibility of considered comparisons, judgement of consequence and effective planning. Bennett-Goleman (2001, p108) explains that there is only a 'one-neuron-long chain" direct from Thalamus[7] to the Amygdala.

[7] Thalamus: "All incoming sensory information (except smell) goes first to the thalamus. From here it is directed to other parts of the brain for additional processing (Sousa, 2001, p18)".

This results in the Amygdala only receiving 5% of the information to base its speedy actions on. Reactive behaviour is therefore not always logical or defensible, it is merely a reaction.

People who habitually react to stimuli instead of considering the issues logically are not using the 'thinking' part of the brain. Goldberg (2001) explains that the interconnections between neurons (neural networks) are constructed by our experiences. It therefore follows that if people habitually use their emotional brain they will not develop strategies for logical rational thinking.

9. The main purpose of a teacher is to train the brains of students to think, to help them lay down the structure of neural networks necessary for logical rational thought. If students are trained to use both reaction and response in contextually appropriate ways it seems reasonable to conclude that classroom behaviour could be more manageable and less stressful for students and teachers alike. Learning can be a risky business, and the ninth assumption of this paper is that a calm safe environment is conducive to the occurrence of learning. We are told that a state of "relaxed alertness" is the optimum state for effective learning (Dryden & Vos, 1999, p168). DePorter (1993, p68) tells us that "Tense muscles divert your blood supply – *and* your attention.". We have already seen that blood supply to the brain is an indication of neural activity, or thinking. If our blood supply is diverted by muscle tension caused by a stressful classroom environment it seems that we are physically unable to feel safe enough to relax and learn effectively. A large part of classroom atmosphere appears to be regulated by the teacher's attitude and ability. Teachers who choose to work with students use less effort and experience less stress than those who try to push students, creating a more stressful classroom environment. Rough (1997, p4) tells us that "...just the language of control can block the dynamic [of learning]".

Bourtchouladze (2002, p20) cites the Brown-Petersen distractor technique which states that if students are distracted and unable to practice new information within a few seconds of

receiving it, the information will be lost. As soon as emotions are triggered logic rational thinking is lost because our brains are run by chemicals, and the release of stress chemicals such as cortisol put us on high alert, evoking survival responses and shutting down neo-cortical processing, this makes us unreceptive to learning (Adam, 2003). Jensen (1995, p24) says our state, or moods, are instrumental in learning, memory and thinking, "In short, a stressful and threatening class climate dramatically impairs learning".

Every human being experiences stress and pain during their life's journey. Pain is not the result of impoverished life, it is caused by impoverished models of the world which cannot deliver the expectations of the individual. Austin describes man's pain like this: "At a very early age he begins to go out of his way to seek or make new problems for himself and others to solve (1966, p30)". The challenge generated by problems helps the individual to work towards expanding his world view by discovering what resources and strategies are needed for the successful attainment of his outcome. Teachers who encourage students to find their own resources, attitudes, skill sets, curiosity, steadfastness, resilience and the ability to maintain the dream and do whatever it takes to achieve it, are preparing students for life outside of school.

Teachers can provide these resources to students. They can teach the thinking skills that will allow each and every student to achieve their dreams. The question guiding this research is based upon the premise that teachers can and do positively impact the world view of their students. They can help students lay down the neural networks they will need to instigate life long learning. Teachers can help students make contextual choices to react or respond, this will affect the behavioural choices of that student for the rest of their lives. This life long skill has the potential to impact positively on society. Roth (2002) tells us that teachers are the interface between the teachers model of the world, the students model of the world and the data being presented. This assumption was found to be useful in guiding the research.

10. The tenth, and final guiding premise is that language and particular forms of its use can influence the brain's processing of the information embedded within it. Chase (1943, p31) expresses this perfectly when he says "Words are meeting points at which regions of experience come together; a part of the mind's endeavour to order itself". The current understanding of how the brain processes language is not a major part of this study, but rather underpins the assumptions expressed in the paper.

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CHAPTER 2: LITERATURE REVIEW

The literature reviewed for this paper has been wide ranging and covering many decades and many topics. The reason that references span from the 1930's to the 2000's is that so much work was done on understanding the cognitive aspects of language before the 1990's and this work has formed a basis for many of the assumptions which we accept without question today. The 1990's was declared the 'decade of the brain' because of the scope and depth of neuro-scientific research in that decade (Sousa, 2001, p2). Some of the most exciting developments about how the brain learns have come out of this period and understanding the theories of educationalists and psychologists that went before can help to develop the context for the new research. This study is examining questioning in an effort to discover whether or not cognitive processes are triggered by specific forms of questions.

As is appropriate for a study about questioning, the structure of this review follows a trail of questions. It uses contrastive analysis of many forms of questioning, comparing them to the constructivist model of learning. The literature reviewed for this study is trying to find the form of questions which facilitate what linguists call a Transderivational Search[8] (Battino & South, 1999, p69). Piaget's theory of intellectual development could be said to be selectional because it 'selects' the schema of best fit for the new experience by comparing new inputs for similarity or difference to existing knowledge before either assimilating[9] or accommodating[10] it (Casti, 1989, p240). This process is called 're-cognition' and means that most of our processing of the perceptions we receive is done below our conscious level, as our brains do the comparisons, in fact we 're-cognize' them. We test the 'fit' by successive steps and our conscious attention is aroused by information that does not 'fit' the context. For instance a door closing quietly when the family is home would cause no alarm, but a door closing quietly on a windless day when you are home alone can trigger alarm.

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[8] Transderivational search - a search across all sensory experiences to find an appropriate schema for the equilibration of new inputs.
[9] Assimilation - when new input is incorporated into existing schema without changing it (Casti, 1989, p240).
[10] Accommodation is said to occur when a schema is changed to incorporate new input (a cognitive map is changed or enlarged) (Casti, 1989, p240).

When questions cause a student to access their own model of the world and consider new data in the light of their own value structure the resulting adaptation, whether it be by accommodation or assimilation causes a change or expansion in the individual's world view – this could be called learning. Behaviour is determined by both the sensory input and how the individual has processed that input (Phillips, 1975, p8). In neuro-scientific terms Fuster (2003) would explain the same process as cognits[11] forming neurons and neural networks to determine an individual's cognitive maps which drive behaviour. Schooling provides an opportunity to fast track learning without having to rely completely on personal experience, which is the slow way. Effectively educating yourself relies on the hunt for information, then the devouring and digestion of it (Zink, 1998). Perhaps a teacher's main role is to blow the horn that starts a student's lifelong learning, and perhaps a question[12] is the sound of the horn that starts action which leads to that lifelong hunt for learning.

This study hunts for data on questions and responses focussing on the form of the questions. Little attention is given in the literature to responses those questions generate. Perhaps this is because a reliable way to gauge responses has not yet been found. This study takes a detailed look at the moment of initial response in an attempt to find a way of interpreting responses at the moment they occur – when the hearer first registers the question.

When I was searching for non-verbal responses I observed that eye movements appeared to be significant indicators of the occurrence of cognitive involvement. Consequently this review branched out into related areas to support the study. Seven areas of research were identified as significant and these have been arranged in such a way as to unfold the information sequentially. As is appropriate for a study on questioning, these seven areas will be explored by

[11] Cognit – "... an item of knowledge about the world, the self, or the relations between them. Its network structure is made up of elementary representations of perception or action that have been associated with one another by learning or past experience (Fuster, 2003, p14)".
[12] A question is "...;interrogative sentence (Collins, 1968, p938)". "...questions serve as guides to particular actions, as sentences that cause thinking and behaving along particular lines (Hunkins, 1989, p30)".

forming responses to questions. The following seven questions form the basis of this quest and the map of the quest appears in Diagram 1.

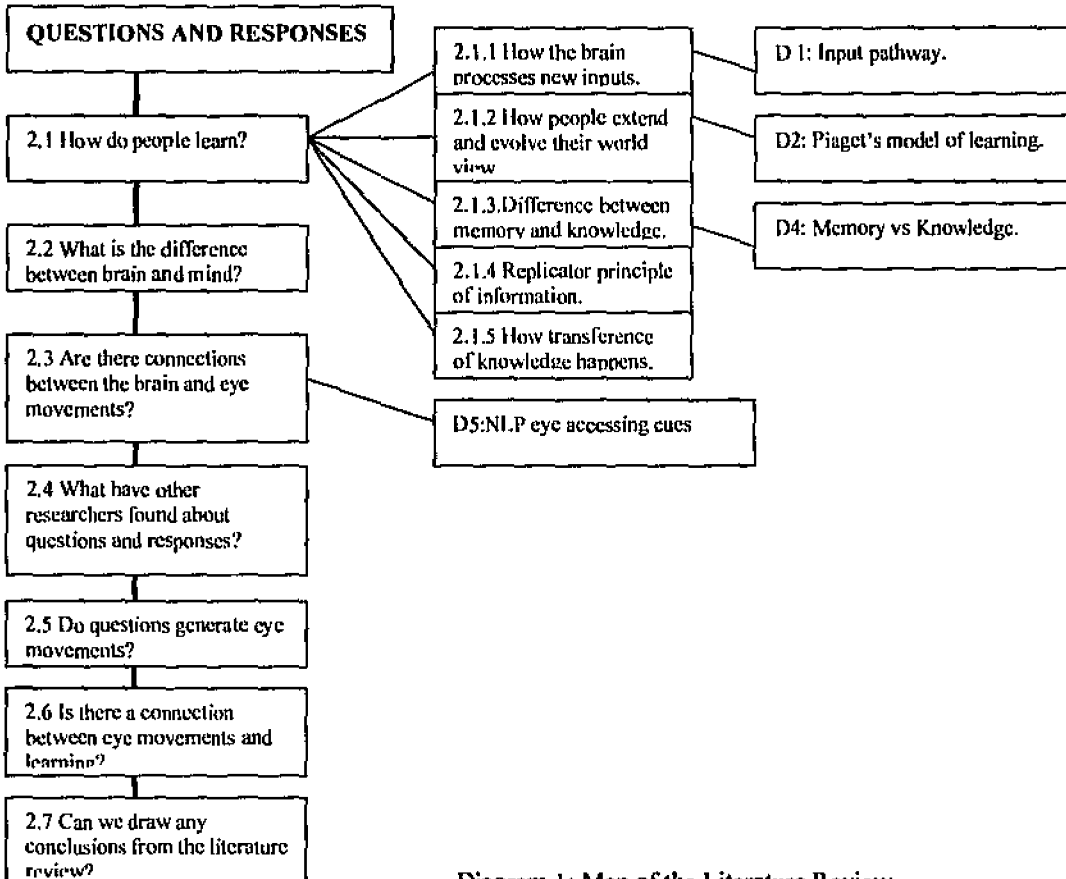

Diagram 1: Map of the Literature Review.

2.1 QUESTION 1 : HOW DO PEOPLE LEARN?

> When the organism is exposed to new patterns of signals from the outside world the strengths of synaptic contacts (The ease of signal passage between neurons and local biochemical and electrical properties) gradually change in complex distributed constellations. This represents learning as we understand it today (Goldberg, 2001, p29)

The focus chosen for this section is the mechanics of learning, intellectually (Piaget), socially (Golman) and biologically (Fuster and Souza). There are many definitions of learning and each reveals the conceptual frameworks adopted by the definer. The conceptual framework of this study is constructivism. Jonassen, Howland, Moore & Marra (2003, p iiv) tell us that "Constructivism is a way of understanding learning phenomenon". Learning is a complex

process, the detail of which is beyond the scope of this study but is so central to questioning and responses that this section of the literature review will summarize some aspects of it. A brief review of learning is necessary to understand the purpose and intent of teacher questions.

2.1.1. How does the brain process new inputs?

"The aim of both the scientist and the child is to understand the world (Peill, 1975, p1)".

The mechanics of the brain as it meets new inputs is important to this paper (Phillips, 1975). Bruner and Piaget each put forward different theories of how this is accomplished. Bruner says the brain receives passively and makes representations of experiences whereas Piaget says that brain actively constructs reality (Peill, 1975, p13). The difference between these two approaches lies in the ways these two models describe the way the brain acts on experiences. An example of the difference between them can be shown in the following sentence: Johnny is terrified of dogs but he needs to get past one on the road.

Bruner: John has built a representation of 'dogs' by nominalising fear and making it a complex equivalent with 'dog'. Dog is fear. Johnny's internal processing is to react (his survival instincts are triggered) – stress chemicals are released and the external action is fight or flight. Behavioural reaction: he screams and runs.

Piaget: In his mind Johnny has constructed a dog as fearful. He has not nominalised fear – he uses it as a mental description, or adjective of 'dog'. Internal processing – Johnny can separate 'dog' from 'fearful' because he can think about all the other adjectives that could also apply to 'dog', and this provides Johnny with choice, to either respond or react. Behavioural response: He nervously crosses to the other side of the road and continues his journey.

My practice has taught me that people who habitually react emotively are doing so out of a perceived lack of choice, when choices are revealed they can choose to respond, or not. Those

people who consistently recognise the choices open to them are those who respond. This paper focuses not on student reactions, but on the responses they generate to questions after consideration of their choices. This is the reason this paper choses a constructivist framework for, as will be shown later, people learn by evolving schema[13] through the choices they make.

The brain's process of evolving schema begins with an external stimulus which is received through the senses. What we see, hear, feel, smell and taste forms the basis of our meaning making from birth to death (Bourtchouladze, 2002; Council, 2000; Fuster, 2003; Goleman, 1996; Greenfield, 2000; Sousa, 2001).

> Thought processing is in one way like the later stages of sensory processing. Just as the various parts of an image – location, colour, shape, size and so on – are brought together and integrated into a whole, so we bring together various memories and imaginings and put them together into a new concept. The big difference is that whereas sensory construction is unconscious, thought processing is done consciously. As the frontal cortex carries out its task it monitors what it is doing. So while an image simply 'arrives' in consciousness, a concept carries with it the knowledge of how it came to be (Carter, 1998, p311).

Golman (1996, p10) tells us " In a very real sense we have two minds, one that thinks and one that feels". He explains that every new sensory input goes through the Thalamus (which acts like a switchboard in the brain) where it is assigned to either the Amygdala (feeling brain) which triggers reactions, or the Neo Cortex (thinking brain), which triggers responses.

The Amygdala are two small almond shaped organs located in the reptilian brain and are responsible for survival of the organism (Goleman, 1996, p298). This part of the brain <u>reacts</u>, instantly, without thought for consequences. This is our emotional centre and decisions made here can seem irrational if survival is not really threatened. Goleman (1996, p16) explains that these are 'acts of impassioned action that we later regret'. In the classroom survival responses could be triggered unless the classroom is a calm, easy, non-threatening learning environment.

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[13] Schema – "…a rule or principle that enables the understanding to unify experience (Collins, 1968, p1032)". This means that a schema is a constantly evolving cognitive map, built up from every experience an individual has. The schema then determine that individual's understanding of that particular concept.

The Neocortex is in the frontal lobe and is responsive, logical and rational, it makes comparisons and comprehends what the senses perceive it is responsible for 'thinking' and comprehending (Goleman, 1996, p11). The following diagram shows the path of new inputs as they are received through the senses, and pass through the Thalamus, which is like a switchboard, deciding where the inputs will be sent. For action of any sort to occur both the brain and the mind have to choose to act. If the input is ignored the pathway to action is not triggered. The following diagrammatic representation (Diagram 2) shows the cognitive and functional pathways that new inputs follow, the black shows the cognitive pathway and the red shows the functional pathway.

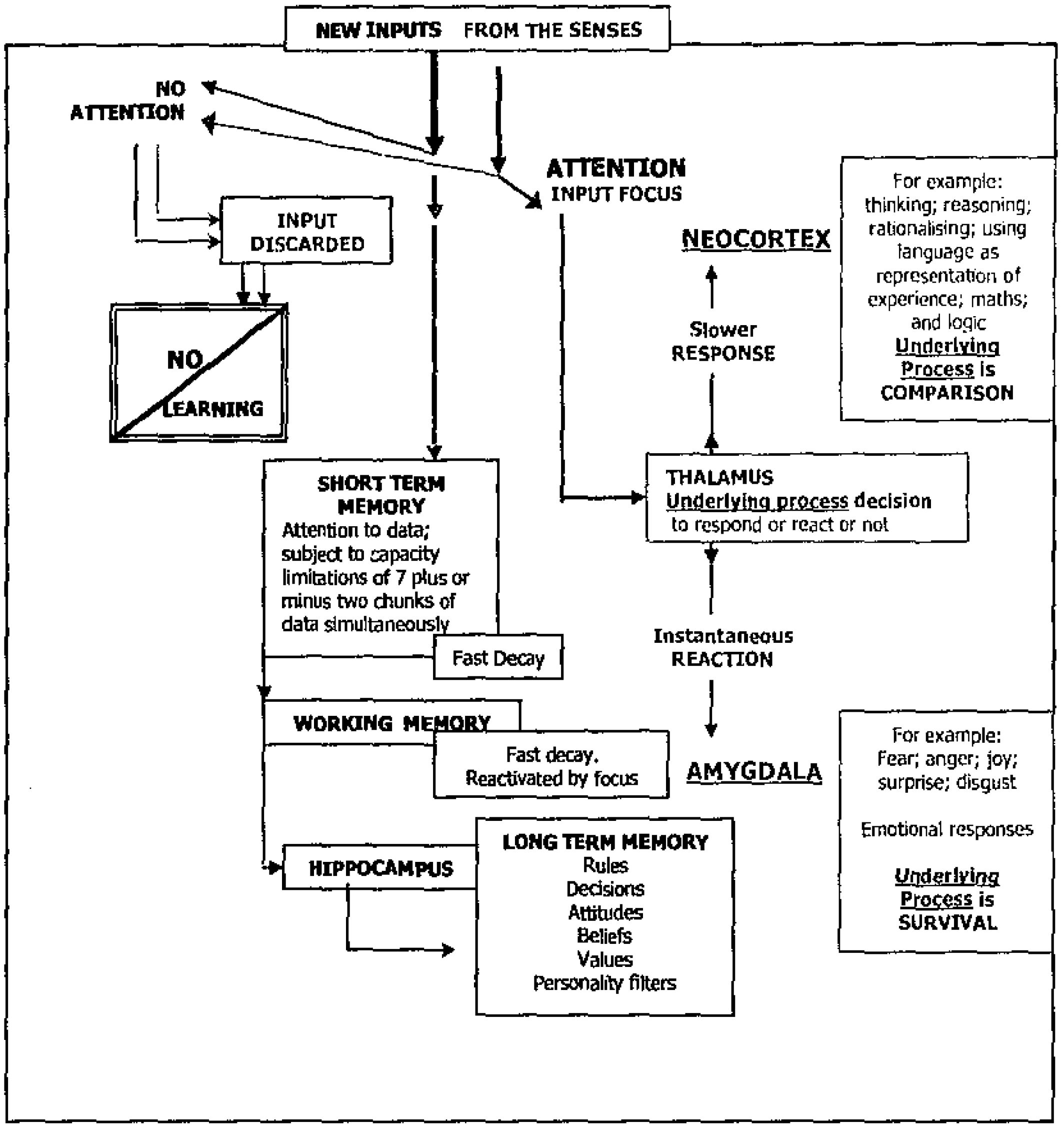

Diagram 2: Input pathway for both brain and cognitive functions

If communicators, including teachers, are not aware of how their communications are directing the brains of their hearers the communications may not have the expected effect. Neurolinguistics (Global NLP Trainers Alliance, 2001) tells us that the meaning of any communication is the response it generates.

Communication skills are essential for anyone wanting to be effective in their dealings with people, especially professionals who are responsible for transferring knowledge, such as teachers, lawyers, medical professionals and those in social services. If the intent of the speaker

is to provoke a thoughtful response and they use words, body language, tone or pitch that evoke emotional survival responses the immediate reaction excludes any possibility of logical rational thinking, and the communication has not fulfilled the intent. At this point an aware teacher will find another way to express the communication. All too often teachers do not have enough knowledge about brain functioning to realise when they are instigating survival reactions that cause students to resist communication. Much of the work done on emotional intelligence (Bennett-Goleman, 2001; Goleman, 1996, 1998) spells out the brain's two processing styles for new inputs and with Piaget's model of the evolution of schema they lay the learning foundations for this study.

2.1.2 How do individuals extend and evolve their world view?

> Whatever their labels [schema] they form a kind of framework onto which incoming sensory data can fit – indeed must fit if they are to have any effect; but it is a framework that is continually changing it's shape so that as many data as possible *will* fit (Phillips, 1975, p12).

How individuals expand and change their world view covers both intellectual and biological aspects of learning. Fuster (2003, pp14-16) calls an item of information about the self or the environment and the relations between them a 'cognit'. Hence a cognit constitutes both the new input and perceived connections to existing knowledge. He explains that cognits are the building blocks of cognitive networks. Other names for these networks, which form the basis of an individual's world view are, *cognitive maps* (Dilts & Bonissone, 1993) or *schema* (Taba, cited in Hunkins, 1973; Ostergaard, 2004). The term chosen in this thesis to be used for the network of knowledge around a certain context is *schema*. This paper could well have used the term *cognitive map* because it focuses on use of language which is representational of actual events the same way as maps are representational of actual places but schema is a well understood term in education so this term is used to facilitate the reader's understanding.

A schema is not a specific 'thing', it constitutes a network of related ideas that have been ordered to facilitate understanding. A schema is all the current knowledge about a certain piece

of information, it is a cognitive map about that information. In the physical brain it is a neural network with chains of information completing the network. As new data comes into awareness it must be either accepted into an existing map without changing it much, [in Piaget's terms this is called *accommodation* (Phillips, 1975)], or it expands an existing map, adding to the reference experiences contained within it [Piaget called this *assimilation*]. Whichever way the new input is cognitively sorted the brain's constant search for balance assures that it will be integrated into the individual's model of the world, becoming a new reference experience through which incoming data will be filtered. This is Piaget's terms is *equilibration*.[14] The construction and evolution of schema occurs when one piece of information is built upon another, this is why it is impossible to teach a topic unless there is existing knowledge to build upon (Sousa, 2001; Zink, 1998). The building of schema acknowledges that all meaning is contextual and for learning to occur both meaning and relevance are essential. The motivation for learning is innate as the brain has "...a persistent interest in novelty" (Sousa, 2001, p27). Rough expressed it another way, he says:

> A structure. Choice creating, is presented which identifies a sequence of thinking. This is not a static, step by step process the facilitator takes people through, instead it is a framework to guide the facilitator in supporting the natural creative process to unfold (Rough, 1997, p3).

Carter (1998, p21) explains that the frontal lobes 'kick in at about six months, bringing the first glimmerings of cognition", and that after the age of one they are "gaining control over the drives of the limbic system". According to Piaget (Casti, 1989; Phillips, 1975) children between the ages of two and five are beginning to use symbols in the form of mental images. During this period they begin to reason from memory and use analogies. As their language develops their memory, and therefore their schema, becomes more complex. They are as yet unable to predict events and much of their processing is still sensory. Between the ages of six and sixteen they start to process cognitively. Everyone, even adults, continue to receive their inputs through their senses. The difference is that adults act on their sensory input with greater

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[14] Equilibration (balance) occurs when new input has been successfully incorporated into an individual's model of the world and now expands his/her reference experiences (Casti, 1989, 240).

sophistication than children because they have more sophisticated schema. Diagram 2 below is an example which illustrates the cognitive process of expanding schema by the addition of new input.

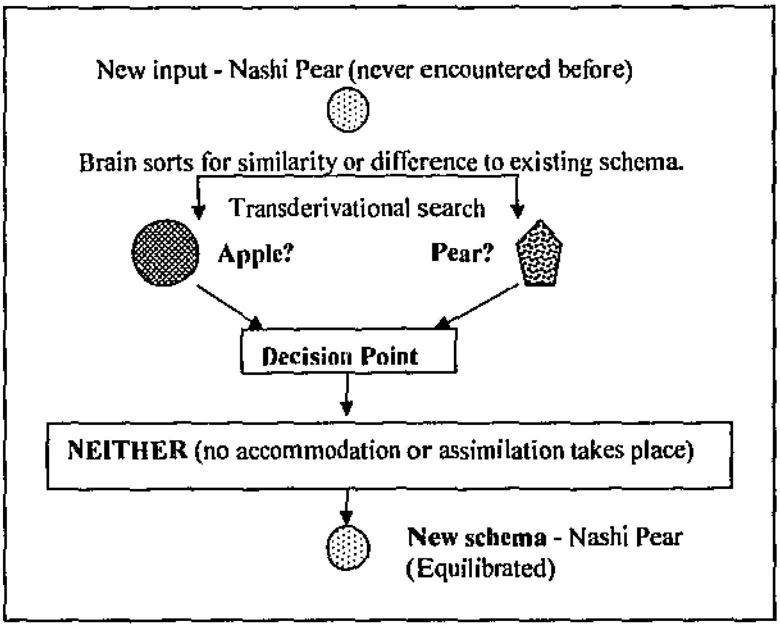

Diagram 3: Piaget's model of learning.

2.1.3 What is the difference between memory and knowledge?

> Great is the power of memory, exceedingly great, O my God – a large and boundless inner hall! Who has plumbed the depths of it? (Augustine, cited in Bourtchouladze, 2002, p26)

The literature on memory makes a distinction between memory and knowledge (Fuster, 2003, p112). It could be said, in simplistic terms that the main difference between memory and knowledge is the impact of time on the information. Connectionist theory (Fuster, 2003, p56) explains the reason for the decay of short term memory is that it requires attention, rehearsal and repetition before the neural networks are established or strong enough for the memory to be stored in long term memory (knowledge). Long term memory, or knowledge, forms a basis of all intellectual functioning so any study of instructional techniques demands an understanding of memory and how access to memory occurs.

"Memory is the capacity to retain information about oneself and one's environment (Fuster, 2003, p111)". Carter (1998, p263) explains that "Memories are groups of neurons which fire together in the same pattern each time they are activated" Therefore our memories help us to adapt to our environments by processing data from sources which are both internal (memory) and external (environmental, and sensory based) (Fuster, 2003). The function of memory as a survival tool is the capacity to receive sensory input and 'make sense' of it, thereby building reference experiences that provide a model of behaviour for similar experiences in the future. This process expands or evolves an individual's model of the world and this expansion is called 'learning'. Casti (2000, p99) tells us that these stimuli are needed to organise the brain into schema which forms the basis of learning.

There is a unanimous description in the literature on memory as it applies to the way the brain stores and retrieves data. Some of it is very technical naming all the neurotransmitters which convey the data from one area to another in the brain (Fuster, 2003). Other writers weight their writing towards the usefulness of the model of memory to human interaction (Bandler & Grinder, 1975a; Collingwood, 2001), and both Souza (2001) and the National Research Council For Education (2000) have specifically described memory as it relates to the education of students in classrooms.

One of the difficulties with much of the literature is that knowledge of the brain has been developed by studying the effects of brain injury and lesions in certain areas. Fuster (2003, p56) tells us that for a 'long time' the study of the effects of brain lesions were the only ways of examining brain function. The study of brain damage has provided information about which areas of the brain process which different kinds of sensory input. fMRI (functional magnetic resonance imaging) technology and the new MEG (Magnetoencephalography) which can provide 4000 images of brain functioning per second in a non invasive way is expected to open many doors to understanding the brain's processes better (Sousa, 2001, p2). This will be particularly interesting as, for the first time, we will be able to see exactly what is happening in

the brain during normal human interaction. We will be able to see what is happening when one human being is attempting to transfer knowledge to another.

To facilitate understanding of fine distinctions between categories of the models of memory it is useful to use the analogy of a computer. Short Term Memory (STM)(Bourtchouladze, 2002) is like the RAM on a computer, holding the data for a short while but with limited capacity. Working memory (WKM) is like the desktop, holding information within easy reach. However not all is 'active' at the same time, and activation is by focus. Long Term Memory (LTM) is likened to the hard drive. The LTM is the basic knowledge that determines an individual's model of the world, it encompasses decisions, perceptions, attitudes, beliefs, values and personality filters and makes up the schema.

As more is learned about mental processing the model of memory is evolving. Souza (2001, p41) splits STM into two parts. He suggests Immediate memory (IM) is like the clipboard which holds new sensory inputs briefly while the Thalamus decides which part of the brain to send it to for processing. Other researches do not split the Short Term Memory(STM) in this way Bourtchouladze (2002) and Fuster (2003) describe the first reception of new input to STM, which is characterized by its very limited capacity. Exceeding the capacity of STM leads to feeling of being overwhelmed and confused. Miller (1955) explains that the maximum capacity of adults is 7 plus or minus 2 pieces of information at any one time. This is easily demonstrated by efforts to remember lists of unrelated objects. After five objects the recitation of the list slows, after seven it slows further and stalls after a maximum of nine objects have been named. Sousa (2001) applies Miller's capacity not to (STM) as other researchers do (Bourtchouladze, 2002; Council, 2000; Fuster, 2003; Sousa, 2001), but to Working Memory (WKM). This term was first introduced by David Olton, (cited in Bourtchouladze, 2002, p73) to describe a component of STM which allows us to remember some data for a short time while we use it, for instance, remembering phone number while we dial and forgetting it seconds later.

Many parts of the brain are used for memory and researchers agree that the hippocampus (located near the limbic section of the brain) plays a major role in moving information from WKM to LTM (Carter, 1998, p151). Bourtchouladze cites O'Keefe and Nadel's (2002, p75) research which shows that behavioural changes occur when the hippocampus is damaged and these could be showing us that the hippocampus is involved in the storing of schema (LTM). They discovered that *displace units* in the hippocampus are concerned with memory related to activity. *Place cells* in the hippocampus maintain spatial memory, which if inactivated by injury makes normal life impossible. As further study is undertaken on the role of the hippocampus a deeper understanding of the specifics of its role in converting memory to knowledge might be better understood.

The complex process of learning needs some sort of trigger to start the process off. Sousa (2001, p46) explains that without the trigger of 'relevance' information is not processed by the hippocampus for long term storage, it decays fast, usually within 24 hours. Relevance is the reason teachers need to pitch their lessons at the student's current world view. If the material is too complex student learning cannot be triggered and learning does not occur. Good teachers layer their student's exposure to new inputs in such a way that both relevance and meaningfulness are triggered together.

MEMORY	KNOWLEDGE
ACQUIRED THROUGH EXPERIENCE.	ACQUIRED THROUGH EXPERIENCE.
New inputs cannot be encoded as a memory without existing knowledge providing a perceptual framework for it.	Interpretation of facts and their relationships through filter of world view.
	Made up of memories
Time sensitive, decays after a short time	Not time sensitive, knowledge is enduring.
'New' memory is interpreting the world through filter of schema.	New inputs form schema which constitute an individual's knowledge base.
Memories are cortical networks	Schema are cortical networks.
Memory is an associative function	Retrieval is dependent upon association
3 levels of processing, STM,WKM & LTM	Knowledge is stored in LTM

Diagram 4: The differences and commonalities between memory and knowledge

2.1.4 What is the Replicator Principle of information?

Education is the expansion of schema by the transference of information. In exploring the social aspects of learning an embryonic theory dealing with the issue of transference of information between people has been discovered. A new finding in neuroscience is the discovery by Ramachandran (Winston, 2002, p290) of mirror neurons. It seems the only function of these particular neurons is to copy actions, behaviours, words and attitudes. This discovery bears out the neurolinguistic model of rapport being the mirroring and matching of the actions between people. Winston also tells us that another name for the mirror neuron is the 'empathy' neuron and says it will do for psychology what the discovery of DNA did for biology. This important

discovery of a neuron that copies information may further strengthen the case for the existence of memes[15], which are replicatable ideas.

Aunger (2002) tells us that the transfer of data requires a 'copying' of information and specifies two forms of replication of data, those which replicate through an individual's own efforts and those which use an outside agency. In the context of the classroom the teacher would be the outside agent, or replicator. A person who is acting as a replicator is a catalytic force speeding change in others by making copies of the information, without being changed themselves.

There is a formula for replication: the number of copies made over the time taken to do so. In the classroom this formula applies to the number of student's in the class over the time period of the school year. Replication as described by Aunger (2002) is still theoretical, at this stage it is not known how much of it will be academically accepted in the future, but it is interesting and relevant to the study of learning so will be briefly included here.

Memetics suggests there is an information-bearing replicator (Aunger, 2002), hidden like a virus in people's brains which directs aspects of the communication process. Another possible description of a Meme therefore could be a thought virus which causes itself to replicate through the minds and mouths of communicators. Aunger (2002) compares the known forms of viruses, biological, cultural and electronic, to 'catching' ideological concepts from one another.

The question that underlies Aunger's work is "What causal forces underlie the communication of information? (2002, p13)". If we knew the answer to this question, teaching could be quite different. At present teaching involves trial and error, some things carry over into

[15] Meme The word was coined by Oxford biologist Richard Dawkins, (cited by Aunger, 2002, p11) tells us the word is taken from the words "memory", "mimetic' and "gene" . He defines a meme as "... a replicator residing in people's brains... able to reproduce themselves during transmission between individuals. Meme's arise as a consequence of social learning...". ... able to reproduce themselves during transmission between individuals. Meme's arise as a consequence of social learning...".

different contexts and groups successfully, and some don't. This is the 'art' of teaching, it is the non-prescriptive relational skills that teachers develop over time and through experience.

2.1.5 How is the transference of information effected?

> It means structuring the educational encounter in ways that awaken our students to life (Hunkins, 1989, p4).

Another author who also uses the theories of Memes describes three types of replicators. Gladwell (2000) explains the transference of information must be taken up by early adopters who will 'market' the idea to others. These are the connectors who have a wide network of contacts from all walks of life to whom information can be spread. Mavens, on the other hand, collect knowledge for the sheer fun of it. They can see the trends in their earliest phases. They introduce the information to strategic people (connectors). Thirdly, Sales people are the ones whose passion and commitment to the idea will speed its journey. The main attribute that salespeople add to information is the 'stickiness' that makes it relevant to other people.

In the classroom teachers need to be concerned about the 'stickiness' of their information and involving students through the use of questions is one of the ways this can be achieved. There is no stronger force for the transference of data than a trained, impassioned teacher who is committed to the educational journey of every single individual in the class and is prepared to do what it takes to achieve this. When teachers realise that knowledge is more than an accumulation of more and more facts and "...learning needs to be conceived of as something a learner does, not something that is done to the learner (Fosnot, 1989, p4)". McCarthy (1996) discusses salesmanship in the classroom as one of the important roles a teachers plays when teaching. She explains that the first role is 'salesman' because it sets the relevance, or purpose of the lesson and links it to the students' current models of the world. The next role is that of 'teacher' which specifies the content. Following this is the role of 'coach' which shows students the 'how' of the lesson, how to use the content. The final role is that of 'mentor' which helps students to cross contextualize and expand the knowledge, making it their own.

To conclude, the answer to the questions 'how do people learn?" is multi layered. Learning constitutes complex physical, intellectual and social influences using both the physical structures of the brain and the cognitive structures of the mind. The way that people learn is by expanding their existing world view which comprises reference experiences of every sensory input they have received to date. This input is equilibrated into their schema through a process of accommodation and assimilation which results in expanded cognitive maps (schema) which people then use to run their lives. Carter (1998, p312) define thinking as "...holding ideas in mind and manipulating them". The literature reveals an understanding of the processes of manipulating data as input, emoting, thinking, encoding and accessing memory. This sequence of events distinguishes humans from other animals. All animals receive and process data in some way, and some of them display memory to a lesser or greater extent. It is the human ability think, to formulate concepts, to build a map of reality and apply it to his life that makes man able to make choices, to change the map and evolve his thinking to a higher level. Corbalis (1991) explains that some thinking skills have come about because humans developed language. Language and the ability to make cognitive maps are central to the recognition of discomfort resulting from expectations not meeting reality. It is this awareness that motivates the integration of new inputs and cause learning to occur. The role of a teacher is to expand the schema of every single student the class.

2.2 QUESTION 2 : WHAT IS THE DIFFERENCE BETWEEN BRAIN AND MIND?

> Functionally, however, the neo cortex is always incomplete. Life experience will continue to change it, especially at the synaptic level, and to increase the range of its functions (Fuster, 2003, p37).

The brain is an organ made up of atoms and molecules located inside the skull. An adult brain weighs about 1.4 kilos, and is divided into left and right hemispheres. The brain has a large, highly convoluted surface area covered in cortical tissue. Initially the brain was not considered to be an important organ, people could see the heart beating or the kidneys excreting but they had no idea what function the brain performed. It didn't appear to 'do' anything, and was not

thought to be the seat of reason. Ancient Egyptian morticians did not preserve it as they did other organs, they thought so little of it that they scooped it out through the nostrils and threw it away (Gellatly & Zarate, 1998, p13). Changeaux, (cited in Corbalis, 1991, p132) suggests that in order to be able to adapt, make selections, there must be some extra capacity in the human brain and that building experiences one on top of another allows for complexity. In his introduction Fuster tells us that "A cognitive order, no matter how it is construed cannot be causally reduced to a brain order (2003 pix)" and that neuroscience has failed to make causal connections between brain and mind. This means that it is not possible to equate all possible actions of the mind to functions in the brain, with our present state of knowledge.

In the brain, neural networks form to carry contextually similar inputs which can be seen as 'lighting up' on scans when they are active (Sousa, 2001, p2). The network model of cognition (Fuster, 2003, p112) is widely adopted for ease of description when it was realised that cognitive functioning was not necessarily a serial process and the neo cortex is never 'full' or 'finished'. As long as they are being used these networks grow to equilibrate new inputs, but if they are not used they decay (Fuster, 2003, p112).

Aptosis is the name given to the brain's 'pruning' of obsolete neural networks based on it's experiences (Sousa, 2001, p23). This building up and breaking down of neural networks is called brain plasticity. Plasticity is the reason that new inputs can physically change the structure of the brain. Plasticity explains the exciting prospects for every individual to 'grow' their brains from conception to death by being exposed to new sensory inputs (Greenfield, 2000, pp51-56).

Thinking, as we know it today, was not practised by ancient peoples, the only people who 'thought' were those who were fortunate enough to receive an education. The common man lived simply and did not have to make complex decisions or do complex planning, they lived by reacting to external stimuli, and doing as they were told. This way of living is not appropriate in

the present technological age where each individual is valued and expected to make choices. This means everyone has to know how to think.

The concept of 'mind' was an invention of literate Greeks at the time of Plato and Aristotle. They "... created a space in which to house thoughts, intentions and desires. This metaphorical space was first called the **psyche**, but is now called the **mind**" (Gellatly & Zarate, 1998, p9). Ancient philosophers worked with this concept and 'invented' many functions that could be carried out by the mind. People started to study other people and explain their observations as if the mind were a 'real thing'. We cannot be sure of what the mind 'is', we can only perceive it through the observation of what it does. Once this was agreed Lev Vygotski (Goldberg, 2001, p9) who is regarded as the founder of neuropsychology, could study the functions of the mind by studying language, memory and cognition.

With the present state of our knowledge a definition of 'brain' could be: an organ located within the skull which we know to be responsible for more mental, spiritual and physical actions than we can comprehend. Likewise a definition of 'mind' could possibly be: a complex theoretical description of the function of an individual's sensory experience of the world we live in, and the actions each individual chooses to take in response to those stimuli. This paper examines both the brain and the mind as it explores eye movements and their role in responding to questions.

Neuroscience now studies both brain and mind in a search for functional and cognitive links. This work was much advanced by researchers in the nineteen nineties during the so called 'decade of the brain' (Sousa, 2001, p2). Only recently has it been possible to examine the brain in a non-invasive way while it is actually processing inputs. An fMRI scan shows brain activity by measuring blood flow to specific areas of the brain and this means researchers can 'see' which part of the brain is being used for specific tasks (Sousa, 2001, p2). "The brain scans showed that the normal participants used quite separate regions of their brains to work out each

answer (Carter, 1998, p235)". Thus the link between different areas of the brain activated by different sensory inputs is now well established, and at last we can observe some aspects of the 'mind' in action.

Sensory information is processed in very particular areas of the brain. Goldberg (2001, p 53) tells us that visual processing occurs in the occipital lobe located in the anterior part of the brain. The auditory centre is the temporal lobe, the left hand side of which processes sounds, speech and some long term memory, and the motor cortex which processes kinaesthetic input is in the central part of the brain, called the parietal lobe. He also explains that although the *sensations* are received into these areas the *interpretations* of that sensory input from the environment are processed in areas contiguous to those specific areas. This might explain the concept of synesthesia, which is the simultaneous reception of data from more than one sensory channel. Predicates can indicate synaesthesia though comments like: "I feel (kinaesthetic) the chicken is cooked when it smells (olfactory) pointy (visual)". Cytowic (1993, p77) tells us synesthesia is important for learning because it makes new inputs memorable, that is, 'sticky'. "The more sensory channels that a memory accesses, the more complete the recall will be (Woodsmall, 1988, p61)". In Pribham and Devore's model, synaesthesia is indicated by eyes staring fixedly straight ahead (Woodsmall & Oka, 2000, p112). Cytowic (1993, p76) explains that synaesthesia is characterised by focus close to the face or in the space immediately surrounding the body, and not at a distance. For the purpose of this study the neurolinguistic model, describing staring ahead as an indication of visual processing has been chosen because it was impossible to assess the distance of focus from the video footage.

In conclusion the question of the difference between mind and brain it might be easier to look at what the brain is not. The brain is not the seat of reason; if you allow the brain to run your life the only possible agenda is survival. The brain is a physical electro-chemical organ whose primary reason for action is survival of the organism. The development of higher cognitive skills such as social strategies, relational skills, intellectual abilities, and higher

emotions such as happiness, calm and satisfaction could be said to be under the control of the mind.

My mind coaching practice has shown that it is difficult for some people to understand that in order to exercise their free will, people's minds need to be the boss of their brains. Another way of putting this could be that people can moderate their emotional reactions by choosing a different response. Like electricity, the mind is not visible, also like electricity it has enormous latent power. Another quality that electricity and the mind share is that the effects of their existence can be seen. The mind starts a flow of energy to the body when it decides to take an action, in the same way electricity needs a trigger to start the flow of current before it can light a bulb. Sceptics who use the excuse that they don't believe in anything they can't see, could refuse to believe in the power of their minds. This approach means they get exactly what they do believe, their brain runs the show and they end up fighting themselves most of their lives. I believe that questioning everything is not scepticism, questioning everything is evolution, without questioning growth is not guaranteed.

Acknowledging that the mind is an important part of every single individual's life and that maturation is the result of making choices gives some credence to the notion of education. Education is a social structure instigated to provide the minds of our children with reference experiences that will mature and develop them. The interesting finding is that as their minds develop, so plasticity changes their brain structures. As focus is turned onto a subject or skill, plasticity adds to the neural networks that make such skill development possible. It is exciting to think that, as a teacher, you can change not only the minds of your students, but their brains as well. Teachers fulfil an important role and can find satisfaction in the fact that their words and action really have made a difference.

2.3 QUESTION 3 : CAN CONNECTIONS BETWEEN THE BRAIN AND EYES BE ESTABLISHED?

"Questions asking is a natural human behaviour (Hunkins, 1989, p19)".

It is quite likely that in a few decades the 'advances' we have made in brain science could prove to be as immature as those of the ancient Egyptians. The state of our knowledge at the moment is all that is available to work with so we move now to a review of the literature on the current understanding of the connection between brains and eyes.

The eyes are directly connected to the brain, and are an extension of it. In common usage is the phrase 'the eyes are the windows of the soul". This attests to a current view that through the eyes one can glimpse the heart and mind of another – and how is this achieved?

We all learn at an early age to observe others and make judgements about what we perceive. This is a normal part of human interaction and can cause misunderstandings, conflict and disruption if our interpretations are not based on sensorily verifiable information. One of the ways we receive this information is through observing others closely. We have all learned that people move their eyes about constantly. This study aims to discover what, if any, importance eye movements have for teachers as they observe their students responding to classroom questions.

In the 1970's Bandler and Grinder (1979) observed eye movement patterns as people responded to certain sensory based questions. They built a model of eye accessing cues which has provided useful grounds for discussion and research. Nate (2004) verified their data, finding that regardless of age, gender or ethnicity, the eye movements shown in response to visual, auditory and kinaesthetic questions were consistent with Bandler and Grinder's model. Woodsmall (2000, p112) cites Devore and Pribham as separating the functions of body sensation recall and memory of emotion into two separate eye movements and added two more

sensory related eye movements, those relating to the processing of inputs of smell and taste. Because this study focuses on the number of eye movements generated by each question the two eye movements relating to smell and taste have been added to Bandler and Grinder's original model. Below is a representation of this model, with the addition of the olfactory and gustatory eye movements shown in grey.

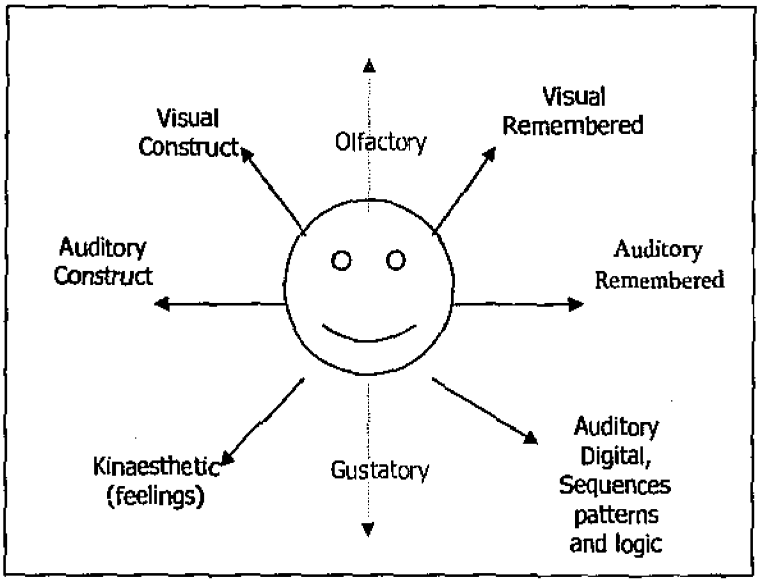

Diagram 5: Neurolinguistic model of eye accessing cues. (Bandler & Grinder, 1979, p25)

Bandler and Grinder decided to label their findings not after the accepted psychological terms of the day, but used labels which defined the functions they were describing (Bostic St Clair & Grinder, 2001, p273) and which would not carry "...undesirable theoretical baggage". Hence the term 'eye accessing cues' was developed to describe brain activation through interpretation of eye movements. Goldberg (2001, p49) verifies that eye movements are indicative of activity in certain areas of the brain.

Dryden and Vos (1999, p130) have described student learning styles as visual, auditory and kinaesthetic and (1999, p362) they explain how to observe patterns of eye movements as indicators of learning styles in the same way as Grinder and Bandler do (see diagram 5). Their term 'learning styles' describes the particular sensory representations people use to process

inputs. The term is well understood in education and for this reason it has been adopted in this thesis.

Another aspect of eye/brain connection is that by simply moving the eyes in certain ways specific areas of the brain can be activated. This is a technique I frequently use in my practice when it would be useful for a client to change their perspective on an issue. I encourage reframing by activating a different area of the brain. For example: When a client is emotional and feels trapped in a particular circumstance their eyes are usually looking down. The simple neurolinguistic technique of getting them to look up deactivates emotional thinking and activates the visual cortex, allowing them to step back and gain new perspectives. Information on this aspect of eye/brain connection is contained in the literature about a form of cognitive therapy called EMDR (Eye Movement Desensitization and Reprocessing) cited in Bond (1999c, section 9, p4). This technique uses very fast eye movements to stimulate various areas of the brain resulting in the detachment of emotions from memories. Ramachandran and Blakeslee (1999, p168) speak of the functions of the amygdala and the visual centres that project to it: they say: "... scientists recording cell responses in the amygdala found that, in addition to responding to facial expression and emotions, the cells also respond to the direction of eye gaze". They also discuss the role of eye gaze in social interaction and remark that one way we interact with others is through the eyes.

The basic premise of this study: that observing eye movements generated in response to questions can show how many areas of the brain are involved in responding to questions. The connection between brains and eye movements occur in both directions. Specific eye movements can cause increased blood flow to specific areas of the brain and that increased blood flow to specific areas of the brain can cause the eyes to move in certain directions. "...blood flow level reflects the level of neural activity (Goldberg, 2001, p49)" and Greenfield (2000, p23) tells us "The harder working the brain region, the greater it's consumption [of brain nutrients] and the greater the blood flow to that site". The sensors in PET scanners monitor the

levels use of oxygen and glucose different parts of the brain are using and the '... most active areas of the brain literally light up in colour" (Greenfield, 2000, p23). This is important to know because eyes can reveal not only <u>when</u> areas of the brain are working, but also <u>which</u> and <u>how many brain areas</u> students are using to process information.

For teachers who include working with learning styles in their instructional techniques this information provides important verification of the 'readability' of eyes. Not only is it possible to see whether their students are making meaning from their experiences via visual, auditory or kinaesthetic learning styles. It is also possible to notice the number of eye movements a student makes in response to questions and discover their level of engagement. This information can increase communication at all levels in all contexts for those who use it.

2.4 QUESTION 4 : WHAT HAVE OTHER RESEARCHERS FOUND OUT ABOUT QUESTIONS AND RESPONSES?

> "The types of questions that elementary and secondary school teachers ask and the techniques and strategies they employ can make the difference between reflective, active learners and parroting passive learners (Wilen, 1987, p89)".

Before we look at the links between questions and eye movements we will review the literature on questions and responses, beginning with the assumption that questions are the guides for any quest and that one way of intentionally evolving the students' models of the world is through the evolution of schema by questioning. Hunkins (1989, p19) describes questions as "...a natural human behaviour". Wilen, (cited in Hunkins (1989, p30) defines a question as "... a specialised sentence possessing either an interrogative form or function" and Babbie (2001) tells us that questions should fully support the student's quest for transformational change.

Many researchers (Brualdi, 1998; Carin & Sund, 1971; Carlson, 1991; Dillon, 1983; Hunkins, 1973, 1989; Morgan & Saxton, 1994; Roth, 2002) have turned their attention to questioning as an instructional tool. Hunkins tells us that questions do cause some sort thinking to occur (1989,

pp30-36). The purpose of this study is to examine whether <u>specific forms of questions</u> can cause <u>specific types of thinking</u> to occur. This review investigates the forms that questions take and the roles they fulfil in education. Questioning is one of the most frequently used teaching techniques in the classroom (Dillon, 1983). Questions and thinking are linked in the literature. Hunkins specifically expresses this when he states that questions are not to be used as a tool for eliciting correct responses, but rather as a means to elicit student thinking.

The Collins Dictionary (1998, p1205) tells us the conventional meaning of the word 'thinking'; "...to exercise the mind as in order to make a decision, to ponder...to make mental choice...to consider carefully before deciding". So in dictionary terms thinking encompasses choice. In neuro-scientific terms thinking is called 'reasoning' and the following definition of reasoning is offered by Fuster (2003, p226): "Reasoning is the transient propagation of rhythmic patterns of activity through the system, each pattern representing an item of knowledge. The essence of the reasoning process is the matching of incoming temporal patterns to those patterns inherent in sub networks that represent specific long term facts"[schema].

The literature discusses different aspects of thinking in relation to high and low convergent and divergent thinking processes and the questions that activate these skills (Hunkins, 1973). Wilen (1987, pp70-74) discusses both convergent and divergent thinking skills as essential for the student to move up the ladder of learning that climbs alternately from cognitive to affective domain. He speaks of teacher's concern with 'right' answers on one hand and questions which encourage student reasoning and critical thinking as another form of questioning.

Morgan and Saxton (1994, p43) divide questions into categories of function. Their Category A questions are used for eliciting information and their Category B function has questions which focus on making connections (Morgan & Saxton, 1994, p245). Another way of describing these two functions could be to speak of content based functions and processed based functions.

Research into the form of questions has complex explanations on both the use and the framing of questions (Austin, 1966, p142). Bennett and Rolheiser (2001, p77) describe Bloom's taxonomy which sets out the steps from knowledge to evaluation to help teachers frame questions at different cognitive levels Wilen, (1987, p164) cites Singer's proposition on the VAIL Questioning strategy: Verification (encoding the data) of the Assertions (accessing memory of the data) and Implications (comparisons) of Language (response). These models can provide frames for teachers to formulate questions but do not impact on this study which is trying to find the form of questions which facilitate a Transderivational Search (Battino & South, 1999, p69) of schema to equilibrate new inputs. When questions cause a student to access their own schema and consider new data in the light of their own value structure the resulting adaptation causes the ability to compare data and make a decision based on that comparison. Whether students think deductively like Sherlock Holmes, syllogistically like Aristotle or predictively like Walt Disney, they are all 'thinking".

Goldberg (2001, pp77-83) discusses the issue of brain response to questions and categorizes them in the same way as other researchers have, except that he calls factual (content) questions 'veridical questions' because they deal with facts, or 'the truth'. He calls high divergent (process) questions 'adaptive questions' because they cause the hearer to access their model of the world and adapt it to accommodate the new inputs, making choices according to "...what is good for me" (p79). He speaks about classroom questions as those that intentionally generate problem solving and points out that outside the classroom the sorts of questions that people encounter are more ambiguous, and involve more choices based on the beliefs and values that constitute their world view than questions in the classroom do. Winnie, (cited in Wilen, 1987,p32) thinks there is no difference in learning whether the teacher uses one form of questioning or another. The purpose of this study is to explore whether or not the form of teacher questioning does impact the number of areas of the brain that students access when formulating responses. Also, whether a decision triggers the acceptance of information, or not. Both Rosenshine (cited in Wilen, 1987, p32) and Goldberg (2001, p79) say that low cognitive

questions do promote student academic achievement because the students show they have mastered the facts the teacher requires. They also agree that this sort of questioning does not give the students skills for life because most of the questions students will meet in life are process questions with highly unpredictable answers.

To facilitate understanding of this thesis the terms to describe the forms of questions teachers use will be taken from Morgan and Saxton (1994). In Chapter seven, in their glossary of questions, they describe closed questions as those which may be answered in affirmative or negative, and open questions are those which suggest the teacher does not have a particular answer in mind. Sullivan, Warren and White (cited in Davis & Forster, 2003, p7) tell us that open questions "...allow more than one pathway, response, or line of reasoning .... Open-ended questions can also be distinguished as being content-spec ..." Hilda Taba, (cited in Wilen, (1987, p13) discusses the form of teacher questions as being set by the teacher's 'expected level of response' which in turn controls the student's 'response pattern'.

This opens the review to opposing views on the purpose of questioning. Dillon (1983) explains that, in his view, 'why?' questions are usually counter productive because they discourage expression of thought by causing the hearer to waste mental resources by trying to work out what the speaker wants to hear. This is a description of a closed question.

The literature (Morgan & Saxton, 1994) suggests questions have many uses in the processes of human interaction in general and classroom practice in particular. Dilts (1999, pp 45-46) says that questions can positively 'reformulate' criticisms by orienting the listener towards information they have not considered or do not have access to. He explains that providing feedback through questions is more generative than delivering statements. An example of what he meant could be to ask a question like this: "How would your answer change if you knew that there is one mammal that lays eggs?"

Dillon (1983) discusses questioning as a social constraint. In assessing society's rules of questioning, he explains that not only are we socially required to reply, it is conventional for us to give only the information asked for. This is verified by Goldberg's statement that "Our whole educational system is based on teaching veridical decision making... (Goldberg, 2001, p83)".

Dillon also says it is harder to ignore a question than a statement because convention allows a questioner to repeat questions, whereas statements should be said only once. Battino and South (1999) would disagree. They postulate that if it is necessary to repeat the same question there must be a reason for the hearer's lack of response. Either the hearer has not understood the question and repeating it in the same words and tone will not clarify it for him/her, or perhaps, the missing element is rapport and further efforts should be made to develop it before asking the question in another way. The pre-supposition which guides this view is "The meaning of your communication is the response you get (Bond, 1999b, p10)".

One view is that questions demand passivity by limiting communication to the speaker and hearer and that they could have a "...negative effect on cognition, affective and expressive processes (Dillon, 1983)". The constructivist view which forms the basis of this thesis asserts that questions have exactly the opposite role. Oldfather, West et al. (1999), tell us that questions direct the mind of the hearer to their schema in a search for a match to accommodate, assimilate or equilibrate the new data (in this thesis these type of questions are called 'schema accessing questions'). The contrary view of other researchers is that questions are used to "Arouse interest and to motivate children to participate actively in the lesson" (Carin & Sund, 1971. p23) and what they are describing here is the form of an open question.

The intent of the question is paramount to the response it generates. "In every work regard the writer's end, since none can compass more than they intend (Pope's essay on criticism, cited in Allan, 2001, p475)". Some questions direct the hearer to deliver content answers and others encourage the hearer to become engaged in process thinking. Content is infinite, and organized

on a descending hierarchy of appropriateness. Process thinking is always appropriate to the specific individual and may bring insight not revealed by the facts of the matter.

There are other uses for questions, such as embedding suggestions or pre-suppositions; this has the effect of softening the command, removing the emotional, protective, survival context and directing the question to the cognitive domain (Goleman, 1996). An example of softening a command by embedding it in a question could be one used by the teacher in the lesson on

Line 1: **"Shall we get started now?"**

When responses are not at the level required, teachers can use further questions to bring student thinking up to the expected level. If the question is directed in a non-threatening way it could trigger a generative response. An example of this sort of question could be: "What haven't you done yet, that you can do? (Battino & South, 1999, p82)".

Other questions can be used to help students evaluate their own academic, social and worldview, strengths and weakness by directing the student's mind to his own internal resources. Encouraging self evaluation can turn a content question into a process question. An example of this is a question I use in mind coaching: "I'm curious to know what you think about the way you decided that."

The art of asking masterful questions demonstrates understanding of other people's world view, smoothing the way for rapport and relationship. Teachers can learn to generate questions to direct the minds of their students in particular ways. Asking the right question at the right time and in the right way is not necessarily automatic, it is a learned skill, demanding very clear intent. The presence of mind required to reflect on a question is not practical in the moment to moment exchanges in the classroom. Teachers have all their STM engaged with so many students demanding their attention. This is why it is important for simple tools to be developed

to provide teachers with questioning skills that can easily become automatic. When this happens the teacher will not be using any of her limited chunks of STM for figuring out how to ask particular questions, as the questions will be automatically and elegantly generated.

2.5 QUESTION 5 : DO QUESTIONS GENERATE EYE MOVEMENTS?

Any person, asked about the eye movements they observe in others is aware that eye movements do occur in response to normal communication, to both questions and statements. Work on eye gaze direction shows that it is a very important aspect of human interaction and something that we all learn to read at a sub conscious level (Ramachandran & Blakeslee, 1999, p168). We know, from personal experience, for instance, when someone is distressed, we notice they are looking down, into their feelings and we even have common phrases which indicate that awareness. For instance the phrase 'it's down right disgusting' shows that in order to feel disgusted we look down to the right (in Bandler and Grinder's model, see p 36, eyes are downcast to the right when accessing feelings).

The literature has more to say about the direction of eye gaze than about the incidence of movement. I could only find one small reference to the number of eye movements exhibited in response to questions. Woodsmall (2000, p111) cites research by Duke (1968) showing that subjects exhibit more eye movements when responding to 'reflective questions' than they do when responding to 'factual questions', I was not able to source Duke's original study.

We can therefore conclude that questions should generate eye movements, though the literature does not state this. It is the role of this study to determine if questions do generate eye movements.

2.6 QUESTION 6 : IS THERE A CONNECTION BETWEEN EYE MOVEMENTS AND LEARNING?

Processing of sensory input from the environment manifests in the brain as an increased flow of blood to the related 'working' area. Various types of stimulation, for instance reading and thinking can be seen on scans as increased blood flow to specific areas (Sousa, 2001, p2).

The brain is a constantly evolving organ which both changes information and is changed by it. This ability of the brain to reorganize neural networks, growing or retiring them according to new inputs is called *neuroplasticity* (Sousa, 2001, p3). Fuster (2003, p37) says "...cortical networks are the result of growth and combination of neural elements that develop in the in the cortical structure promoted by experience", and Souza (2001, p3) explains that "Teachers try to change human brains every day" (by providing new inputs which develop both schema and neural networks). The explanation of a connection between eye movements and learning is put forward because learning necessitates brain activity and brain activity both causes and is caused by eye movements.

2.7 QUESTION 7: CAN WE DRAW ANY CONCLUSIONS FROM THIS REVIEW OR FORMULATE A HYPOTHESIS?

A review of the literature on questions, brains, eyes and learning seems to reveal that there is a very strong two way link between brain and eyes: the movement of eyes can affect brain processing and the processing in the brain can be indicated by eye movements. Goldberg (2001, p49) cited in Martin, Wiggs and Weisberg 1997) has shown on scans that the level of brain involvement is greater when tasks are novel than when they are practised. This could mean that some questions in the classroom would instigate more brain activity than others and that those questions with a known answer would cause less activation than questions whose response demands consideration. If, as appears to be the case, the more movements the eyes make when responding to questions, the more areas of the brain are being activated, there are ramifications

for education. Because eye movements are easily observable the teacher could see what level of thinking student is using in the moment, and respond accordingly.

The hypothesis that emerges from this review of the relevant literature is for the formulation of a chain of events instigated by asking questions. This chain can be represented as follows:

Question	=	Eye movement response / or not	=	Brain activation	=	Learning

This brings us to the research question: <u>What do eye movements tell us about how students are responding to the form of teacher questions?</u>

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CHAPTER 3: METHODOLOGY

This investigation began by observing a classroom lesson of 38 minutes and 32 seconds. Those present were seven year 4-5 students, two teachers, and the researcher who was filming the lesson. The lesson was from the life and living section of the science curriculum on life cycles. The data examined was a video film of students' non-verbal responses to particular forms of teacher questions in the hope of discovering some non-verbal indicator that showed whether or not the form of teacher questions influenced the level of student thinking.

METHODOLOGY

3.1: Conceptual framework	**3.2: Theoretical framework**	**3.3: Method of data collection**	**3.4: Procedure**	**3.5: Ethical issues**	**3.6: Limitations of the study**

3.3. 1Participants: teachers
3.3.1.1 Attitude and manner
3.3.1.2 Communication skills
3.3.1.3 Non-verbal aspects of questioning
3.3.1.4 Intent embedded in the questions
3.3.1.5 Expectations for and of answers
3.3.1.6 Words teachers used to frame questions.
3.3.2. Participants: students

3.4 Procedure
3.4.1 Management of venue
3.4.2 Sound management
3.4.3 Psycho-social aspects
3.4.4 teacher/researcher discussion

3.6.1 Limitations of Scope
3.6.2 Limitations of filming

<u>Diagram 6:</u> Map of the methodology

3.1 CONCEPTUAL FRAMEWORK

This paper observes and reviews processes to do with questioning, thinking and learning. These topics are so vast and their influence ranges across so many different disciplines that it a tight conceptual framework to maintain relevance was necessary. I have a strong holistic philosophy which has influenced the views expressed in this paper. My approach is 'systemic' (Gerhardt, 2004, p9) because I believe people are open systems, influenced by their interactions as well as their environment. Another aspect of the holistic slant to this study comes from cybernetics which is a theory of feedback systems. Wiener, cited in Woodsmall (1992, pp-28-29), tells us

that "Feedback is a method of controlling a system by reinserting into it the result of it's past performance", he also says that "...all purposeful behaviour may be considered to need feedback". In my view, learning assumes a self corrective feedback loop, without it we would be unable to accommodate or assimilate external input. The question-and-answer instructional technique specifically utilizes feedback. Both Gerhardt (2004) and Woodsmall (1992) tell us that epistemological paradigms are changing. They tell us that the old paradigm is 'logic based', 'anticontextual' and 'reductionistic' and the emerging paradigm in the social sciences is 'non-linear', 'contextually based' and 'relational' (Woodsmall, 1992, p32). The new value system embraces evolving paradigms rather than the old model of sequential logical progressions. Accordingly this study applies cause/effect relationship in which the effect is noted before the cause. This means that observation of the response triggered an analysis of the question which caused it.

Questioning, as an instructional tool, fits very well into the generative learning model as discussed by Osborne and Wittrock (1983). They tell us that ideas develop from each individual's understanding of the world and that the world view of students is important because;

> The essence of the generative learning model is that the mind, or the brain, is not a passive consumer of information. Instead it actively constructs it's own interpretations of information and draws inferences from them (Wittrock cited in Osborne & Wittrock, 1983, p492).

Constructivism has been chosen as the conceptual framework for this study because it states that each individual, regardless of age, gender or ethnicity 'constructs' their own model of the world as a result of all the experiences they have had "What constructionism claims is that meanings are constructed by human beings as they engage with the world they are interpreting (Crotty, 1998, p43)".

Constructivist theory rejects the existence of ultimate reality and employs a subjective epistemology (Stufflebeam, 2001, p71). It could be said that a basic assumption guiding the

constructivist approach is that students are magnificent bundles of pure potential that need information to open them to their own possibilities. Conversely the behaviourist approach is more likely to assume that there is something 'broken' in the student who has to be 'modified', that is 'fixed' by punishment or reward.

This thesis is guided by the basic constructivist pre-supposition that each individual, regardless of any differentiating factors, including age, has a model of the world which they use as a map to guide their actions (Oldfather et al., 1999). This map is constructed and refined with each experience and is unique to that individual. The reward for learning is the brain's innate desire for novelty (Goleman, 1996; Sousa, 2001).

It could be that one of the causes of stress in the classroom might be the interaction of so many people, each believing that their model of the world, or constructed map of reality, is real. Unless educators have awareness of learning styles it is possible they could transfer data only through their own model of the world, for instance, if most of their own understanding is gained through the visual cortex a teacher could facilitate data transfer mainly in that modality. This would mean that auditory or kinaesthetic students (Dryden & Vos, 1999, p362) would not be catered for and would find the whole learning experience more difficult than if the teacher was aware and using all modalities. Using all the modalities to educate a group of young minds among which there are likely to be students using a range of learning styles could be described as 'coming from where the child is at'. A common understanding of this phrase, amongst teachers, however, could be consideration of age appropriateness. Not all teachers have an understanding that modality appropriateness is as important, or maybe more so than age appropriateness. Inflexible delivery of instructional material could result in a student feeling defensive about his/her own constructed reality and might lead to the automatic discarding of new inputs.

Although constructivism is not specific to the method of data collection or analysis the concept guides the assumptions that are implicit in the exploration.

3.2 THEORETICAL FRAMEWORK

As the data emerged the theoretical framework of grounded theory was adopted. Grounded theory attempts to make a model, or find patterns in observed data (Babbie, 2001, pp 284-5). Crotty (1998, p78) explains grounded theory as "... a specific form of ethnographic inquiry that, through a series of carefully planned steps, develops theoretical ideas". The theoretical ideas gathered through this study have lead to a model of awareness and intent for the formation of questions which could increase the effectiveness of questioning as an instructional tool. "Grounded theories, because they are drawn from data, are likely to offer insight, enhance understanding, and provide a meaningful guide to action (Strauss & Corbin, 1996, p12)". Whilst the data analysis was guided by a theoretical position identifying the importance of eye movements, the classification of the eye movements themselves arose solely out of the data collected. In other words, the data drove the development of categories as is appropriate in grounded theory.

3.3 METHOD OF DATA COLLECTION

Learning springs from curiosity – the need to know (Morgan & Saxton, 1994, p18)

3.3.1 Participants: teachers

The two teachers who agreed to allow a researcher into their classroom to investigate their student's responses to questions were motivated by their intense desire to educate effectively. They are committed to professional development and work constantly together to assess, motivate and inspire each other. These teachers volunteered to participate in the study and have been involved with the researcher in previous professional activities.

3.3.1.1 The teacher's attitude and manner

These dedicated teachers are caring and respectful of each student's world view. They did not engage in adversarial or belittling comments or questions. Previous experience in these teachers' classroom has shown me that this inclusive approach is the norm for them. The atmosphere in the classroom was conducive to thinking at all times. Goleman tells us that "... how a teacher handles her class is in itself a model, a de facto lesson in emotional competence – or lack thereof. Whenever a teacher responds to one student twenty or thirty others learn a lesson (Goleman, 1996, p279)".

3.3.1.2 The teacher's communication skills

The communication skills of these two teachers are well honed. They begin communicating at a point the students understand, and then move them carefully through every exchange from one stage to the next. This develops not only student thinking but also their life skill strategies (identified as working within the Zone of Proximal development in Vygotski's theory of development (Moll, 1990, pp349-357).

The communication styles of these two teachers are totally different but the intent of their communication is always aligned and clear. They communicate and work together very well to develop the young minds under their tutelage. In this lesson Teacher 1 was more energetic and caused students to have uptrend thinking which was proactive and energetic. Teacher 2 was quieter in her manner and she provided a balance with a calmer more considered way of interacting, encouraging students to ponder.

3.3.1.3 Non-verbal aspects of questioning

The tone and pitch of a teacher's questions dictate the amount of enthusiasm in the answer because the student's mirror neurons unconsciously match the style of the teacher (Winston, 2002). "A baby in the babbling phase is thrilled to have someone who will use the same sounds, with the same rhythm and tempo (C. Andreas & Andreas, 1989, p89)". The considered

responses that Teacher 2 engendered were slow, quiet and gentle, well suited to students who were processing kinaesthetically. Teacher 1 delivered questions calmly and with care but her vocal qualities were different to her co-teacher. She used a higher pitch, well modulated voice, delivered with higher energy and evoked excitement for the answers. These two very different styles are equally effective. The students have had nearly three quarters of the year to become accustomed to the teachers styles and respond well to both.

3.3.1.4 The intent embedded in the question

The teachers prepared the questions used in this lesson together. They were very clear on the purpose of the questions and their role in developing the intent for the whole lesson. They kept the lesson on task and appropriate for age. There were no misleading or distracting questions asked.

3.3.1.5 Expectations for and of the answers

The 'dip-in-and-ask technique' these teachers employ is guided by their expectation that each student is doing their own thinking and is ready and able to answer when called upon to do so. The expectation of focus and attention is built into their classroom practice and it shows. One of the first things I noticed in the classroom was the high level of attention the students gave the teachers throughout the lesson. There were no distracting behaviours, inappropriate comments to peers or signs of boredom. After contributing and concentrating for more than 38 minutes the students were showing signs of tiring, with one or two yawns, yet even in this state they were paying attention.

3.3.1.6 The words the teachers used to frame the questions

In this lesson the teachers used many questions, of five different types; these will be expanded upon and discussed in relation to the responses they generated. The words they chose to use

were either easily understood or explained, for example: Line 445: **"...quite a sophisticated relationship there - sophisticated meaning quite complicated".**

When the teacher used sensory based words all the student's eyes moved to the representational position indicated by her predicate, whether or not it was their own chosen learning style. For example: one student displayed an auditory processing preference during the lesson and when Teacher 1 asked: Line 551: **"And the animals in the environment would all disappear, wouldn't they?"** the student's eyes went straight to visual construct to 'see' them disappearing in her mind's eye.

These teachers allow for the fact that all students have different models of the world, and each comprise amazing bundles of human potential, just beginning to open to their own magnificence. They delight in expanding their students, encouraging them to engage in self-comparison and matching their results to their own goals.

3.3.2. Participants: students

The teachers were not given any criteria for choosing the students for the study. They were asked to do a random selection and they used the students who would be most likely to return their permission slips on time. In the first few minutes, as a preliminary to the lesson, the students were filmed as a group. It was explained to the teachers that an accurate gauge of learning styles was needed as a basis for later analysis of non-verbal responses.

In neurolinguistics observed eye movements usually conform to a pattern (Laborde, 1983, p59). (Please see page 36 for the diagram of the normal eye patterns which can be observed during thinking). Eye movements to the right indicate mental construction and eye movements to the left indicate mental remembering (Bandler & Grinder, 1979, p25). Occasionally, however, an individual is found to be exhibiting eye movements to the right when remembering

and to the left when constructing. At this stage of the study it was not known whether or not this phenomenon would be important to the analysis, so two or three questions were devised to ascertain how the students were moving their eyes in response to questions about remembering and constructing. At the same time they were closely observed to determine their preferred sensory learning style, as indicated by their eye movements (Laborde, 1983, pp58-67).

The teacher directed the students to 'remember in their heads' without replying to the questions: "What is the number of your house?" and "What is your age?" In response to both of these questions all the student's eye patterns clearly showed their eye movements tracking to the left when remembering something they already knew. Next the teacher instructed the students to 'make something in their heads' and then directed them to "Imagine your birthday number is THIS BIG – now imagine it is this small". All the student's eye movements tracked to their right. From this it was concluded that all the students' eye movements were tracking normally.

During this first examination of eye patterns it was also noticed that the four students seated on the right displayed preferences for one of each learning style; one visual (eyes up when thinking) one kinaesthetic (eyes down to the right when thinking), one auditory digital (eyes down to the left when thinking) and one auditory (lateral eye movements when thinking). These four students were purposively selected out of the group of seven, and the filming concentrated on their responses to the questions in the lesson. From time to time the responses of a fifth student were also captured in the frame and these were also analysed, this student was also processing kinaesthetically.

3.4 PROCEDURE

Teachers are not trained to calibrate non-verbal clues beyond those which most people develop unconsciously when they learn, as children, to relate to others. Some teachers, including these two, are exceptional at 'reading' non-verbal responses and the fact that it is

possible to do so has not occurred to others. The need to conserve the non-verbal responses for later analysis determined the method used, video filming. However, using video introduced a range of practical issues that needed to be addressed before quality data could be captured. The logistical parameters for consideration included constraints of video capture.

3.4.1. Management of the venue for adequate lighting and sound capture.

The classroom was prepared by hanging white sheets over roll-in whiteboards to provide a uniform, non-reflective background to the lesson. The non-verbal responses were the subject of the video, so the teachers were not filmed; their questions were captured on the audio track of the video. The student's chairs were casually grouped, close together, in a semi-circle around the teachers, who were seated at the same level as the students, in front of a low easel on which they displayed the charts and diagrams. The LED display which indicates the camera is filming is usually visible by those being filmed. This light was covered by many layers of tape in order to hide whether or not the camera was running and disguise where it was aimed. The camera used is a small handheld DCR-TRV20E Sony Digital camera with a 120x Carl Zeiss digital zoom and vario sonnar. The film used was a Sony mini DV cassette. No tripod was used because flexibility to zoom or move to capture responses if necessary was thought to be important.

3.4.2 Sound management

Good sound pick up without interference from outside sources was necessary. The filming was done in an area of the classroom which was sectioned off with whiteboards as dividers, enclosing the space and concentrating the sound pick up. This proved effective.

3.4.3 The psycho-social aspects for students and teachers

This lesson was unusual for both students and teachers. The teachers are very competent and did not seem to be impacted by the filming of the lesson. They were aware that non-verbal responses were the focus of the study and wanted to provide high quality data. Both of them

were easy, relaxed and confident and this set the frame for the students. Teacher 1 explained her expectations clearly and simply to the students and started the lesson by integrating the camera naturally into the lesson (**"...is eve, ything working OK now? Good, let's begin..."**). The students were all very keen to be involved and appeared to be engaged and relaxed. The only distraction came when the battery of the camera ran out and the teachers used embedded commands to regain student attention as filming recommenced.

3.4.4 Opportunity for teachers to have feedback and discussion with the researcher

Due to a medical emergency only one of the teachers was available to debrief. She explained how they had worked together on the number and structure of their questions for the lesson. The statistics of the lesson were impacted by the confirmation that they used the same sort of questions they usually did, but more of them in order to supply as many responses as possible.

3.5 ETHICAL AND SECURITY ISSUES

These included the impact of the filming on teachers and students, confidentiality and security of data. Because the students were in their own classroom with their own teachers, doing a lesson they were scheduled to do, there appeared to be no impact other than their curiosity about the filming. The teachers framed the whole experience for them and they seemed at ease.

All permissions were received from the school, the parents and the teachers before the research began. Neither the transcripts nor the thesis reveal the identity of either teachers or students. The students are identified by the letter S followed by alphabetical references (for example: SA, SB) and the teachers were identified by T followed by numerical references (T1 and T2).

Security was maintained by passwords on the researcher's computer, all data being locked in her home office filing cabinet while analysis was undertaken and then taken for storage to a secure area at Edith Cowan University campus in Bunbury.

3.6 LIMITATIONS OF THE STUDY

The limitations of this study can be divided into limitations of scope and of filming.

3.6.1 Limitations of scope

The scope of the study is very limited because it only observes a maximum of five students during one lesson, in one classroom, on one day. All the students are from the year 4/5 classroom, they are all 9 or 10 years of age. There was only one example of each of the learning styles, on occasion when a fifth student strayed into the frame a second kinaesthetic style was observed.

The study examined questions generated by only two teachers. These teachers are exceptional in their profession because they have a high level of motivation and commitment to ongoing professional development in their own time. They are also unusual because sharing a classroom provides for each of them many more opportunities for external feedback than a single teacher in a single classroom would ever have access to. The teachers are constantly developing and improving their instructional techniques through their own action based research. Not all teachers engage in this level of personally directed professional development and it is not known how this has impacted the results of this thesis.

The level of engagement of the students was, in my experience, exceptional. Only one student showed any evidence of being off task for a minute or two towards the end of the lesson. My first impression of the classroom when I visited the day before the filming was of an active, relaxed learning environment where the teachers were totally student-focussed. Not all classrooms would be like this.

This study did not include sight impaired students. Further studies would need to be carried out to find out whether the same results would apply to them. Anecdotal evidence (many discussions with my seriously sight impaired mother) would suggest that even people with impaired vision move their eyes about if they are physically able to. It is also to be noted that in order to observe students who wear glasses they would need to be seated in such a way that reflection off the glass does not hinder observation of their eye movements. No students of other ethnic groups who might have cultural bias against eye contact were observed for this research. It might be more difficult to observe their eyes movements if their eyes are downcast. Some work with aboriginal people who have this cultural bias has shown me that it is possible to observe their many eye movements without the necessity of eye contact.

The scope of this study is inadequate for generalisation. It is not possible to declare that it will apply across all primary schools, all schools, tertiary institutions or the population as a whole.

3.6.2 Limitations of filming

The limitations of filming came about because the initial intent of the filming was to examine non-verbal responses to questions. If it had been known at the outset that the number of eye movements would provide the desired response the filming could have been done more effectively. The number of responses to the questions could have been greatly enhanced if five students had been filmed all of the time, instead of filming each student individually for a few minutes. If this had been done there would have been more opportunity to compare the responses of all the students to each question.

As a result of these limitations this study should be considered indicative and may be used to form the basis of further investigations.

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CHAPTER 4: DATA ANALYSIS

The video was downloaded onto an iMac computer and the downloading and editing feature used was the 2004 version of imovie. This programme made it possible to slow down the video for frame by frame analysis, pull out still frames for detailed analysis and slow the sound down enough to make transcribing easier. Expressions, eye patterns, heightened colour and intensity of response was clearly visible on the film.

The lesson was viewed many times, until patterns began to emerge in the researchers mind. The first analysis of the data was a search for the structure and statistics of the lesson as background, or context of the questioning strategy which would influence the responses. The sequence of analysis was as follows:

1. A transcript of the film was prepared and each line of the transcript was numbered.
2. The text was divided into meaning units – these were not made up of sentences, but rather of groups of words that were intended to convey something to the students.
3. Various types of meaning units were identified and later discarded as not relevant to this study. They did, however provide an attitudinal context of the teachers and their instructional style and are to be found in the appendix (p108).
4. The interrogative structure indicative of questions were easy to identify by rising tonal inflection or by the context of the surrounding material.
5. Next the structure of the lesson was examined.
6. The literature review was used as the starting point in developing the classifications of question forms. Initially four forms of questions were identified – closed, open, tag and embedded questions.
7. The coding of the questions was checked and it was revealed that the coding of open questions were inadequate. Open questions appeared to fall into two different categories, those dealing with content and those dealing with process. The coding was further refined to take this into account open questions were defined as

demanding a content response and schema accessing questions was added as a new category to examine questions which demanded a process response.

8. The position of the questions was charted against the structure of the lesson to discover whether or not the question form changed across the progression of the lesson (see p70)
9. The role of questions in the lesson was examined.
10. Next the responses were examined. At first many still frames were examined for minute details of changes in the non-verbal areas of skin tone changes, and micro muscle movements. Neither of these proved fruitful as the responses seemed to be individual, not consistent across all students.
11. Eye movements seemed to be the only non-verbal responses that occurred across all the students in response to all the questions. At first the neurolinguistic model of eye movements (see page 36) was used to chart the responses but it quickly became obvious that these, too, were individual not generalizable responses. The eye movements displayed were consistent with the learning style of the individual students, but not consistent to every student.
12. When it was realised that all questions evoked eye movement responses, and that even no movement of the eyes was a response, the focus of the examination changed from the direction of eye movements to the number of eye movements.
13. At this point lists were made of all the five categories of questions and the student's code was recorded next to the eye movements they displayed in response to the question. The way the movements were recorded was by using the neurolinguistic directional patterns to record eye movements. This was chosen as the preferred way of recording the data because I have many years of experience at noticing this form of eye movement. Movements were coded as follows:
    1. **Vr** – upper left quadrant
    2. **Vc** – upper right quadrant
    3. **Atr** – lateral movement to the left

4. **Atc** – lateral movement to the right
5. **K** – lower right quadrant
6. **Ad** – lower left quadrant
7. **O** – eyes straight up
8. **G** – eyes straight down
9. straight ahead -- straight ahead
10. **Vec** - eye contact with teacher or chart

14. Next a code was developed for counting the number of eye movements.

 1. **RNF** = Response not filmed
 2. **NVC** = No visible change (in eye movement)
 3. **ECR** = Eye contact response (looking at teacher or chart)
 4. **R1** = One eye movement in any direction. The first direction shown being the position of the eyes at the start of the question. If the eyes did a quick flick movement in another direction and returned to the original gaze position it was counted as one movement.
 5. **R2+** = Two or more movements of the eyes (any direction).

15. When these were counted the number of eye movements in response to each of the forms of questions were available for analysis (see appendix pp109-113).

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CHAPTER 5 : RESULTS

The research question: Teacher Torque: What do eye movements tell us about how students are responding to the form of teacher questions?

5.1 USING THE RESULTS TO FURTHER SHAPE THE FOCUS OF THE RESEARCH.

The purpose of the filming was to ascertain the non-verbal responses to teacher's questions. The reason this was undertaken was to investigate the neurolinguistic premise that non-verbal clues are as valid as words. The study was proposed in order to discover if there were any easily identifiable consistent non-verbal clues that teachers could use to asses the level of thinking of the students when they are responding to questions.

Questioning was an appropriate investigative tool because it is more effective at eliciting responses than statements would have been. The non-verbal responses initially examined were the micro muscle movements of the face, changes in skin tone, changes in breathing rate and eye movements. Of these only eye movements appeared consistently in all students and justified further examination.

The investigation started with the neurolinguistic model of gaze direction. This revealed only the preferred processing style of individual students. This study was looking for a consistent non-verbal response that was generated by all students so the data on gaze direction was discounted. The literature on synaesthesia was revisited (see literature review page 33) and showed that it is possible to observe through gaze focus when many different areas of the brain were being accessed simultaneously. When this was considered alongside the literature on the impact of eye movements on brain functioning and brain functioning on eye movements, (see literature review pages 37-38) it provided a trigger to turn the analysis towards counting the number of eye movements instead of studying specific gaze directions.

The theoretical premise which guided the study then became the number of eye movements as the external indicator for assessing the number of brain areas involved when responding to questions. The number of brain areas activated showed the level of engagement of the student's brain while responding.

The inclusion of findings from brain science as well as education has the potential to challenge the conventional view that ALL questions cause students to think. What this could mean for the normal classroom is that teachers might have to think about their questioning techniques more deeply and be prepared to evaluate the responses their questions are eliciting in a different way. Busy, stressed teachers might reject this study owing to the need to make extra time available to develop the unconscious skills necessary to follow this strategy in the classroom. A professional development session could overcome this barrier.

Coaching provides the opportunity to prove to themselves that questions asked in certain ways fully support the students' quest for transformational change. Coaching during the professional development session could also help teachers to convince themselves that the way they ask questions can carry the intent for learning outcomes. It is expected this coaching would be welcomed by teachers, teacher educators and curriculum developers because any technique that reduces stress and progresses learning outcomes is desirable.

Intense scrutiny of eye movements soon revealed that a lack of eye movement was also a response and this realisation further supported the premise. As analysis of the number of eye movements unfolded, an interesting trend was seen to develop. It seemed that some questions evoked more eye movements than others. The remainder of this data analysis focuses on the number of eye movement's student's display when responding to classroom questions. The analysis examined responses to different types of questions separately as the Literature Review indicated different learning was associated with different question forms.

Before we can examine the responses it is necessary to examine the role that questions played in the lesson and the form of the questions which were used.

5.2 THE ROLE OF QUESTIONS IN THE LESSON

1. Simple questions were used to check for information. These included procedural matters, such as the whereabouts of things, whether specific actions had taken place, or to suggest action. The following are all examples from the transcript.

Line 200: **"Would it be helpful if I held this up for you?"**

2. Questions were also used to evaluate student cognitive memory (checking for understanding).

Line 186: **"What would this one there be?"**

3. Some questions posed problems, sought solutions, or challenged the student and elicit a variety of emotional responses. These questions channelled responses along a single line of inquiry to elicit an expected answer allowing for a variety of possible answers. The following two examples from the transcript demonstrate a single line of enquiry: Line 136: **"Similarities and something else...?"** and this example shows a variety of possible responses.

Line 115: **"What are you thinking, Name?"**

4. Some questions elicited whole brain responses that lead to linkage of existing schema with new input or when appropriate the formation of new schema. These questions intentionally gave students the opportunity to review their schema, or practice the thinking skills required to be learned, for example: Line 301: **"For...?"**

5. Incidental questions did not rehearse previous instructions and had an expectation of generalised information. For example: Line 71: **"Do you think that chickens and other birds could have a similar sort of cycle?"**

6. Some questions were used to <u>direct higher cognitive functioning</u> such as analysing data, problem solving and predicting outcomes. <u>Line 582:</u> **"Because we've got macros, we've got frogs and we've got birds, so what? What does this information you have just given me mean for our wetland?"**

5.3 FORM OF THE QUESTIONS IN THIS LESSON

The three types of questions of most concern to this study are closed questions (CQ), open questions (OQ) and schema accessing questions (SAQ). The responses to these three types of questions can be compared to each other for analysis purposes. Two other useful forms of questions were also identified. It is not possible to assess these two forms of questions with the same criteria as the others because their responses were different and cannot be compared. They will be briefly discussed here before moving on to the main questioning forms.

<u>5.3.1 The two forms of questions that are not the main focus of the research</u>

5.3.1.1.Tag Questions (TQ)

This form of question is used for "...discharging the negativity or resistance ..." (Battino & South, 1999, p117) that students may feel when being <u>told</u> what to do. They ask the brain to make a decision. An example from the lesson: <u>Line 151:</u> **"Let's call it bird, OK?"**. TQ do not always carry an expectation of a 'yes' or 'no' answer, they cause people to consider the data that preceded the tag.

Tag questions, providing as they do, an opportunity for students to instigate a transderivational search, often elicit agreement because of the brain's survival imperatives for energy conservation. In previous times the supply of energy was not assured as living standards were not as high as in Australia today. Humans evolved with a survival imperative to conserve every bit of energy. A discussion with an aboriginal elder in Bateman's Bay in NSW in 2001 illustrated this to me when someone asked her why they tore the small trees out by the roots

instead of taking only the branches they needed for shelter. The Elder replied that conserving energy was the most important survival imperative in the desert, it was more energy efficient to pull the small tree up than remove many branches. The energy requirement of actions dictated which were undertaken and which passed over. Casti (2000, p35) cites Zipf's work on the human behaviour and the principal of least effort which states that the energy expended to achieve the desired result is an important criteria for deciding which actions to undertake. Carnegie Mellon University scientists have found that the law of least effort may also apply to the brain (Reischle, Carpenter, & Just, 2000). This means that people will expend the least amount of mental energy to achieve the desired result.

Applying the principle of least effort to question responses means that tag questions have low energy requirements. Agreement involves less energy expenditure than disagreement, which often leads to expending energy on justification. The elegance of tag questions comes from the apparent choice that students are given when a tag is added. The word 'apparent' is important here. When a new input appears to imply no choice the person will often react with emotion and resistance rather than with logic. If a thinking response is desired it is important to make sure the communication is processed by the neo cortex, and the simplest way to do this is to provide a <u>perceived</u> choice. So called "Clayton's choice" implies that the choice is real, even when it is only apparent. Tag questions encourage agreement gently and covertly and without instigating resistance from the hearer. Golman (1996, pp8-9) tells us that

> "There is a steady gradient in the ratio of rational-to-emotional control over the mind; the more intense the feeling, the more dominant the emotional mind becomes-and the more ineffectual the rational [mind becomes]".

Another example of a tag questions from the transcript causes the students to wriggle a bit, making themselves comfortable and clearly preparing to settle and pay attention. <u>Line 1:</u> **"Let's get started, shall we?"**

5.3.1.2 Questions which embed commands (ECQ)

The second form of questions to be discussed but not analysed are those which embed commands. It could be said that this type of question is specifically designed to soften a command in order to 'send' it for neocortical processing and cause students to think. Questions formed in this way allow no excuse for the brain to resist the question or the command embedded within it, for example, <u>Line 6</u>: **"Could you have a look at this diagram?"** contains the command to look at the diagram.

If a command is delivered in such a way that it triggers an emotional reaction some students will automatically refuse to comply. If, on the other hand, a command is delivered to the thinking part of the brain the response can be considered and accepted, or not. Another example occurs on <u>Line 2:</u> **"Can I just ask you to have a look at this...?"**, the students all responded by lifting their eyes to chart.

The following types of questions produced results that could be compared and this section of the paper lays out the criteria for the three different types of questions, the responses will be discussed in section 5.7 (see page 74).

5.4 QUESTIONS THAT FORMED THE BASIS OF THE DATA ANALYSIS.

<u>5.4.1 Closed questions (CQ)</u>

When asking closed questions the questioner expects a predictable answer, often the expected answer is "Yes" or "No". Closed questions do not demand a student to search his/her schema. They are often procedural and not important to the evolution of student thinking but may be to the progression of the lesson. Closed questions are essential in human communication to check for understanding or the whereabouts of objects. They are always questions about content. The following three examples of closed questions come from the transcript. <u>Line 76:</u> **"Are you**

thinking that?", <u>Line 104:</u> **"Can you see them if I put them like this?"** and <u>Line 385:</u> **"What did you find more difficult?"**

5.4.2 Open questions (OQ)

Open questions also elicit content, and unlike closed questions, they have unpredictable answers. This kind of question elicits the hearer's current world view. They often include the word "what", which is the indicator of expectation of a content based answer. This type of question directs the hearer's brain into certain channels of thought, like this; <u>Line 360:</u> **"So when they grow to an adult they're... what happens?"**, directing the hearer's brain towards the options within 'adult' context only. Another example of this can be found on <u>Line 554:</u> **"What were you thinking?"**, this question also asks for content.

5.4.3 Schema accessing questions

These questions are aimed at producing higher cognitive processing. They are designed to help students unconsciously access their schema and evoke adaptive (process) responses. These questions instigate expansion of existing schema or the creation of new ones through the consideration, accommodation or assimilation of new input. This type of question causes the brain to evaluate; that is, to compare the new input with existing schema, causing students to make links, patterns and connections in their thinking. These in turn lead to new neurological networks and expansion of their world view. These questions can cause a deeper understanding of the subject and where it fits into the bigger picture. An example from the transcript is <u>Line 343:</u> **"...and how does that relate to the frog then?"**. The consideration of these types of questions whether generated externally (asked by someone else) or internally (asked of oneself), are essential for the expansion of schema. These types of questions often include the word "how", which directs the hearers brain towards process – this is thinking about how you are thinking. There were no 'how' questions asked in this lesson so the following example is not from the transcript: "How did you think about making the chart easier to see?" or "How would

you solve the problem of not being able to see the chart?" In this lesson many of the SAQ used the words 'why'; Line 271: **"Why?"**; Line 592: **"Why is it important that we know this and what does it mean for us?"**; and 'so what' Line 626: **"So what...?"**; and 'because'; Line 630: **"Because....?"** This form of hanging questions is very effective, not only is it asking the students to make connections, it also directs their attention to the possibility of connections or relationships and engages them in predictive thinking as they try to decide what the teacher wants to hear.

Bernice McCarthy (McCarthy, 1996) explains that there are four roles a teacher plays during a lesson. If the teacher uses these roles with awareness and balances them well, the students' brains and minds learn most effectively. Each role promotes the asking of different forms of questions. In her model the first role is that of sales person; at this time the teacher is asking or giving the reasons or purpose for learning the information (motivating). This phase of the lesson encourages students to access their current understanding of the information to be expanded upon. The second role is that of teacher; during this time the teacher presents the information and asks the content based OQ questions like "What?". The third role is that of coach; here the teacher coaches the students on how to do the work. The questions that might follow from this would be SAQ because they ask students about expanding or connecting the 'what' to their existing schema. The fourth role the teacher plays is that of mentor; these questions are the other form of SAQ that asks "So what, or what else is connected here?" and as the lesson progresses the cycle of the four roles continues.

It would not be possible to ask only SAQ during a lesson. The students need to slowly explore what the information is and expand their understanding before they can think about how it relates to the schema they brought to the lesson. This process of understanding the new data takes a little time. This is why it is important to use all three forms of questions appropriately, gradually bringing the students from the lowest cognitive levels of the new data to the highest.

5.5 DISTRIBUTION OF THE FORMS OF QUESTIONS THROUGHOUT THE LESSON

To facilitate analysis of both question forms and responses a review of the structure of the lesson and the distribution of the questions within that structure were examined. It was found that the lesson fell easily and naturally into six distinct phases.

5.5.1.The first phase (Lines 1- 103)

This was the instructional phase. The students were given all the information they would need to work with. The teachers used many ways of conveying information, including questioning. They drew the data from the student's own experience and developed it from the revealed understandings. In this phase of the lesson both open and closed questions were used to ascertain the students' current understanding of the subject matter. The open questions asked the students 'what' they were thinking. Tag questions were used to gather agreement from students on the next action. For example: Line 79: **"So we can transfer this into being the life cycle of a bird, can't we?"** Even though this was the very beginning of the lesson there were two questions asked that were designed to encourage higher cognitive processing, showing the teacher how students are linking new inputs to existing schema, both questions were: Lines 37 and 78: **"Is anyone thinking anything different?"**. The transition into the second phase came when the teacher praised the students and told them they were now to move on to looking at the different sections of the data together.

5.5.2 The second phase (Lines 104 – 197)

This was the procedural phase when students were given explanations on how to think about the data. The teacher played the role of coach, explaining how to do the work at hand. Twenty closed questions were asked to check student understanding of the data. The four open questions at the very beginning of this section elicited student understanding about the format of the work they were about to undertake. They had used this format before and were encouraged to review the process. Tag questions elicited agreement from the students. During this phase the teacher

used two questions which embedded commands and acted as softeners to the data contained within them. The only schema accessing question designed to extend student thinking was on Line 184: **"...so what?"**. The transition to the next phase came when the teacher told the students to **'have a go'** (Line 193) setting them to work independently.

5.5.3.The third phase (Lines 1,8-248)

This was the operational phase. This phase provided opportunity for the student's to do their own work, using the format the teachers had explained. This phase was passed mainly in silence, with students and teachers asking occasional clarifying questions. One open question and five closed questions were asked. The transition was the teacher calling the class attention to the start of a **'sharing'** time (Line 249).

5.5.4.The fourth phase (Lines 249-399)

This was the debriefing phase during which time the students were encouraged to make comparisons and discover each others thinking. Ten closed questions checked for understanding. Twelve open questions elicited the content of the information the students had been working on, four tag questions helped to formulate student agreement. Two commands were embedded to regain student attention, Line 382: **"...can I just have your attention over this way?"** and Line 383: **"Can you look over towards me?"** During the debrief phase there were eight questions that accessed student's schema by asking them "how" they were processing. The main method of asking these questions was to expand cognitive engagement by using short incomplete sentences which neither limited nor directed their thinking. For example, Line354: **"Are all...?"**. The transition to the next phase came when the teacher started to explain the next level of thinking required.

5.5.5. The fifth phase(Lines 400-592)

This was the extension of thinking, the time when the students looked for patterns, contexts and connections between the facts they had been working on. It was a very active time for the students who were thinking throughout. The teachers extended student cognitive functions still further by helping them to find patterns, connections or relationships in their data. The closed questions all had predictable 'yes' or 'no' answers, for example, Line 458: **"...could [they] all live in an environment together?"** The open questions displayed teacher directed unpredictable answers, an example of this was provided on Line 465/6: **"What do you think the environment would look like for these three?"**, directed them to the visual aspects of the environment. The transition from this phase was the question from Line 592: **"...and what does this mean for us?"**

5.5.6. The sixth and final phase (Lines 593-640)

This was the review, summarizing and re-energising of the data for the students. The way the teacher re-energised the data was by using tone, pitch and intensity to drive the lesson home. The two schema accessing questions were on Line 626: **"So what..?"** and on Line 630: **"Because..?"**, these words were delivered in a loud inclusive voice which consolidated student learning.

All five types of questions were used in a contextually appropriate manner throughout the lesson. The distribution of types of questions showing the highest number of open questions during the data transfer in the beginning and the lowest numbers during the explanation of work format and the work itself (see summary in Table 1, p72). This finding affirms these two stages as those with high content. The highest number of closed questions was used during the explanation of the work format, while checking for student understanding. Tag questions were highest when agreement was needed at the beginning of the lesson and also when eliciting affirmation in the extension of thinking in phase five. The highest number of questions which

embedded commands was at the very beginning of the lesson during introduction and towards the end of the extension of thinking phase when the students were starting to tire. Not surprisingly the highest numbers of schema accessing questions were asked during debriefing and the extension of thinking stage.

The following table shows the percentage of the five different types of questions of the total number of questions and the number of each type in the six phases of the lesson.

Questions Type	% of Q	Total Q's	Ph#1	# 2	#3	#4	#5	#6
Closed Questions	30.52%	58	5	20	5	10	14	4
Open Questions	40.52%	77	23	5	1	12	32	4
SAQ Questions	11.57%	22	1	1	0	7	10	2
Tag Questions	11.57%	22	5	5	0	4	8	1
Embed Commands	5.78%	11	2	2	0	2	4	0
Total Questions	100%	190	37	33	6	35	68	11

Table 1: Distribution of questions during the six phases of the lesson.

5.6 ANALYSING RESPONSES TO VARIOUS FORMS OF QUESTIONS

The student's preferred representation system, (visual, auditory or kinaesthetic) was revealed by their eye movements in the first few minutes of filming before the lesson commenced. Each student returned to their preferred system from time to time but none of them used their preferred modalities exclusively. Eye movements towards or away from their preferred representational system were counted as eye movements for the purpose of this study.

Examination criteria for the assessment of eye pattern responses to questions were set according to the number of movements of the eye to each of the eye gaze positions (see page

36). The emphasis was on the number of eye movements not gaze direction. They were logged against the questions that generated them to see if any useful patterns emerged.

5.6.1.Codes adopted to categorize the number of eye movements:

NFR No filmed responses. It was not possible to anticipate which student the teacher would call on for a response so from time to time the camera was not able to film the responses.

ECR Eye contact response - when the students maintained eye contact either with the teacher or the chart. It was not possible to see whether or not there were eye movements as their heads were down, so these responses were not used except to count the movement towards or away from eye contact.

There were 9 unfilmed responses and 22 eye contact responses which were not possible to observe. These were not included in the figures for the analysis.

5.6.2.Three types of eye movements were analysed:

NVC - No visible change - when no eye movement occurred in response to a question, that is, when the eyes remained in the same position without a flick of movement.

R1 - One eye movement in any direction from where their eyes were when the question was asked. If the student did one quick flick in another direction and went straight back to the position their eyes were in when the questions was asked it was counted as only one movement.

R2+ - eye movements in two or more different directions as the student scanned different areas of their brains for appropriate information.

5.7. QUESTIONS AND RESPONSES FROM THE LESSON

An examination of the percentages of NVC, R1 and R2+ in each of the three categories CQ, OQ and SAQ was undertaken. The eye contact responses are not tabled because they do not provide comparable data.

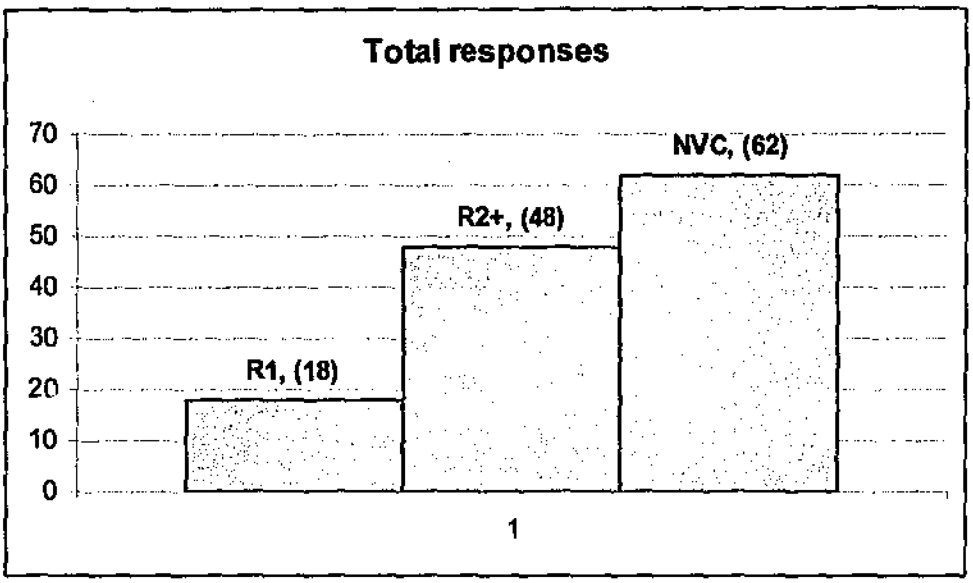

Chart 1: Incidence of responses in the lesson

Chart 1 shows that out of the total 128 responses that were focussed upon: NVC – no visible changes accounted for 62 responses (48%). R1 – one eye movement from where their eyes were looking at the time the questions was asked accounted for 18 responses (14%). R2+ - eye movements in two or more directions after the asking of the questions accounted for 48 responses (38%).

Chart 2 shows the numbers of questions and responses in the study. The number of responses exceeds the number of questions because in some cases where the entire group was being filmed more than one student's responses to the same questions were noted. In all categories there were some responses that were not filmed.

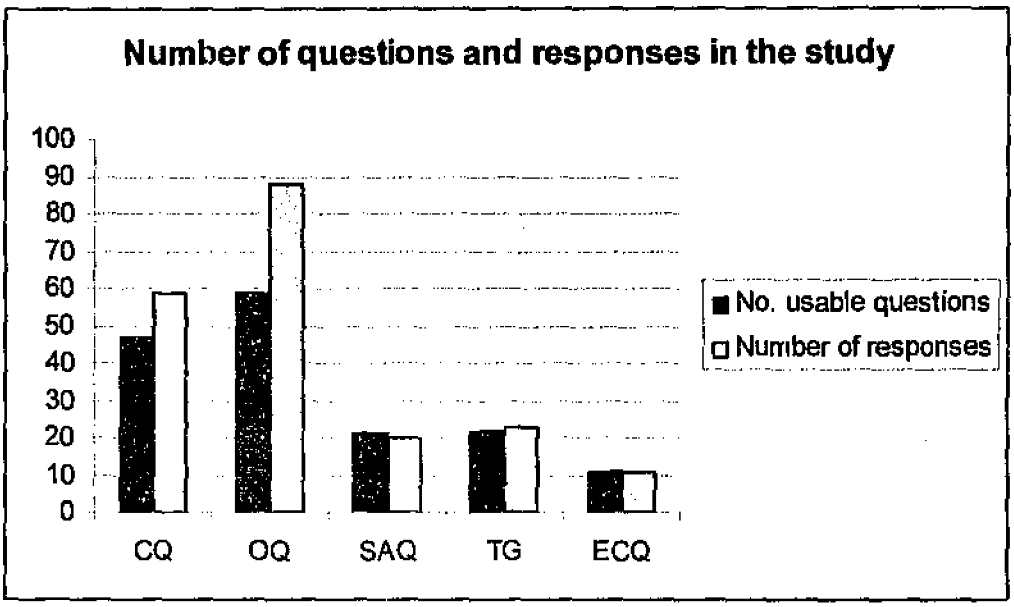

Chart 2: Number of questions and responses in the study.

The analysis mentions but is not concerned with the NE responses because the percentage of non-engagement in this lesson is so small. Neither does it take much note of the two response types that occur only in tag and embedded command questions. These are Agree/obey and NVR (no visible response). Chart 3 shows the incidence of each of the other responses from the lesson in percentages.

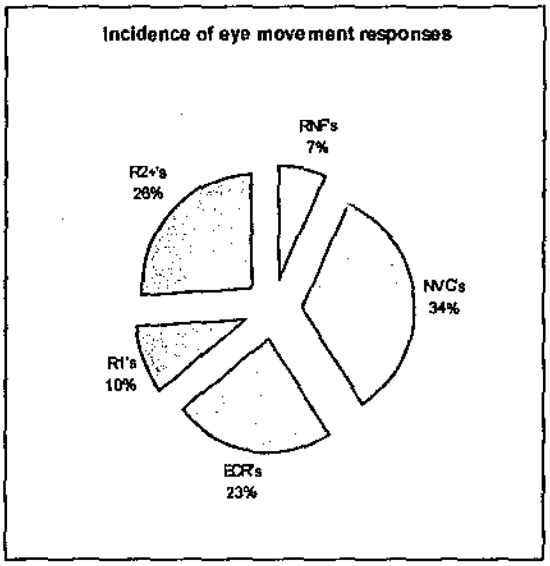

Chart 3: Incidence of responses in percentages.

The main responses under review are generated by open, closed and schema accessing questions and the table below shows the actual number of responses generated by each of the question forms.

Responses	CQ	OQ	SAQ
NVC	33	22	5
R1	11	4	2
R2+	12	28	6
Totals	56	54	13

Table 2: Number of NVC,R1 and R2+ responses to each of the question forms

In order to develop a basis for comparison the figures were converted to mean values.

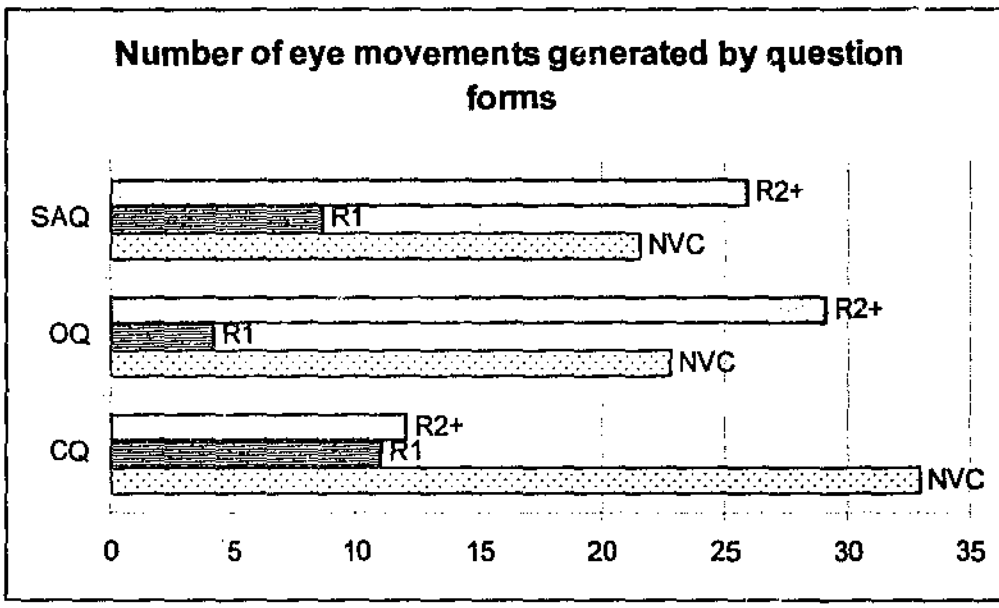

Chart 4: Number of eye movements generated by questions forms.

5.7.1.NVC Responses:

The highest number of no visible eye movements were generated by closed questions. This could mean that no thought was occurring because brain areas were not being activated. The least number of NVC's were generated by schema accessing questions, which could indicate that more thought was occurring as more brain areas are activated.

5.7.2.R1 Responses:

The highest number of R1 responses arose out of closed questioning. This could mean that students are looking for content they already know and not engaging in higher cognitive skills. The lowest number of R1 responses were generated by OQ which indicates that students were accessing content least often in response to OQ. This is a surprising finding given that open questions are designed to elicit content and R1 is a content response.

5.7.3.R2+ Responses:

The highest number are to be found in OQ, this could be explained by predictive thinking, students trying to predict what the teacher wants to hear. A surprising finding here is the high number of R2+ responses in closed questions. This might also be due to predictive thinking. It could also be that students were not listening to the questions and might have been thinking about something else. Without further evidence of brain activation it is impossible to be sure.

5.7.4.Responses to closed questions

Nine percent of closed question responses were not filmed. In addition 5% of responses were ECR, the students were looking at either the teacher or the chart and it was not possible to see whether or not their eyes moved. This left 86% of closed questions to analyse.

The responses being studied are NVC, R1 and R2+. The data revealed that 51% of responses to closed questions evoked no eye movements and did not appear to be signalling an internal search for answers. Seventeen percent were R1 (one movement of eyes) and 18% showed eyes moving to two or more directions as they accessed more areas of the brain in their search to find their responses.

It was not possible in this study to find out exactly what the students were thinking at the time, there are several possibilities:

- perhaps they were in 'neutral' and not thinking at all,

- perhaps they were not engaged by the question,
- perhaps they were thinking of something else,
- maybe closed questions give the students a 'mental rest': when thinking for extended periods people need small rests for their brains and perhaps this is a role closed questions can fulfil.

Further research is needed before anything definitive can be made of this. The trend, however, is that more than half of closed questions do not cause the eye movements that indicate which areas of the brain are being activated. The literature review indicated that eye movements cause and are caused by brain activation. It is important to know whether or not closed questions extend student thinking because, as I have found in my training practice, many people find it easier to generate closed questions when under stress. Smythe (2001) tells us that teacher's work is changing and becoming more stressful, therefore it is possible that many teachers are using more closed questions than these two teachers. This could mean that they might not be making students think as much as they think they are. Further research will be needed to ascertain whether or not this is the case, or whether these two teachers are typical of all teachers questioning style. The problem with asking a high proportion of closed questions in a lesson is not the form of the question but the frequency of use. If closed questioning is the predominant style a teacher uses, opportunities to extend student thinking appear to be limited.

Closed questions are also used to clarify or check understanding but the monosyllabic responses closed questions evoke appeared to be automatic. For instance a question like "Do you understand this?" might elicit a response that will cause the least effort for the hearer who automatically responds in the affirmative without consideration, perhaps even lacking the understanding the teacher is attempting to check for. More than half of the closed questions asked during this lesson elicited student responses which displayed no eye movements, no replies, or monosyllabic replies. Two examples of closed questions from the lesson were:

Line 75: **"Are you thinking that....birds would lay eggs and would hatch?"** the responses from all students were monosyllabic, *"Yup"*;

Line 281: **"Is their lifecycle shorter?"** at this question there were no verbal answers, a student kept speaking as if he had not even heard the question, as it if were rhetorical.

The Literature suggests that closed questions are essential to normal human interaction but do not consistently elicit thoughtful responses. Chart 5 shows the responses to closed questions generated during the lesson.

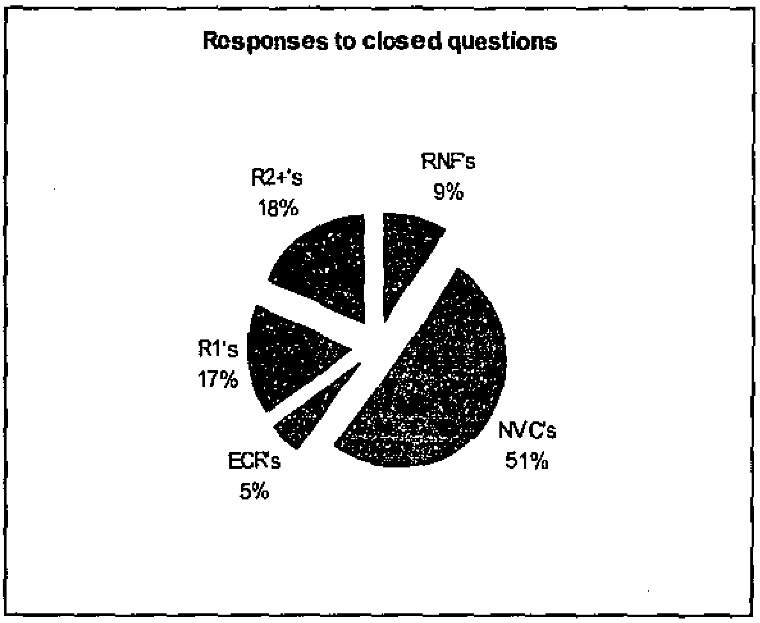

Chart 5: Responses to closed questions

5.7.5. Responses to open questions

The most commonly used questioning form in this lesson was open questions. These are questions which do not have a predictable answer, so in this way are defined as 'open'. Open questions expect to recover content (facts). They are, however, only 'open' in so far as the answers are unpredictable. The manner in which they are asked indicates the parameters within which the student is expected to answer. Some of these parameters are exposed to students in the context of the question being asked, some are directly specified. For instance the question:

"What do they do?" has an unpredictable answer which is 'directed' by the way in which the question was asked. The word 'what' indicates an expectation of content, the lack of referential index indicated by the word 'they' implies the context being discussed and the unspecified verb 'do' implies a relationship with what has been done before. Therefore the teacher has given the students 'clues' about how she wants the question answered. The students, however could answer that question with many different facts related to 'doing'.

Open questions recover facts about the student's existing schema, or opinions on the topic. The following example from the lesson demonstrates the parameter the teacher sets before the question and 'what', (the content) the teacher is aiming to recover. Line 7-8: **"What does this diagram actually tell us...what are you thinking?"**. To which the student's verbal response was: *Line15:* ***"The lifecycle of the water mite?"*** This could have been interpreted as a closed question because the answer was predictable, but in fact the student could have replied: "It's about how a baby water mite grows into a grown up water mite" or, "It's water mites being born, laying eggs and dying", or many other answers. Therefore, although the answers are similar, they are not predictable and are therefore categorized as open questions.

More examples from the transcript:

Line 268: **"...and that is different to the...?"** Verbal response *Line 269* ***"Um, bird".*** This sounds like a closed question, but is not because the student could have answered 'frog' or 'mammal' or 'dinosaur'. Here the teacher is clearly expecting a segment of content from the lesson under discussion. The student complies, but the point of an open question is that it is asked in such a way that the hearer might choose to go off in another direction. Open questions can also be implied questions, such as the incomplete hanging question in the following example. Line 287: **"How about you, [Johnny], would you like to share something with us?"** This open ended invitation to comment also contains an expectation of sharing content or experiences within the context of the lesson's parameters. It elicits the answer *Line 288:* ***"Um,***

the frog and the water mite, they both live in fresh water." This reply shows the student's level of cognitive processing, he knows there is a difference between salt and fresh water environments, and that it has an effect on the creatures that inhabit each. If appropriate this information could have been used to take the lesson in a different direction. This last example of an open question has a different function in the mental processing of the hearer. <u>Line 464-466:</u> **"Can you just imagine, in your mind, for a moment, what you think the environment would look like for these three animals to share – to live in?"** This type of open question directs the hearer to a specific aspect of the content. In this case the direction to use their visual processes to build an internal visual representation of the environment under review. Verbal student responses, <u>*Line 478:*</u> ***"Water"***, <u>*Line 480:*</u> ***"Grass and pond"***, <u>*Line 482:*</u> ***"Food for all the bird and the frog and the macro"*** show clearly that students are all thinking at different levels of complexity. Eye movement response of the only student filmed during this exchange shows that he quite clearly flicked his eyes up to visual construct when the teacher asked: <u>Line 476:</u> **"What would you be able to see?"** This student's preferred learning style is kinaesthetic, yet he flicked his eyes into visual construct when instructed to do so. Using open questions in this way can give students a rich experience of flexibility in the use of different learning styles which can evolve their world view in hitherto unexplored ways. Table 3 illustrates the eye movements of three students during the asking of an open question.

<u>Line 12-13:</u> **"Could you tell me what this diagram is telling us, or what it represents?"**

Student A:	Vec,V,K	R2+
Student B:	O,K	R1
Student C:	K, head Ad eyes	R1
Student D:	Atr,Ad,Atr,K	R2+
<u>Student E:</u>	Vr,K,Vc,K,Atr,K,Atr	R2+

<u>Table 3:</u> Eye movement responses of five students to the same open question

Open questions are also essential in human interactions, they keep discussion and debate going, albeit in unpredictable directions. Open questions direct people's thinking while also allowing them to feel free to comment. Hilda Taba, (cited in Wilen, 1987, p13) tells us that the way the teacher formulates a question gives the students clues about how to answer, and in this way the teacher controls the responses to the question even when the answers are allowed to be unpredictable. This is a perfect description of an open question as defined by this study. Another example from the lesson, in table 4 below, demonstrates three different student's responses to open questions.

Line 14: **"What are you thinking, Name?"**
(the teacher wants facts, what are you thinking)

Student A eye movement response is to move from eyes up, where he was when the questions was asked, to eyes down to the right. This was coded as R1.

Student B No eye movements.

Student D demonstrates an R2+ category response. She starts with eyes lateral to the left then moves her eyes to look at the student asked, then moves her eyes straight ahead, then to down to the right, then laterally to the left, then back down left before making lateral eye movements to the left. She engaged many neural networks, increasing the blood flow to all these areas of the brain and demonstrating the level of her brain's involvement in thinking.

Table 4: More multiple responses to the same question.

Twenty three percent of open questions elicited no visible change in eye movements, if we were to add the 34% of ECR responses the figure jumps to 57%, more than half of open questions. It was not possible to film what the student's eyes were doing when they were looking at teacher or chart, but it seems reasonable to predict that there were NVC, R1 and R2+ movements involved as they tracked and thought about the presentation. Of the eye movements we could see, only 4% of open questions elicited one eye movement and 30% elicited more than two movements.

Logic dictates that it might be expected that open questions would have a higher number of R1 responses as the student decides what specifically the teacher wants to hear. However the figures state otherwise, 30% of responses were at a higher cognitive level than the question, that is, R2+ responses. This unexpected finding might be because in order to satisfy the teacher's request for a response the student might be instigating a complex transderivational search of all his/her schema to find the most appropriate answer to match the teachers perceived expectations. Predictive thinking comes under the R2+ category. If this is the case then open questions are also good tools for eliciting higher cognitive processing. Whether the motivation for the search is for predicting what the teacher wants or for other reasons is not important. The important thing is that many areas of the brain are being accessed and when the student does a transderivational search, for whatever reason, the opportunity to expand his/her schema is generated.

In this lesson the teachers thanked students often for their contributions. They frequently used the words, "Excellent" "Good" and "well done", thus providing affirmation the students needed to confirm the correctness of their predictions. This encourages more predictive thinking in the future.

It is also interesting to note that student responses to instances of praise were delight followed by disengagement. After they had been praised they sat back, smiled and defocused for a short while. This bears out the well known phrase "clarity is the enemy of learning". As soon as the student gets it "right" he/she can stop thinking because of the human biological need to conserve energy triggering the principle of least effort.

Overall, the findings of this study point to open questions being useful for causing students to think, but not all open questions cause deep thought. Chart 6 on the next page summarizes the various responses to open questions asked in the lesson.

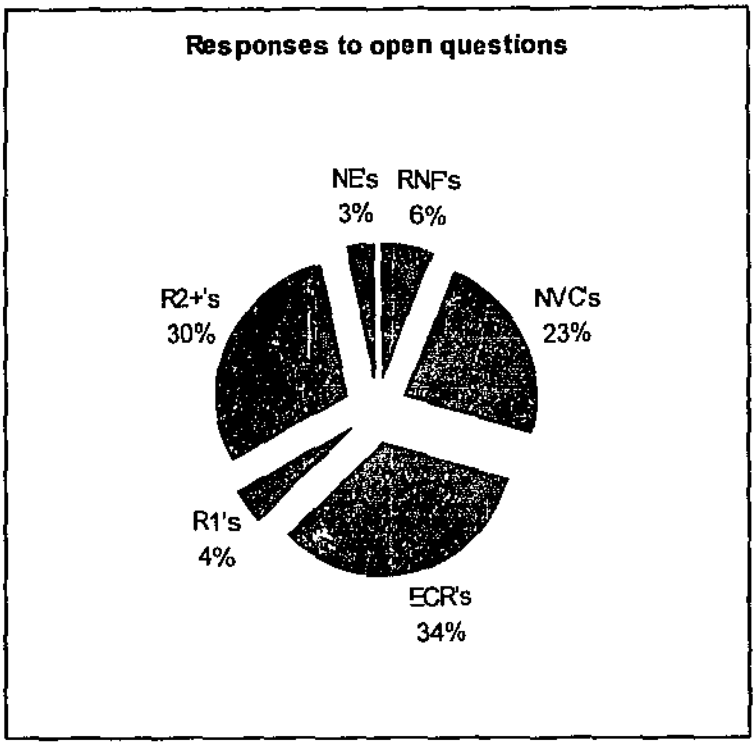

Chart 6: Responses to open questions

5.7.6. Responses to schema accessing questions.

When the research was proposed it was thought that questions would form only two categories, open and closed. When the responses were noted, however, it became necessary to make a further distinction. Open questions were found to elicit content. The new category, schema accessing questions, are described as a discrete type, rather than a sub-section of open questions. This distinction hinges on the important finding that schema accessing questions do not relate to content, they are process driven.

The content question asks what is happening. A process question is one that encourages people to think about the way in which things are happening. Process thinking includes such things as analysis, evaluation and prediction and involves connecting data in original ways.

When formulating schema accessing questions the intent of the questioner is to encourage the hearer to instigate a transderivational search, to compare and make a decision to link new inputs to existing schema, or not. The brain responses that these sorts of questions elicit cause activation of many areas of the brain which flood with nutrient rich blood and activate the eyes, causing them to move around. This is the process we can observe as the different brain areas become activated. It means that for R2+ responses to occur many areas of the brain are being activated. This type of brain activation is essential for cognitive innovation.

SAQ do not provide clues or context to guide the answer. They are achieved by giving as little information as possible in order to allow the hearer to make their own mental connections. Tonal inflections, body language and eye movements of the questioner become the only clues to questioner's intent. The brain of the hearer searches for non-verbal clues. If any clues about the interpretation of the question are found the question becomes 'open' and does not necessarily generate schema accessing. If no clues are found the hearer's attention turns inward, searching their own schema for the links that connect the new inputs to their existing knowledge in ways that are original and innovative to them.

In this lesson the question **"What are you thinking [Johnny]?"** was in frequent use. It asked the student for content (what? = facts), so it was classified as an open question. If the teacher had wanted to induce schema accessing she would have asked it in a different way – for example she could have asked: "How did you get that?" or "How are you thinking about it?" these would have been process questions to prompt schema accessing.

Now let us examine a SAQ from the study. Before this question is asked the students have thought through a tri-venn diagram and mapped the similarities and differences between the lifecycles of each of the macro, frog and bird. The teacher then has a question for the students about their own processing style, she asks them what they found more difficult, finding the

similarities or the differences. The student's eye movements showed no response, so the question was classified as a closed question because the students perceived the need for a predictable either/or response. Their verbal responses were predictable and monosyllabic and there was no indication through eye movements that their brain responses were complex.

The teacher masterfully drew the student's thinking along and then overtly asked them to make links, or display schema accessing thinking. <u>Line 441:</u> **"Name_What are you thinking?"** and received the reply *<u>Line 442:</u> "That it's like they go low on the food chain, birds eat frogs and the frogs eat the macro?"* The upward inflection at the end of the reply indicates the student is unsure if the answer is acceptable. Because of the word 'what' the question became OQ not SAQ. Had the teacher asked the question in a different way the answers might have been process oriented. For instance: "How are you thinking about the food chain?" might have elicited an answer like "Do we have a food chain too?" or "Some things are low on the food chain and some things are high"

The analysis of questions expected to elicit process responses shows that of the SAQ questions asked 5% of responses were not filmed. 10% of responses were not engaged (NE). These all came at the end of the lesson from one student who was yawning, rubbing his eyes and obviously weary. These are not considered important to this study.

The highest number of eye movement responses to SAQ questions was R2+'s (28%); a result that shows SAQ do elicit higher cognitive processing. Ten percent of responses were R1, NVC accounted for 23% and ECR for 24%. The breakdown of responses to SAQ is contained in Chart 7.

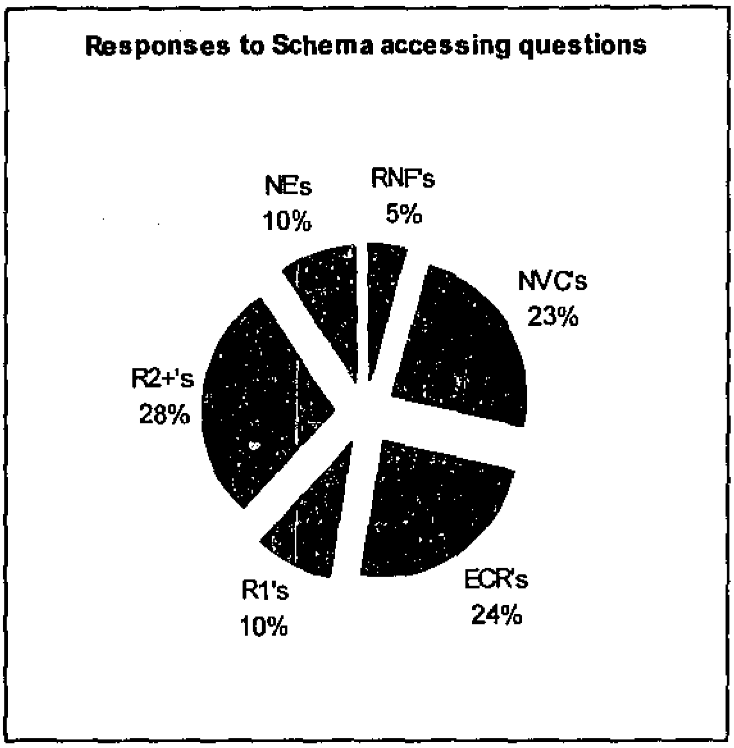

Chart 7: Responses to schema accessing questions

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CHAPTER 6: CONCLUSIONS

The findings of this study are not conclusive and should be taken as indicative only. The assumption that thinking leads to learning is accepted in concept for this study while it is also acknowledged that variables come into play whenever choice is involved. An individual student's interpretations or understanding of the question through his/her model of the world will impact on the response generated.

In this study it was discovered that of all possible non-verbal responses only eye movements were easy to observe and furthermore occurred consistently in all students and consequently can be considered as indicators of brain function (see Literature Review). Only trends can be seen from the charts above as these results are not clear cut. Part of the reason for this can be explained firstly by the unpredictability of the 'human element' and secondly by the fact that the research design did not have the scope to ascertain exactly and specifically how the students were thinking, the chain of events from question to eye movements to brain activation of specific areas to level of cognitive engagement was indicated by the literature.

The filming could have been better targeted to demonstrate eye movements if it had been known from the outset that eye movements would be the behavioural indicators of thinking. A theoretical model has been postulated from the review of the literature but further research is needed, possibly by using fMRI brain scanning technology while the subject is asked the different forms of questions.

It appears that questions do not ALWAYS cause students to think. The most important finding is that eye movements seem to be indicators of the brain's engagement. It can give teachers some indication of whether or not student attention and focus is activated. It can also alert teachers to the fact that when their students eyes are still moving about they may need more wait time to process their thinking and responses.

In relation to responses to various forms of questions some findings of interest to instructional design are revealed. Closed questions do elicit the lowest evidence of brain functioning by the indicators shown by this study. It is possible that the form of the question directs students not to engage because there is no necessity for engagement in procedural questions. It could be useful for teachers, when using closed questions to check for understanding, to attempt to elicit more meaningful responses than yes or no, but perhaps, in many situations negative or affirmative answers are sufficient.

Closed questions could be the way a balance of activity and rest for the brain is accomplished in the classroom. Another way of talking about this resting downtime for the brain is by using the words 'on task' and 'off task', suggesting that "… teachers are more likely to keep students focussed *during* the lesson segments if they go off task *between* the segments (Sousa, 2001, p93).

When wide awake and learning the brain operates in Beta which cycles at 13-25 cycles per second. When cycling in Alpha, the learning state of 'relaxed alertness', the brain cycles at 8-12 cycles per second (Dryden & Vos, 1999, p168). It therefore follows that the brain uses more nutrients (glucose and oxygen) (Carter, 1998), in Beta than in Alpha. Just as a runner can only sprint at maximum effort for short spells before stopping to 'catch his breath'; so too the brain. It can only operate at full power for short spells before it needs to slow and 'catch it's breath', perhaps this is a very important function of closed questions – a mental rest.

The main disadvantage to closed questions is the fact that they are easy to generate because they are habitual and do not involve clear teacher intent. Conversely, the main advantage to busy stressed teachers coping with the complexities of a classroom every day is the fact that closed questions can be automatically generated and they work almost half of the time. Awareness of the form of questions they are generating, and more important, that the intent of their questions really matters, is the value of this research to teachers.

The results of open questions are the most surprising. They elicited more R2+ and more NVC than they did R1. Of the 65 open questions 14 were identical and 7 repeated the spirit of the previous question, albeit not in the same words. An example of this occurs in an exchange starting on Line 90: **"What are you thinking name?"**, followed by Line 94: **"Name?"**, Line 97: **"Name?"** and Line 99: **"Name?"** as the teacher called on different students one after the other to reply to the same question. This means that 21, or nearly one third of open questions were essentially the same. The responses to these questions, however, are not consistent at all. The above example of the exchange from Line 90-99 elicited 1 unfilmed response, 1 response of the R2+ type and 2 which had no visible eye movement changes.

It is also interesting to note that open questions, related to content do not necessarily engage the students' cognitive processing. Perhaps a single eye movement involves memory retrieval of a fact which is closed, that means it needs no further thought because it is already known or so far outside the student's current world view that it has no relevance.

A surprising finding is the high number of both NVC and R2+ responses generated by open questions. This might be explained by the different ways the students interpret the question because of their level of thinking at the time. Perhaps when students respond to OQ with R2+ responses they are attempting to predict the teacher's expectations and are involved in predictive thinking, which is process thinking. It seems that students can turn content questions into questions about thinking as well as the other way around. This too could be investigated in further studies.

An example of this comes from the lesson: Lines 409-417: "**Now looking at the similarities and differences, um between animals is kind of level 2 and it's really good thinking, and you're doing some excellent thinking here this morning. Now if we want to take you that one extra step - the 'so what' and into the next phase of thinking we need**

to be able to say 'How do these three animals, birds, frogs and macros, how do...are there any connections between them?" It takes some time for the students to realise she is not asking them for facts (content), but for connections (schema accessing). As soon as one student mentions a food chain all the others realize how their thinking is being challenged and their responses quickly show they have also made the link.

If misinterpretation of the form of the question occurs in the mind of the hearer it is almost impossible for the form of response to be completely predictable. Misinterpretation of the question could occur because the teacher is not sending a congruent message via the question. For example, if the teacher uses the word "what" when s/he wants to elicit a process response, the student's mind will look for content, (the 'what'). If the teacher uses the word "how" the student's mind is instantly directed towards process.

On further investigation the responses to open questions were not as surprising as first thought. It is possible that the reason for the low number of R1 responses could be that open questions are designed to access content and if the content is new to the students it might not yet be integrated into their schema. We know that some people need a number of exposures and some people need a certain amount of time to pass before they accept new data. This could explain why the responses to content based questions are showing a high number of NVC responses. The schema are not expanded to include the new data until the brain has accepted and integrated it. Sometimes data is not integrated until after a REM sleep cycle has provided an opportunity for mental review. It could be postulated that the ability of the brain to put data 'on hold' until further consideration is an important survival skill because if people automatically accepted all the data they received as 'true' there would be no discrimination, no choices and no growth of schema.

One of the things that make each one of us unique and valuable is the differences we have constructed in our models of reality. If every piece of information was given equal cognitive value and acceptance there would be no conflict or difference of opinion. Conflict, obstacles and differences of opinion causes evolution or growth of an individual's schema.

Schema accessing (process) questions do cause more eye movements than either of the other two question forms. The surprise finding was that SAQ also elicit a high number of NVC responses, slightly more than open questions. This could be because of misinterpretation of the question form. It could also be students waiting for further clues from other responses because they don't want to be seen to be incorrect. It could be students taking a 'brain rest'. A very possible reason could be that because this film was not able to distinguish the distance of focus it was not able to distinguish when students were thinking with more than one brain area simultaneously. (Refer to the literature review page 33 to see that synaesthesia can be indicated by defocused eyes staring into the distance ahead. In this study staring straight ahead has been interpreted as eye contact or looking at the charts and is a very common response). If this could be proven it would mean that schema accessing questions were more effective than appears from the scope of this study. If this is the case there is an adequate reason for teachers to be very clear of the intent of their questions and direct them in such a way that the level of thinking necessary for the appropriate processing of that question is optimized.

In summary, the study does indicate trends in the response patterns to various question forms. Of course it is possible that other indicators of complex brain processing exist, perhaps the students <u>were</u> doing complex work when their eyes didn't move and the scope of this study was not adequate to identify this. The information that could be disseminated to teachers could be listed as follows:

- It is very important to have clarity of intent for the questions you ask. Some questions are asked from the teacher's perspective and these kinds of questions cause students to resist.
- Eye movements that students display are not random actions, they are indications of brain activation.
- All the question forms are important in human interactions generally and the classroom in particular.
- When transferring information to the students it is the balance of question forms that is important, students need all three to integrate the lesson.
- Closed questions are less than half as effective at encouraging students to build neural networks in all areas of their brains than open and schema accessing questions.
- The results showed that tag questioning is a good strategy for helping students integrate the data by agreeing to it, which expands their schema.
- Questions which embed commands are very successful at obtaining student compliance.

6.1 SIGNIFICANCE OF THE STUDY

What do student eye movements tell us about how they are responding to the form of teacher's questions?

A danger of the results of this study is that teachers may think that SAQ should form the major part of each lesson. Generally the forms of questions people use must allow for the balance of natural processing to occur. The use of <u>SOME OF EACH OF THE FORMS OF QUESTIONS IN A LESSON will provide balance and the brain activity most likely to increase attention, cognitive engagement, logical processing and achievement of learning outcomes.</u>

The main significance of this research is that it shows teachers what sort of responses their questions are most likely to generate. It provides an invaluable opportunity to observe the level of cognitive function at the moment of asking the question while allowing for immediate

feedback or attention as soon as the response is observed. It also provides an increased opportunity for the building and maintaining of rapport, thereby encouraging more efficient teaching practice and teacher job satisfaction.

This study can provide teachers with a way of consciously asking questions to elicit specific responses and a means of recognising whether or not those responses have been generated. This study is indicative of the sorts of responses students generate to specific forms of questions. As has already been shown in the literature review, see pages 35-37, the movements of eyes can both indicate and cause blood flow to tissue in specific areas of the brain, at the same time it shows that blood flow to specific areas of the brain is indicative of cognitive function.

The three most valuable components of human communication are;

- Having specific intent for your communications
- Being able to observe the responses
- Having enough flexibility to make the most useful correction in the moment.
- In the classroom skilled communication which involves both observation and congruent response is the essence of skilled teaching.

The challenge in every classroom is bringing those students with immature cognitive skills up to the level of the rest of the class. When teachers can easily and quickly identify the level of cognition being displayed by students it would be easier for them to adjust their responses in the moment. The findings of this paper could help teachers examine their questioning practice and become more effective at relating and transferring data to students.

It is not possible for a teacher to observe the eye movements of every child in the class simultaneously. The teacher's attention moves from one student to another in the same way that normal human interaction occurs within a group. The speaker's attention is drawn to individuals from time to time, whether by those individual's actions, words or intensity. A teacher, for

example, will draw out shy or unresponsive students and encourage rowdy unthinking students to focus. The value of these eye movement patterns is that the teacher can immediately see whether an apparently unresponsive student is using cognitive functions or not. This can be observed covertly, even if the question was not directed specifically to that student. Conversely, if a teacher can see that a student who has difficulty focussing is only moving their eyes in one direction that student can be given tasks to develop greater mental flexibility which makes thinking an easier skill to master.

Intentionally framing questions for specific brain responses impacts on the lives of both students and the teachers who use it. It will impact all their personal and professional relationships. The interactions teachers have with students and parents, fellow staff, their own children, spouses, family members and every other form of social exchange could be more conscious and effective. Teaching is a highly complex profession with many, many variables affecting the classroom culture and behaviour of the students (Bennet & Rolheiser, 2001, pp6-8). Among these are student morale, learning outcomes, curriculum issues, disciplinary issues, issues of self worth, inclusivity and sensitivity of students. Over, above and through this complex web weaves society's mandate to teachers to evolve these young minds into mature, thinking adults. It is a huge responsibility to evolve anybody's world view. To be able to expand someone's schema gently, respectfully and with grace is the very essence of pedagogy.

In summary, the significance of this research is:

1. When calibration of response is used as a measurement of the effectiveness of any communication greater opportunity exists to develop the cognitive skills of each individual student in the class.

2. These findings could be used to help some teachers formulate meaningful questions rather than speaking frenetically all day in the hope of getting facts into the brains of their students.

3. These findings show that it is possible in the classroom, without sophisticated technology, to measure what was previously thought of as unpredictable non-verbal responses in a sensorily verifiable way. This could knit the art and science of teaching into the fabric of instructional excellence.

The expansion of both speed and quantity of data in this technological age is in danger of rendering irrelevant those people who, for whatever reason, are not able to participate. Teachers need to develop in their students both the appetite and the strategies for lifelong learning. The basic education that students receive will be more critical in a world that cannot wait for a slow reader or a person who counts on his fingers. Critical thinking and effective use of the power of the mind are important skills that every teacher needs to transfer to the adults of the future. This is why every bit of information that can help teachers to be more effective is essential. This includes not only data transfer, but also relational rapport skills, communication skills and strategies which develop enthusiasm and passion.

6.2 SUGGESTIONS FOR FURTHER RESEARCH

A study conducted along the same lines as this one, filming and counting the eye movements in response to the three main forms of questions could be very useful if it increased it's scope by:

- filming more students,
- filming more effectively by having five students in the frame at all times, which would generate a greater opportunity for comparing responses to the same question,
- gathering the data in such a way that all eye movements are recorded. Perhaps by using the equipment that relays every eye movement to a computer,
- gathering data from many teachers to find out whether they all use these same question forms in consistent proportions.

6.3 THE MODEL WHICH CAN BE DERIVED FROM THE DATA

Grounded theory does not begin with a theoretical base in mind, it is; "A set of well-developed concepts related through statements of relationships, which together constitute an integrated framework that can be used to explain or predict phenomena (Strauss & Corbin, 1996, p15)". The data gathered in this study leads to a model of teaching effective questioning as an instructional tool for the use of trainers of teachers.

6.3.1 The reasons for the development of this model from the data.

- questions are a normal part of human interaction and they are used in classrooms
- using questions more effectively takes no more effort than using them habitually
- with a little training people could question more effectively and the return in learning outcomes could be greater than the expended effort
- questions provide a good opportunity for teachers to better understand the processing style of each student
- teachers who are confident in their own ability are better teachers – part of that ability is the maintenance of intent for the lesson
- if a teacher is clear on exactly HOW to speak to students they can be more effective in achieving learning outcomes
- everyone who speaks to anyone could learn this model, therefore it can make communication more effective in all relationships, not just the one between teachers and students.

6.3.2. The content of the model

This model includes the knowledge which has been considered for this study:

- brain and mind
- how the brain learns
- advanced communication skills

- maintaining learning outcome intent by quality questioning
- using questioning techniques which soften and validate, while at the same time evolving and expanding each students' model of the world

6.3.3. How could this be achieved?

1. By using the findings of the study to develop a training programme on question form and their responses.
2. Training existing teachers through one day professional development days.
3. Training trainers of trainee students.

6.3.4. What else could the study impact?

This model can be used by anyone who communicates with anyone else, it can be generalised to anyone who is interested in learning it, including anyone who works with people, such as parents, grandparents, and childcare workers. This list could also include the students themselves who would learn valuable communication skills from anyone who practices the model. A further advantage of this model is that it is not difficult to learn or to teach and could be taught to interested groups in an interactive one day training.

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APPENDIX

The following pages are copies of the letters of consent for the filming of students in the classroom.

Document 1: Letter to the parents.

Dear Parent,

Technology is changing the world so fast. Researchers in many fields, including education, are looking for ways to make our lives richer in the future. A research project starts with what is happening in the school now and then finds ways to improve it. We are always looking for ways to make your child's experience at school as easy, stress free and rich in learning as possible.

The Principal and Teachers of your child's school have agreed to allow a researcher from Edith Cowan University Faculty of Education to do her Master of Education research in your child's classroom. The Edith Cowan University Ethics Committee has also approved this project. If you would like more detail than this letter provides, they are happy to discuss it with you.

The purpose of this letter is to let you know what is proposed. The study group will be in the normal classroom at the normal time for that lesson. It will involve the usual sort of small group work a teacher does in a project with six students. They will be doing a project that is a part of their normal year's work, so they will not miss any work by taking part in the research, the only difference will be that the children will be videoed so the responses the teacher gets to her questions can be studied to see how questions are helping learning.

The study aims to find out whether questions help students to think for themselves. Creative thinking is one of the skills identified as necessary in the future and we are trying to find out how to help students develop this skill. When a child thinks creatively they are able to work things out effectively for themselves, grow their independence and get better jobs.

The study will be looking very closely at the questions the teacher uses and also at the student responses. Measuring student response will be by analysing a video of the group as they are working in the classroom, to find out how students respond to the questions asked. The videos will be kept under lock and key until the analysis is complete. After this time they will be destroyed. No names will be used in the final results, as we are analysing questions, not students.

Please feel free to contact either the researcher, her supervisor or independent advisor if you need to, you may contact them before, during or after the study if you have any queries.

Researcher: Ani Lewis. [redacted]

Supervisor: Dr M Sims, Co-ordinator Children & Family Studies, Community Studies.

Edith Cowan University, 100 Joondalup Drive, Joondalup, WA 6027. Phone 6304 5629

Independent Contact: Dr G McKay, Head of School ICCS. Edith Cowan University, 100 Joondalup Drive, Joondalup. WA 6027 Phone 6304 5589

If you would like your child to be a part of this research, please fill in the form on the next page and send it back to school tomorrow. Once all the permissions are received we will set a starting date, hopefully within a couple of weeks. The study aims to have the filming completed in two lessons.

Yours sincerely,

Ani Lewis 26.07.04

Document 2: Permission to include the child in the filming.

PERMISSION TO INCLUDE MY CHILD IN THE VIDEO STUDY ON QUESTIONING.

I (name)..being the parent/guardian of

(student name)..................................at (school).........................

in year..................have read the information letter enclosed with this form.

I understand the information provided and know that I can contact either the researcher, the supervisor or independent advisor with any questions or issues I may have now or later.

I understand that my child will be videoed to enable the researcher to study student responses to teacher questions.

I understand that the videos will be kept confidential and that the study will not identify any of the participants, and that the videos will be destroyed at the completion of the study.

I understand that the videos will only be used for the purposes of this research project and how the information is to be used.

I understand that I am free to withdraw from further participation at any time, without explanation or penalty.

I freely give permission for my child to be videoed for the purpose of this research /

Signed..

Dated...

This signed consent must be returned to the class teacher before your child can participate in the study.

Document 3: Explanation of research for Principal and Staff of the school.

20th September, 2004

Dear Mrs Nankervis and Staff,

Thank you for allowing me to explain my proposed research for a Master's of Education through Edith Cowan University, the University Ethics Committee has approved this project. I hope that once you have read about it you will give me permission to carry out the study in your school.

The title of the research is ***Teacher Torque: do questions encourage students to think?*** I know from working at your school that innovation is a high value for you all, and it could be very interesting for your staff to be able to access a report on the findings. If I discover something useful about questions causing students to think I will be most happy to deliver a staff session at your convenience to explain the findings..

PRACTICAL CONSIDERATIONS.

- The study will focus on questions and responses, not students.
- The study will examine a small group of six students working with one teacher in the normal classroom, doing a normal scheduled project. As we discussed, one of the shared classrooms where two teachers work simultaneously would be ideal, if the teachers are willing.
- The students will be videoed to facilitate analysis of the responses.
- The information letter to parents and 'permission to video your child' forms are attached for your records.
- I will be in the classroom for the duration of the lesson, it will, however be necessary to have a trial run, possibly the day before, to check the technical aspects of the filming are correctly adjusted. I will take advice from yourself and the classroom teachers on the best way to go about the videoing with minimum disruption.
- All data will be secured in a locked cabinet in my home office until they are transferred to an imac computer. The only people with access to the data will be the researcher, her supervisor and one other person who will check the researcher's coding of the data. All these people are covered by confidentiality provisions. The videos on the computer will be stored under double passwords. No identification of students or teacher or school

will be made in the final thesis, the emphasis is on the questioning style and the response it generates, not the people involved.

- At the conclusion of the study the data will be permanently deleted from the cassettes and the computer.

INFORMATION ABOUT THE PROPOSED STUDY.

- No one knows at this stage whether questions cause students to think. The refinement of video technology has enabled us to undertake a study of student responses to questions. The assumption I am working under is that if students automatically accept or discard data without thinking about them the time between questions and response will be short, If the question causes the student to think there will be a time lag between question and response while they consider the question. The study will measure this time delay to analyse student responses.
- We know so much more about how people use their brains to think and we are gradually incorporating this into research of educational practice.
- Teachers are skilled questioners and it could be valuable to know whether or not student thinking occurs because of questioning.

Please feel free to contact either myself, my supervisor or independent contact at any time before, during or after the study if you have any queries.

Researcher: Ani Lewis. [redacted]

Supervisor: Dr M Sims, Co-ordinator Children & Family Studies, Community Studies. Edith Cowan University, 100 Joondalup Drive, Joondalup, WA 6027. Phone 6304 5629

Independent Contact: Dr G McKay, Head of School ICCS. Edith Cowan University, 100 Joondalup Drive, Joondalup. WA 6027 Phone 6304 5589

I look forward to your response.
Yours sincerely,

Ani Lewis

Document 4: Explanation of the research for the two teachers who volunteered to be involved in the research.

20th September, 2004

Dear Mrs X

Thank you for expressing interest in participating in classroom research that I am proposing for my Master of Education thesis. I would like to assure you that the Edith Cowan University Ethics Committee has already approved this project and this letter outlines the practical issues that will need to be addressed if you agree to participate.

These are:

- The study focuses on observing the student's response to your questions..
- Neither you, nor the children, will be identified in any way in the final paper.
- The only people with access to the data are myself, my supervisor and one other person who will check my coding for accuracy. All of us are covered by confidentiality agreements..
- The study parameters are to film six students (a whole class would be too many subjects to analyse) as you work through a normal school project in the classroom. I know that you share the classroom and sometimes do projects of this nature with small groups. We would need a white background to ensure the film captures the detail of non verbal responses. We will also have sound recording with a tiny minidisk system as backup in case we miss a verbal response if a student turns their head away from the camera's sound.
- I am aware that an extra person in the classroom, especially one with a camera can prove to be a distraction to all students, including those not involved in the study. To familiarize them, I will do a trial run the day before to check the technical aspects of the videoing.
- A little 'stage management' will be necessary to facilitate the analysis of the videos. It would be much easier for the filming if the students could be sitting on chairs in a half moon pattern so all their faces are level with the camera and each one can be clearly seen. If when we do the technical test six students prove too many to fit into the frame we might need to reduce the number.
- I hope to position the camera behind your shoulder on a stand. This will mean your voice will be captured on the sound, but you would not be filmed. Only the student responses will be filmed.
- You can do any social studies lesson which fits into your timetable. The content is not important to the study.

- I will provide you with information letters and consent forms for the parent's of the participating students.
- After the data has been analysed I would very much like to discuss the findings with you before I finalise the paper. I'm sure that with all your experience with growing the minds of the next generation you will have some valuable insights.

If you have any questions and would like to talk to either of us, both my supervisor and I would be happy to hear from you. I have also provided the contact details for an independent contact.

Researcher: Ani Lewis. [redacted]

Supervisor: Dr M Sims, Co-ordinator Children & Family Studies, Community Studies. Edith Cowan University, 100 Joondalup Drive, Joondalup, WA 6027. Phone 6304 5629

Independent Contact: Dr G McKay, Head of School ICCS. Edith Cowan University, 100 Joondalup Drive, Joondalup. WA 6027 Phone 6304 5589

If, after reading this, if you have decided to participate in this research, please would you sign the declaration and return it to me.

Many thanks,

Ani Lewis.

Document 5: Teacher's permission to participate

AGREEMENT TO PARTICIPATE IN THE PROPOSED CLASSROOM RESEARCH.

I (name)..being a teacher of year....................

at (school).............................

I have read the information letter enclosed with this form.

I understand the information provided and know that I can contact either the researcher or the supervisor or independent advisor with any questions or issues I may have now or later.

I understand that my participation will involve teaching a small group of six students in the normal way, and that the questions I ask in the course of the lesson will provide the basis for student responses which will be analysed to discover if the questions have caused the students to think.

I understand that the videos will be kept confidential and that the study will not identify any of the participants, and that the videos will be destroyed at the completion of the study.

I understand that the videos will only be used for the purposes of this research project and how the information is to be used.

I understand that I am free to withdraw from further participation at any time, without explanation or penalty.

I freely agree to participate in this research.

Signed..

Dated..

Document 6: Ethics declaration for the person who checked the coding

ETHICS DECLARATION

I agree to check the coding on the research project Teacher Torque.

I have read and agree to abide by the conditions and constraints set out in the Edith Cowan University Statement on Ethical Conduct of Research Involving Humans.

APPLICANT:

Name...

Signature..

Date..

Appendix Table 1: Statistics of the lesson.

Film Length:	38 minutes 32 seconds.			Percentages.
Word Count:	T1	3359		57.17% of total words
	T2	538		9.15% of total words
	Students	1683		28.64% of total words
Wait Time:	558 seconds = 9 minutes and 30 seconds. 24.13% of lesson time			
Number of Meaning Units:		438		
Number of Instructions:		58		13.24% of Meaning Units
	Content instructions		23	39.65% of Instructions
	Process instructions		35	60.34% of instructions
Number of Softeners:			97	22.15% of Meaning Units
	Included 55 Embedded Commands			
Sensory based Words:		478		8.13% of total words
	Visual	89		18.61% of SBL 1.51% of total
	Auditory Tonal	61		12.76% of SBL 1.03% of total
	Kinaesthetic	166		34.72% of SBL 2.82 %of total
	Auditory Digital	164		34.3% of SBL 2.79% of
Number of Agreements:		24		
Number of Disagreements:		4		
Validating Statements:		203.		46.34% of Meaning Units
	Group validation		58	
	Praise of Individuals		48	
	Thanks		27	
	Use of student names		62	
	Use of other teacher name		8	
Number of Modal Operators:			109	
	of Necessity	43		39.44% of Modal Operators
	of Possibility	66		60.55% of Modal Operators
Number of Causal Linkages:			27	
Number Attention gathering Incidents:			8	1.82% of Meaning Units
Repetitions:			75	
	Clarify understanding		5	6.66% of repetitions
	Defacto wait time		8	10.66% of repetitions
	Reframe or repeat instructions		15	20% of repetitions
	Repeat in another sensory channel		10	13.33% of repetitions
	Rapport with students		13	17.33% of repetitions
	Emphasis		19	25.33% of repetitions

In the following count sheets the questions are not stated in full because of lack of space, the main interrogative phrase is used, the questions are not stated in full because of space constraints in the spreadsheet.

Appendix Table 2: Responses to closed questions

	Line	Closed Questions	Responses to Closed Questions	Count
1	37	.. like to share it with us?	No eye movements	1xNVC
2	72	...similar sort of cycle?	SA V NVC: SB V nods, NVC : SC K,NVC SE K NVC	4xNVC
3	76	...eggs would hatch?	SB V nods NVC : SD Atr NVC : SE V nods NVC	3xNVC
4	76	Are you thinking that	same as above	3xNVC
5	79	So can we transfer it?	SC V NVC	1xNVC
6	104	can you see it if I put it...?	SC K,V,K R2	1xR2+
7	123	could I borrow yours?	SB K,V,K,R2	1xR2+
8	123	..got one there/	same as above	nil
9	127	You right there?	No ey~ movements	1xNVC
10	132	..remember what we use it for?	SB Vr Vec Vr Atc R2	1xR2+
11	132	Name?	SB Atc,Ad.K.Atr.K.Atr V R2	1xR2+
12	136	similarities and something else?	SB K Ad V Atr R2 other students= 3xNVC	1xR2+3xNVC
13	144	clear about where we pout things?	SB Vec,V,Vr,V,K eyes closed Vr Vec R2	1xR2+
14	148	..would that be helpful?	All students writing RNF	1xRNF
15	149	Shall we call that macro?	All students writing RNF	1xRNF
16	165	...questions to ask?	SC Vec NVC : SA Rubs eyes, blinks Vc hand up R1	1xNVC1xR1
17	167	...use this first?	SE Atc NVC	1xNVC
18	179	...that one?	SA Vec NVC	1xNVC
19	172	...this bit here?	SA Vec NVC	1xNVC
20	181	OK?	SA Vec NVC	1xNVC
21	183	...was a frog was it?	SA eyes still on chart NVC	1xNVC
22	186	What would that be?	SA flick Vc ,Vec R1	1xR1
23	188	...and this one here?	SA Vec NVC	1xNVC
24	190	...and the one in the centre?	SA Vc flick Vec R1	1xR1
25	200	...would it be useful if I...?	No eye movements	1xNVC
26	215	breathe in water?	SA Vec NVC	1xNVC
27	217	breathe in water?	SA Vec flick Atc Vec R2	1xR2+
28	221	Doesn't have a timeline?	No eye movements	1xNVC
29	245	..don't you think so?	SA smiles V K V R2 : SC V K Vec R2	2xR2+
30	257	..get one in each thing?	SA Vec Ad Vec R2	1xR2+
31	318	...trying to say there?	Eyes roll around all over the place - trying R2	1xR2+
32	329	...can you see?	No eye movements	1xNVC
33	331	...with that picture?	SA Vec K R1	1xR1
34	350	...are all chickens white?	SA Vc Vec R1	1xR1
35	356	... are all chickens yellow?	No eye movements NVC	1xNVC
36	384	what did you find more...?	SB Vec blinksx2 Vr K Vc Vec Atr K R2	1xR2+
37	385	...more difficult?	No eye movements NVC	1xNVC
38	387	...or was it differences	No eye movements NVC	1xNVC
39	400	...spoken to you haven't I?	Vec K R1	1xR1
40	456	thinking something different?	No eye movements NVC	1xNVC
41	456	...about the relationships?	No eye movements NVC	1xNVC
42	457	...the same process of thinking?	SB Atc Ad R1	1xR1
43	459	...live in the environment?	SB Vec flick Atr Vec R1	1xR1
44	461	...could they live	NFR	1xRNF
45	461	...share and environment?	NFR	1xRNF

46	497	...right there?	No eye movements **NVC**	1xNVC
47	535	...because there is no food?	**NFR**	1NFR
48	562	Put pressure on there...?	**SE** Ad Vec **R1**	1xR1
49	564	What would happen then?	**SE** Atc K **R1**	1xR1
50	566	...happen to the poor frogs?	**SE** Atr Vec **R1**	1xR1
51	601	Need to look after the...?	No eye movements **NVC**	1xNVC
52	611	Can you see it, can you imagine it?	No eye movements **NVC**	1xNVC
53	613	Can you see it?	**SC** hands over eyes **NFR**	1xRNF

Totals 35 NVC : 6 RNF: 11R1 : 12R2+

Appendix Table 2: Count sheet of responses to closed questions

Appendix Table 3: Responses to open questions

	Line	Open Questions	Responses to open questions	Count
1	7	What tell us?	All students looking at chart	4xECR
2	8	...what it represents?	All students till looking at chart	4xNVC
3	13	...what it represents?	**SA**Vec+V,K-**R2** :**SBO**+K-**R1**: **SC**K+head Ad eyes K-**R1**	2xR1
			SD Atr+Ad,Atr,K-**R2**: **SE** Vr+K,Vc,K,Atr,K,Atr-**R2**:	3xR2+ 1xR1
4	14	What are you thinking, name?	**SA**V+K,K **R1**:**SD** Atr+looks at SA,Ad,V,K,Atc,Atr,**R2**:	1xR2+
5	17	What were you thinking, name?	**SA** looks at SE K,V,O,K **R2**:**SB** Vr+K eyes closed VcR2	2xR2+
			SC looks at SD at watch Vc,K **R2**:**SD** K+V,K **R2**	2xR2+
6	25	Name, what are you thinking	All look towards student whose name was called	4xECR
7	28	Could you tell me something?	Not filmed	RNF
8	33	What are you thinking, name?	**SB**K+Vc while answering, Vr,Atr,Vr,K,V **R2+**	1xR2+
9	39	Name?	**SS** V+K,V **R2+**	1xR2+
10	42	Name?	**SC** K+V **R1**	1xR1
11	51	....pictures represent?	All looking at chart	4xECR
12	52	What do they tell us?	All looking at chart	4xECR
13	53	What are you thinking?	All looking at chart	4xECR
14	54	Name?	All looking at chart	4xECR
15	62	What are tou thinking, name?	**SE** V+Vc,V **R2+**	1xR2+
16	67	What are you thinking, name?	**SC** K **NVC**	1xNVC
17	86	What does this represent?	**SE** frowns, eyes V head K, focusses in V **R1**	1xR1
18	86	What is it trying to tell us?	No eye movements	1xNVC
19	88	What are you thinking?	Not filmed	1xRNF
20	90	Name, what are you thinking?	Not filmed	1xRNF
21	94	Name?	**SE** K+Atr,Vr,V **R2+**	1xR2+
22	97	Name?	No eye movements	1xNVC
23	99	Name?	No eye movemnts	1xNVC
24	111	...why would we call this...?	All looking at diagram, can't see eyes	1xECR
25	114	...a trivenn diagram?	All looking at doagram, can't see eyes	1XECR
26	115	what are you thinking, name?	**SB** Vr+ Vec,Ad,Atr,Ad,Ad,Atr looks down at chart, Atr,Vr	1xR2+
27	120	..add their thinking to that?	**SB** Atr+Vec,blink,Atr,eyes back to chart **R2**	1xR2+
28	167	Name?	**SE** Atc	1xNVC
29	241	part..in and part out?	**SA** V straight ahead **NVC**	1xNVC
30	265	..share one of your similarities..?	**SA** V straight ahead **NVC**	1xNVC
31	269	..and that is different to the..?	**SA** Flick Ad, Vec **R1**	1xR1
32	280	...answer that questions for us?	**SA** V straight ahead **NVC**	1xNVC
33	280	..or the big one?	**SA** Ad,Vc,Ad,Vec **R2**	1xR2+
34	287	Name, share something with us?	**SB** Vc **NVC**	1xNVC
35	294	Name?	No eye movements	1xNVC

36	301	For...?	No eye movements	1xNVC
37	328	..what would you put..?	Not filmed	1xRNF
38	346	Name, what are you thinking?	Not filmed	1xRNF
39	354	Are all...?	All looking at chart, no eye movements	1xECR
40	360	So when they...what...?	**SA** Atc, Vr,K,Vec,Atc,Vr,Vec **R2**	1xR2+
41	425	So you are talking about?	**SB** Atc, Vec,Ad,Vec **R2**	1xR2+
42	441	Name, what are you thinking?	**SB** Ad,O,Vec **R2**	1xR2+
43	448	Name?	No eye movements	1xNVC
44	452	What are the...?	**SB** turns to student, no eyes visible	1xRNF
45	466	...to share...to live in?	**SC**Ad flickVc,K,Ad,K,Atr,Ad,Atc,Vc,K,Ad, sighs,**R2**	1xR2+
46	474	...in this environment?	**SC** yawns, squiggles, eyes K **NVC**	1xNVC
47	476	able to touch...?see...?	**SC** yawns, squiggles, eyes K **NVC**	1xNVC
48	477	...in this shared environment?	**SC** yawns, squiggles, eyes K **NVC**	1xNVC
49	479	Name?	**SC** Atc,Vc flick K **R2**	1xR2+
50	481	Name?	**SC** looks confused (previous response inappropriate)	1xNVC
51	483	What would this food look like?	**SC** still loooks confused, no eye movements, all K	1xNVC
52	500	What do you think would...?	**SE** Atr, V,Atr,V head to Ad eyes to V **R2**	1xR2+
53	502	What think...for good?	**SE** O,Atc,Vec,Atr,O,V,Atc,K,Ad,Atr,Ad,Vc,O,Ad,Vc,O,Atc,Atr,K R2	1xR2+
54	511	...animals away?	**SE** Atr,V,Vc,K,K,Vr,Vec, (continuing)**R2**	1xR2+
55	514	...over time?	**SE** (cont)Vc,Ad,V,Ad,C,Asd,K,Atr,V **R2**	1xR2+
56	515	...start with Name?	**SE** Ad,Vc,V while listening to other student answer **R2**	1xR2+
57	521	What would happen to...?	No eye movements to record	1xNVC
58	587	...what mean?	**SC** eye movements continue over three questions	1xR2+
59	588	...what...make sure of?	Ad flick, Vec,Atc,Adhead,eyesK, Vc,Atr,Atc frowns,	1xR2+
60	588	...what do...doesn't happen?	K,Ad,G,Atc., frowns,K,Atr,Ad. Flick Vr **R2**	1xR2+
61	591	Name, what are you thinking?	**SC** lost focus, not engaged **(NE)**	1xNE
62	607	What are you thining, name?	No eye movements	1xNVC
63	613	...what colour...?	SC hands over eyes	1xNE
64	619	..a chain with food on it?	SC rubs eyes, yawns, NE	1xNE
65	628	Well of course, it;'s very...?	All students ECR	4xECR

Totals: 22 NVC : 6 RNF: 3 NE : 34 ECR : 4 R1 : 27 R2+

Appendix Table 3 Count sheet of responses to open questions.

Appendix Table 4: Responses to schema accessing questions

	Line	SAQ	Responses to SAQ	Count
1	37	... thinking anything different?	**SA** K: **SB** V: **SD** K **SE** K	1xNVC
2	78	... thinking anything different?	**SB** Vr,V,Vc,V **R2**	1xR2+
3	184	So what?	No eye movements	1xNVC
4	271	Why?	**SA** Atc,K,Ad **R2**	1xR2+
5	273	And it's different...because?	**SE** Vec,Vc **R1**	1xR1
6	282	Is it so?	**SA** Vec closes eyes, Vec, G,Ad,Vec,Ad nods **R2**	1xR2+
7	296	...whereas the frog?	**SC** Vc Atc Vec as he answered with head in K **R2**	1xR2+
8	299	... the small?	No eye movements	1NVC
9	343	...relate to the frog then?	**SA** appears not engaged, doesn' hear the question	1xNE
10	352	So they can change?	All looking at chart no eyes to observe	1xECR
11	417	..any connections between them?	Staring at chart, lost in V **NVC**	1xECR
12	420	...are there any connections?	**SB** Ad,Vr,Vec **R2**	1xR2+
13	421	.relationships, do they come into?	No eye movements	1xNVC
14	423	..so.bird..?	No eye movements	1xNVC
15	487	...and I want to know why?	Eyes on chart	1xECR

16	490	...your why?	NFR	1xNFR
17	581	what does this mean for our...?	SC Atr,Vec,Atc,Vec,Vc,Vec,Vc hand up **R2**	1xR2+
18	583	and we've got birds, so what?	SC Vc,Ad eyes down head to Ad **R1**	1xR1
19	584	...mean for our wetland?	included in above response	
20	592	...and what does it mean for us?	SC not engaged	1xNE
21	626	...so what?	All looking at chart no eyes to observe	1xECR
22	630	Because...?	All looking at chart no eyes to observe	1xECR
	TOTALS	**5x NVC : 6xR2+ : 2xR1 : 2xNE : 1xNFR : 5xECR :**		

Appendix Table 4: Count sheets of responses to schema accessing questions

Appendix Table 5: Responses to tag questions

	Line	Tag Questions	Responses to Tag Questions	Count
1	1	Lets get started then, shall we?	All watching teacher,getting comfy, settling in	Act/obey
2	11	...ask you what you think, OK?	SE nods **NVC**	Act/obey
3	46	...or representing a bird, OK?	All looking at chart **NVR**	1xNVR
4	78	...different, no?	SB Vr Vc V **R2**	1xR2
5	80	...cycle of a bird, can't we?	**NVR**	1xNVR
6	120	...add anything to that, no?	All Vec **NVR**	1xNVR
7	151	...let's call it bird, OK?	SB eyes down **NVR**	1xNVR
8	154	...call it frog, shall we?	**NVR**	1xNVR
9	158	...macro, isn't it?	all heads down and writing **NVR**	1xNVR
10	183	...was a frog , was it?	**NVR**	1xNVR
11	263	...really good, wouldn't it?	SA V at preceding Q no change at tag **NVC**	1xNVC
12	393	...these animals, is that right?Yes?	SB staring straigh ahead **NVR**	1xNVR
13	400	...haven't I?	SB Vec **NVC**	1xNVC
14	401	...haven't I?	SB Vec **NVC**	1xNVC
15	440	Yep? OK?	SB Ad O Vec **R2**	1xR2+
16	451	....not really?	**NVR**	1xNVR
17	456	....no?	SB Vec straight ahead **NVC**	1xNVC
18	515	...this time, shall we?	**NVR**	1xNVR
19	523	...be sad, wouldn't it?	**NVR**	1xNVR
20	550	...bit of an impact, isn't it?	SE Vec, nods,Atr **R1**	1xR1Act/obey
21	551	...disappear, wouldn't they?	SE Vc **NVC**	1xNVC
22	637	...back in five,OK?	**NVR** they bend to gather their books and leave	Act/obey
TOTALS	**3xact/obey : 2xR2+ : 1xR1 : 11NVR : 4xNVC**			

Appendix Table 5: Count sheets of the responses to tag questions

Appendix Table 6: Responses to questions which embed commands

	Line	Embedded Command Questions	Responses to Embedded Command Questions	Count
1	1	Lets get started then, shall we?	All watching teacher put the chart up, settling in	Action/obey
2	2	Can I ask you to have a little look?	All looking	Action/obey
3	6	could you have a look at...?	All still looking at chart	action/obey
4	108	...you have a little look?	All looking	action/obey
5	157	...shall we call it macro?	All writing NVR	1xNVR
6	382	...can I have your attention ...?	SC "Yep" K Vec all others look at teacher	action/obey
7	383	...can you look over towards me?	Same as above	action/obey
8	427	can you have a little look..?	SB Atc Vec Ad Vec	action/obey
9	464	can you look at me ....?	SC K head down K head up looks at T, yawn Vc K	action/obey
10	578	...can I have your attention...?	SC Atr Vec Atc Vec Vc Vec Vc hand up	action/obey
11	578	...can you look at me?	same as above	action/obey

TOTALS 1xNVR : 10Xaction/obey

Appendix Table 6: Count sheets of responses for questions which embed commands

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