BRAIN COMPATIBLE LEARNING IN RADIATION SCIENCE

With permission and thanks to Theodore Meyer

Brain Compatible Learning in the Radiation Sciences

by
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Bellville October 2003

DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my original work (except where acknowledgements indicate otherwise) and has not been submitted or published in its entirety or in part at any technikon or university for a degree.

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DATE: ...16... February 2004

"Whatever you can do
or dream you can do,
begin it
Boldness has genius,
power and magic in it."
- Goethe.

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ABSTRACT

Brain Compatible Learning (BCL), as its name suggests, is a type of learning which is aligned with how the human brain naturally learns and develops. BCL offers many different options and routes to learning as alternatives to conventional 'chalk and talk' methodologies. A BCL curriculum is planned to define the structure and content of a programme of learning, but it also provides opportunities for students to participate in activities, which encourage and enhance the development of an active and deep approach to learning. Using BCL approaches in the classroom thus creates both a stimulating and a caring environment for student learning.

This project researches a BCL intervention in a Radiation Science course. The use of BCL techniques has tended to have been done predominantly in the social sciences; this research fills an important 'gap' in the research literature by examining how BCL might be implemented in a technical and scientific context.

The research was conducted using an adapted Participatory Active Research methodology in which classroom interventions were planned (within a constructive framework), rather than implemented and then reflected on by all participants. The PAR method was supplemented with a series of detailed questionnaires and interviews.

The broad findings of this study relate to students' experiences of BCL in Radiation Science in terms of 'process' and 'product' issues. In terms of process, or the methodology of BCL, students' responses were largely positive. Students enjoyed the varied learning experiences of the BCL classroom. There were, however, some students who experienced difficulty with BCL methodologies. This could be attributed to the nature of educational innovation in a context where students have mainly been exposed to a conventional, 'transmission' educational approach.

There are two main conclusions with regard to the 'products' of the BCL intervention. Firstly, students' marks may improve (due to the interactive and reflective nature of

the BCL program) and there may be an increase in students awareness of their own learning styles and preferences – with a resultant growth in the students' self confidence as learners.

Other conclusions drawn from this study are that there are considerable strengths in the BCL when used in the technical and scientific context of Radiation Science. BCL facilitates a thorough grounding in core areas and the practical and analytical skills that are at the heart of Radiation Science II B. BCL contributes to a learning environment which is conducive to effective learning for individual students as well as for groups of students, and in which the responsibility for the effectiveness of learning from discussion in group activities lies with students, rather than the lecturer. BCL plays a role in increasing students' abilities to analyse complex problems by drawing on methods, which are closely aligned with the natural process of how the human brain learns and develops.

There is a need to improve the quality of teaching, learning and assessment in Higher Education in South Africa. There is also a need to increase the quantity of diplomates and graduates with technical and scientific qualifications. This study offers a contribution to the improvement of Higher Education by suggesting a way in which Higher Education staff could align their practices with how students learn.

The report concludes that there is a place for BCL in teaching the subject Radiation Science to second year radiography students. Methods to introduce these changes are discussed further to show more varied approaches.

LIST OF ABBREVIATIONS

BCL	Brain Compatible Learning
ETQAs	Education and Training Qualifications Assurors
GABA	Gamma-aminobutyric acid
IE	Instrumental Enrichment
LPAD	Learning Propensity Assessment Devices
ME	Modifying Environment
MI Theory	Multiple Intelligences Theory
MLE	Mediated Learning Experience
MRC	Medical Research Council
MRI	Magnetic Resonance Imaging
NLP	Neuro-Linguistic Programming
NQF	National Qualifications Framework
NSBs	National Standard Bodies
PAR	Participatory Action Research
PET	Positron Emission Tomography
REM	Rapid eye movement
SALTT	Suggestive Accelerated Learning and Teaching Techniques
SAQA	South African Qualifications Authority
SCM	Structural Cognitive Modifiability
SET	Science, Technology and Engineering
SETAs	Sector Education and Training Authorities

SGID	Small Group Instructional Diagnosis
SHOHR	Stimulus (learning condition) Human (mediator) Organism (Learner) Human (mediator) Response
SPSS	Statistical Package for the Social Sciences

CHAPTER 1
INTRODUCTION

1.1 AN INTRODUCTION TO BRAIN COMPATIBLE LEARNING

Radiation Science is an applied science and is an area of study in the Radiography undergraduate curriculum. The subject Radiation Science is often perceived by students to be a difficult subject. This study investigates how brain compatible learning (BCL) can improve students' understanding of Radiation Science.

BCL is a purposeful learning programme which is intended to enrich the learner's cognitive engagement in the learning process. Approaches based on BCL draw on the latest research on the brain and incorporate this understanding in the teaching and learning process.

During the first three terms of 2003 (from January to September 2003) BCL techniques and approaches were used in the teaching, learning and assessment of Radiation Science II B, which is a second year undergraduate course in the Radiography curriculum.

BCL tends to empower students with life skills as well as learning tools. Jensen (1998) claims that BCL is not a panacea, but it does provide some important guidance. Brain based learning has been called a combination of brain science and common sense. Hart (1983) calls the brain "the organ of learning." He advocates that teachers should learn more about the brain in order to design effective learning environments. Caine and Caine (1991) developed twelve principles that apply what is known about the function of the brain to teaching and learning contexts. These principles were derived from an exploration of many disciplines and are viewed as a framework for thinking about teaching methodology. The principles are:

- The brain is a complex adaptive system.
- The brain is a social brain.

- The search for meaning is innate.
- The search for meaning occurs through patterning.
- Emotions are critical to patterning.
- Every brain simultaneously perceives and creates parts and wholes.
- Learning involves both focused attention and peripheral attention.
- Learning always involves conscious and unconscious processes.
- We have at least two ways of organising memory.
- Learning is developmental.
- Complex learning is enhanced by challenge and inhibited by threat.
- Every brain is uniquely organised.

For deep level learning to occur, Caine and Caine (1991) have identified three conditions:

- Relaxed alertness – a low threat, high challenge state of mind.
- Orchestrated immersion – a multiple, complex, authentic experience.
- Active processing – making meaning through experience processing (Caine and Caine, 1991).

Challenge and feedback in the learning process are well-known conditions for brain enrichment. Mental challenge can be accomplished with new material, and adding a degree of difficulty. It can also be accomplished through varying time, materials, access, expectations, or support in the learning process. It is important that challenge is just right – too much or too little can cause students to give up or become bored. Changing instructional strategies could also be used to create challenge (Greenhough, W. T. *et al.*, 1994).

Feedback should be maximised, because it reduces uncertainty, and it can increase coping abilities. Caine and Caine (1991) advocate that when we feel valued and cared for, our brain releases endorphins and dopamine, known as the neurotransmitters of pleasure. In supportive group interaction, where constructive feedback is provided, learners could experience pleasurable feelings – and associate these with effective learning. Several conditions make feedback more effective: it should be specific and not general and it should be immediate to be most useful. It has been found that many students who would fail at attempts at semantic storage and retrieval are successful with the use of reflective strategies (Hennessy, J. W., King, M. G., McClure, T. A. and Levine, S., 1977).

The techniques used and described in the literature have been tested and measured in school programmes (at primary and secondary levels) and in some higher education programmes. The methods combine confidence building, learning skills and communication skills, amongst others. The techniques used have allowed students to have multiple options for engaging with information, making sense of ideas, and expressing what they learn.

1.2 DEFINITION OF TERMS

Brain Compatible Learning: BCL is a purposeful programme to enrich the learner's cognitive engagement with learning approaches based on in-depth learning. The term BCL is interchangeable with brain-based learning.

Suggestology: Suggestology involves the use of different techniques that would imply that suggestion can and does affect the outcome of the learning situation. Some of the techniques used are to provide positive suggestion by seating students comfortably, using background music in the classroom, increasing individual participation, using posters to suggest greatness, while reinforcing information (Druckman *et al.*, 1989).

Accelerated learning: Druckman *et al.* (1989) says accelerated learning could be described as techniques used in order to enable students to learn at great speed with little conscious effort, and a great deal of pleasure. It brings together elements that at first glance do not appear to have a lot in common: fun, games, colours, positive thinking and emotional health. The followers of accelerated learning believe that positive language promotes positive actions – an important factor for stimulating the most effective brain functioning. Researchers of accelerated learning advocate that accelerated learning could take place when strenuous mental work is combined with relaxed physiology. Various studies have found, after intensive experimentation with students, that music was the key. They found that relaxation induced by Baroque music leaves the mind alert and able to concentrate (Druckman *et al.,* 1989).

Neuro-Linguistic Programming (NLP): Neuro – acknowledges the fundamental idea that all behaviour stems from our neurological processes of sight, hearing, smell, taste, touch and feeling. We experience the world through our five senses. Our neurology covers not only our invisible thought processes, but also our visible physiological reactions to ideas and events. It refers to how the mind works, such as preferences in thinking patterns, whether you are a "big picture" thinker or a "nuts and bolts" thinker, whether you see patterns or mismatches, etc (Andreas and Andreas, 1987). **Linguistic** – suggests the use of language to order our thoughts and behaviour and to communicate with others. The word "linguistic" refers to how teachers and learners use language, how they ask questions and how they use metaphors, symbols and other figurative language in their thinking (Andreas and Andreas, 1987). **Programming** – refers to ways we can choose to organise our ideas and actions to produce results. It refers to learning new ways of doing things by modelling others and developing effective strategies. Thus NLP is about learning through 're-programming' the ways in which one thinks and uses language. Or simply put – the study of how the brain organises information. It probes the relationship between language and behaviour and can be used to create rapport between students and lecturers (Andreas and Andreas, 1987).

Multiple Intelligences Theory: Gardner (1985) challenged the traditional belief that intelligence was fixed and immutable. Multiple intelligences (MI) theory broadens the possibilities of what is understood to be a classroom. Gardner (1985) described a multiplicity of intelligences that provides a strong foundation for the development of classroom environments and instructional strategies that take teachers and students well beyond traditional limits. MI theory proposes that people use at least eight relatively autonomous intellectual capacities – each with its own distinctive mode of thinking – to approach problems and create products. He explains that every normal individual possesses varying degrees of each of these intelligences, but the ways in which intelligences combine and blend are as varied as the characters and the personalities of individuals. Each child is a unique set of intellectual strengths and weaknesses.

1.3 THE AIM OF THIS STUDY

The aim of this study is to understand how learning in Radiation Science could be made more effective and meaningful to the students by using a BCL approach. Students from previously disadvantaged educational institutions, and those who have been historically marginalized from the field of science education, are likely to benefit from this research. Self directed and teacher directed pedagogic techniques are used because they are in tune with how the brain works and with the ways in which a person learns best.

It is clear from my literature survey that these brain compatible techniques have not been applied in radiation science education, and have not often been applied in science, technology and engineering (SET) programmes (Caine & Caine, 1991). This study therefore intends to find out whether the particular ways in which different techniques have been combined are beneficial for Radiography students doing Radiation Science as a subject. With BCL, they learn about theory and practice. It will be evaluated whether BCL contributes to the student in terms of building self-confidence, feeling more successful in life, and enjoying learning experiences. Data have been gathered from various questionnaires, interviews and from observation of the students in the Radiation Science programme.

1.4 PROBLEM STATEMENT

This study investigates BCL in the Radiography undergraduate, second year Radiation Science programme of the Peninsula Technikon, making use of participatory action research and using mainly qualitative methods with some quantitative methods, in order to understand how teaching, learning and assessment practices could be improved.

1.5 RESEARCH OBJECTIVES

The research objectives of this study are as follows:

- To define brain compatible learning within the context of Radiation Science.
- To find out if BCL can be successfully incorporated into Radiation Science content.
- To identify and describe opportunities for brain compatible learning in the Radiation Science curriculum.
- To develop a framework for the development of brain compatible learning activities within Radiation Science.
- To improve the Radiation Science students' attitude towards Radiation Science and thereby
- To improve their assessment marks.

1.6 HYPOTHESIS

In this study the following hypotheses are put forward:

- There are opportunities for BCL in the second year Radiation Science curriculum (therefore BCL is possible in that context) and
- A framework for BCL in Radiation Science can be developed.

1.7 CONTEXT

In the 1970s the Technikons took over the development of the Radiography curriculum from the Department of Education.

In 1990 the Radiography curriculum was revised. It was decided to change the name Radiation Physics for the second years into Radiation Science II B and to change the name Image Recording into Radiation Science II A. Radiation Science I is a pre-requisite for Radiation Science II B.

On 4 October 1995, the Department of Education implemented the SAQA Act (No. 58 of 1995) and in 1997, the Higher Education Act (No. 101 of 1997). Towards 1999 came the establishment of National Standard Bodies (NSBs) of which Health Science and Social Services are field 09, Standard-Generating Bodies (SGBs), Education and Training Quality Assurors (ETQAs) and Sector Education and Training Authorities (SETAs). The SAQA and the Higher Education Act demanded that institutions of higher education deliver academic courses using a programmes and outcomes-based approach. The new programmes had to be designed to be more flexible and combine the rigorous requirements of professional bodies with inter-disciplinary electives and generic skills.

The aim of the SAQA Act is to provide for the development and implementation of a National Qualifications Framework, and for this purpose to establish the South African Qualifications Authority. This act enables South Africa to develop its own integrated National Qualifications Framework (NQF) accompanied by a supporting quality assurance system. The NQF consists of eight NQF levels providing for general, further and higher education and training bands.

The Radiography curriculum was once again revised in outcomes-based learning programmes, to combine a strong academic foundation for the professional skills required in the world of work. Outcomes-based learning implies that learners must demonstrate the achievement of an outcome, as well as involvement in the learning process. According to Du Pré (2000), outcomes-based learning implies that the lecturer should not teach but rather facilitate learning by stimulating creativity, critical thinking and discovery by learners themselves. In the assessment of outcomes-based learning, assessment is a continuous activity. Assessment is based on assessment of knowledge, skills and achievement of outcomes.

According to Du Pré (2000), outcomes are separated into critical outcomes and specific outcomes. Following the SAQA Act, learners who meet the criteria for achieving a specific set of critical and specific outcomes will qualify for a credit. In order to qualify for a credit, learners should be capable of demonstrating that they can achieve the following outcomes at specific levels:

- Critical cross-field outcomes: These outcomes are designed by SAQA and apply to all learners' areas;
- Specific outcomes, which draw on specific knowledge and skills displayed in a particular context.

The Aim of Radiation Science II B is:

- To provide the student with sufficient theoretical and practical knowledge of ionising radiation & radiation protection.

At the end of the Radiation science II B Course the student must:

- Have knowledge of the production and characteristic properties of ionising radiation.
- Understand the interaction of radiation with matter.
- Be able to calculate problems related to radiation protection.
- Have knowledge of the biological effects of ionising radiation.
- Be able to meet the needs of industry through a commitment to a co-operative learning environment.
- Apply knowledge in a practical/clinical environment.

Critical Outcomes

The purpose of critical outcomes is to direct educational activities towards the development of the learners within a social and economic environment. The following critical outcomes are generic outcomes determined by SAQA, but contextualised for Radiography:

- Application of problem solving skills in Radiography
- Effective work within the health care team and educational environment
- Appropriate use of science and technology applicable to Radiography
- Demonstration of skills in information literacy

Credit Level Outcomes

Credit means the value assigned to a given number of notional hours of learning. One SAQA credit equals 10 notional learning hours. 120 SAQA credits are equivalent to approximately to one year of study. Exit level outcomes means the outcomes to be achieved by a qualifying learner at the point at which he/she leaves the programme leading to a qualification. The credit level outcomes for Radiation Science II B is the following contextually demonstrated end-products of the learning process:

- Apply radiographic techniques, appropriate to the clinical presentation, for the production of optimum image quality
- Apply appropriate health and safety regulations, guidelines and codes of practice in the performance of radiographic services
- Access, organize and present information applicable to the radiography context using appropriate information technology

Radiation Science II B Content

The table in Appendix A is intended to provide a brief overview of the main topics covered in Radiation Science II B with the relevant assessment criteria. Assessment for this subject is a continuous activity. The assessments are based on assessment of knowledge, skills adherence to specific processes, as well as the achievement of the specified outcomes. In this way the assessments becomes part of the learning process.

Each module is a coherent self-contained unit of learning, designed to achieve a set of specific learning outcomes assessed within that unit of learning. For the purpose of this study the whole of module one (all 8 specified outcomes) with the appropriate assessment criteria was used.

1.8 RATIONALE

Radiography students perceive Radiation Science as 'difficult' and do not always enjoy or understand it. In this study, the latest research on the brain will be reviewed as a backdrop to an understanding of how BCL could be applied in the subject area of Radiation Science. The purpose is to find out if students' attitudes towards the subject Radiation Science could be changed to a more positive one, with the added result of improving assessment marks.

CHAPTER 2
LITERATURE SURVEY

In this literature survey, the latest research on learning and the brain will be reviewed in order to implement some of the latest techniques in the second year radiation science programme. Reflective enquiry of the literature will be undertaken to try to improve the learning situation in the classroom. New ideas alone are not enough to generate better education. Educational practices and classroom organisation must also be changed to ensure improvement.

2.1 BRAIN RESEARCH

During the 1990's, brain research developed into several sub-disciplines. These include genetics, physics, pharmacology, neuroscience, etc. Many new theories about the brain have been developed. A subsection of the brain known as the cerebellum has been found to contain over half of all the brain's neurons. Robertson (2000) states that the final place that information is processed is the neodentate nucleus in the cerebellum. This small area is present only in humans and may have a significant role in the thinking process, by linking the brain and the mind. According to Robertson (2000) linking movement and thinking is inescapable; one of his patients had cerebellar damage, and as a result had impaired cognitive function. There are, of course, aspects of cognition, feeling, language and other human attributes that are not yet understood by brain researchers.

New ways of thinking about the brain as an organ have been developed by drawing on technical knowledge about the brain. Brain scanners such as Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) have provided researchers with new ways of seeing and understanding the brain. A new generation of computer-based technologies has enabled neuroscientists and clinicians to develop maps of the brain that have revised current thinking on how the brain works.

MRI machines provide high-quality cross-sectional images of soft tissues like the brain without ionising radiation. An MRI machine is a large magnetic field generator. When the machine's powerful magnet is turned on, the atoms of the body begin to align themselves. A second magnetic field is then briefly turned on and off. When on, it causes the atoms of the body to oscillate like a radio wave and, when off, to "relax." When the body's atoms return to their initial orientation, they emit energy, which can be recorded by sensitive detectors and fed into a scanning computer to create an image (Stein, G. S., Brailowsky, S., Will, B., 1995).

One of the atoms that is activated in MRI is hydrogen. Hydrogen is one of the most sensitive molecules to magnetic forces, and also one of the most abundant in biological tissue. MRI can also measure oxygen consumption and blood flow in very small regions of the brain. For quite some time now it has been known that, as brain cells become active, they use more oxygen. For brain cells to get oxygen, there has to be an increase in blood flow to the activated area. MRI can detect this increase in blood flow and create an image of where this is happening. Oxygenated blood has a different magnetic fingerprint to that of de-oxygenated blood (Stein *et al.*, 1995).

Investigators can use MRI to see which areas of the brain consume more oxygen when they ask a person to visualise an image, or think about something specific. Researchers have found that different areas usually "light up" (utilize more oxygen) in different people. Many brain regions are involved in thinking and the areas that "light up" will depend on the individual's unique brain organisation, as well as on the thoughts they have. What still remains unresolved is whether highly precise measures of blood flow can represent neural processes directly and accurately (Stein *et al.*, 1995).

A PET scanner is an imaging device that detects the distribution of radioactive tracers as they travel through the brain. The radioactive labels are usually chemically attached to substances, like glucose, that are known to be taken up in the blood stream, from where they travel to the brain. Glucose, which all cells need to maintain their activity, is therefore a good example of a substance that can be made radioactive and able to penetrate the brain easily. Each molecule of glucose has radioactive labels attached to it, so when the glucose concentrates in a particular brain area, there will be relatively more radioactivity to measure than in areas where there is less glucose. Glucose, a form of sugar, is an essential fuel for all cell metabolism, including neurons in the brain and the uptake and distribution of radioactive glucose will thus reflect brain metabolism (Stein *et al.*, 1995).

PET scanners can demonstrate that many different brain areas, some quite distant from one another, work together to produce complex patterns of nerve activation and blood flow that are associated with learning behaviour. There are substantial individual differences in the areas of the brain that become active during the performance of a task. In other words, some people may show a lot of activity in one part of the frontal cortex (site of creativity, problem-solving, etc.) during a reading task, while others, performing the same task, might show more activity in the temporal cortex (site of memory, meaning, etc). Different people use their brains in different ways. No one is yet quite sure what causes this variability and a great deal of research is still needed in this area (Stein *et al.*, 1995).

2.2 THE HUMAN BRAIN

The human brain is the most complex mass of protoplasm known to exist. The adult human brain weighs more or less 1350 grams. Humans have large brains relative to body weight. The brain consists mostly of water (78%), fat (10%) and protein (8 %). The cerebral cortex makes up critical portions of the nervous system and its nerve cells are connected by more than one million kilometres of nerve fibres.

In the 1970's and 1980's the theory of the **Triune Brain** was very popular. According to this theory, the brain has three basic parts: the stem or "reptile brain", the limbic system or the "mammalian brain" and the neocortex. MacLean (1990) has termed it the "Triune Brain" because of the three parts, each of which developed during a different time in our evolutionary history. The diagram below shows these three basic parts.

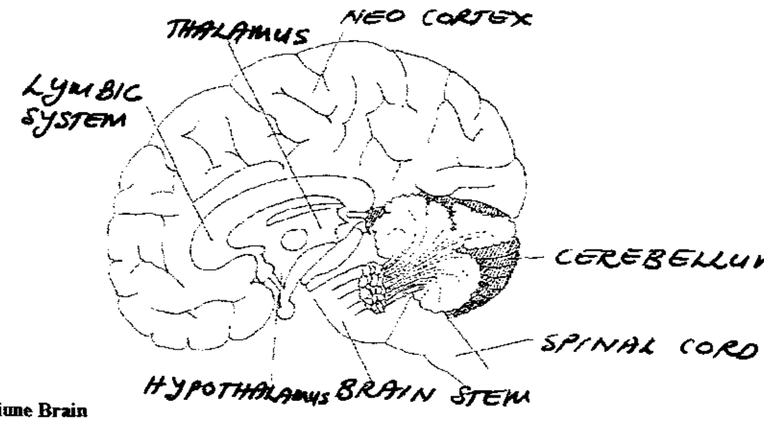


Figure 2.1: The Triune Brain (Author's diagram)

Each part has a distinct neuro structure and set of tasks to perform. First in the evolutionary development was the stem or the **Reptile Brain**, so known because we share this part with all reptiles; it is the lowest intelligence component of the human species. This part of the brain is in charge of sensory motor functions – knowledge of physical reality that comes from our five senses.

Behaviour that is seated in the reptile brain is related to the survival instinct and the sex drive to promote the species. The concerns of the reptile brain are food, shelter, reproduction and protection of territory. When you feel unsafe, the reptile brain prompts you to stand and fight or run from danger. This is the so-called "fight or flight" response. Particularly in the early development of *homosapiens* this was a necessary response (MacLean, 1990).

MacLean (1990) postulates that when the reptile brain dominates, we are unable to think at a very high level. Surrounding the reptile brain is the enormously complex **Limbic System**, or mammalian brain. According to MacLean, it functions at a higher level, in evolutionary terms, and this is the part we share with all mammals. The limbic system is situated in the middle part of the brain (also called the mid-brain). The main functions of the limbic system are emotional and cognitive. It contains feelings, experiences of pleasure, memories and the ability to learn. It also controls biorhythms, such as sleep patterns, hunger, thirst, blood pressure, etc. (MacLean, 1990).

The limbic system distributes the information it has gathered to the thinking part of the brain, which MacLean called the **neocortex**. The neocortex wraps around the top and sides of the limbic system, making up 80% of the total brain matter. According to MacLean (1990) this part of the brain is the seat of the intellect; all the higher intelligences that make human beings unique as a species are located in the neocortex. It sorts out the messages that are received through vision, hearing and other bodily sensations. The results of these sorting processes are: reasoning, cerebral thinking, decision-making, purposeful behaviour, language, voluntary motor control and nonverbal ideation (Le Doux, 1993).

There is some dispute among researchers with regard to the limbic system. For example, there are scientists who claim that there is no limbic system, only specific structures that process emotion, such as the amygdala, a mid-brain structure (Le Doux, 1993).

This model of the Triune Brain is now considered outdated. Today scientists divide the brain into four lobes. They are the occipital, frontal, parietal and temporal lobes. There is some overlap in the functions of the lobes (Robertson, 2000). Below is a diagram depicting the lobes of the brain.

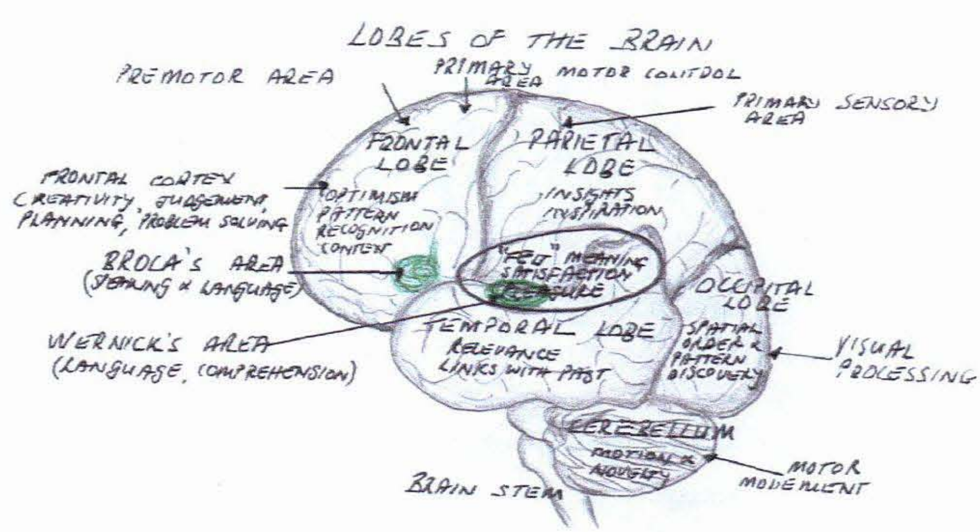


Figure 2.2: The Lobes of the Brain

(Author's diagram)

The **occipital lobe** is in the middle at the back of the brain. Its primary responsibility is vision.

The **frontal lobe** is the area behind the forehead above the eyes. It is involved with purposeful acts like judgement, creativity, problem solving and planning. In human evolution, the last part of the brain to develop was the frontal lobes. These make up more than 40% of the brain's volume. This is also the last area in the brain to develop in the growing child. It is only fully developed in the late teens or early twenties. It is this part of the brain that makes us truly human (Robertson, 2000).

The **parietal lobe** is on the top at the back of the brain. Its duties include processing higher sensory and language functions.

The **temporal lobes** (left and right) are above and around the ears. These areas are primarily responsible for hearing, memory, meaning and language.

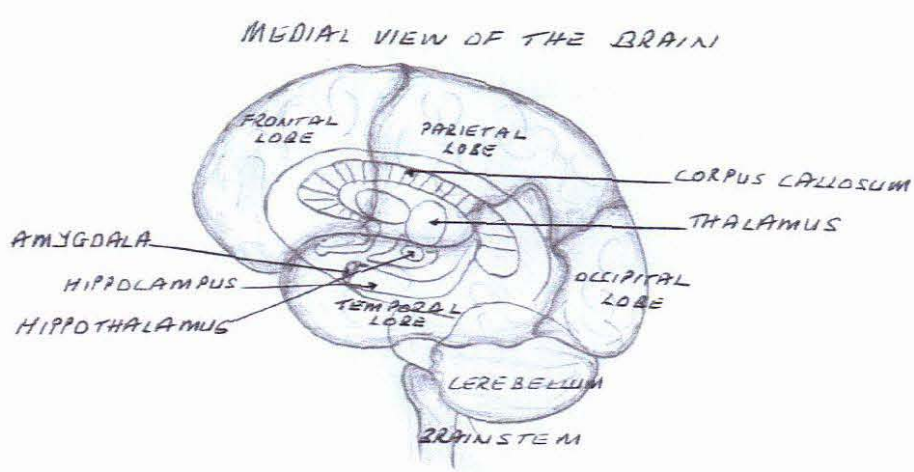


Figure 2.3: Medial View of the Brain
(Author's diagram)

The above diagram shows a medial view of the brain. As can be seen on this diagram, the middle of the brain includes the hippocampus, thalamus, hypothalamus and the amygdala. This mid-brain area is also known as the limbic system and represents 20% of the brain volume, and is responsible for emotions, sleep, attention, body regulation, hormones, sexuality, smell, and production of most of the brain's chemicals. Gardner (1993) has identified specific intelligences that may be more or less developed within individuals. Some of these intelligences are linguistic, mathematical, visual/spatial, *kinaesthetic/tactical, musical, and inter- and intra-personal intelligence, amongst* others.

Robertson (2000) states that the brain area where "consciousness" is located is disputable. It might be dispersed throughout the cortex, in the thalamus, or it may be located near the reticular formation on top of the brain stem. Much of the cerebrum, which makes up 75% of the total volume, has as yet no identified single purpose and is often referred to as the "association cortex." Grey neurons or cell bodies form the cerebral cortex and other nuclei. White matter in the brain is the myelin sheath that coats the connective fibres (axons).

The sensory cortex monitors the skin receptors. The motor cortex is responsible for the body's movements. It consists of narrow bands across the top middle of the brain. In the back lower area of the brain is the cerebellum. The cerebellum is primarily responsible for balance, posture, motor movement and some areas of cognition. Recent experiments strongly support the conclusion that essential long-term memory traces for motor learning are located in the cerebellum (Robertson, 2000).

2.2.1 Left and Right Hemispheres

The brain has two cerebral hemispheres, the left and the right. Bundles of nerve fibres connect the two hemispheres. The largest of these nerve fibres is called the corpus callosum. The corpus callosum has about 250 million nerve fibres. Each side of the brain processes information differently. Generally the left hemisphere processes information more systematically and sequentially. The left-brain thinking processes are logical, linear and rational. This side is highly organised and although based in practical reality, it is capable of abstract and symbolic interpretation. The right hemisphere, on the other hand, is more holistic. The right brain thinking modes are random and intuitive. It is well suited for nonverbal ways of knowing, such as feeling, emotions, spatial awareness, shape and pattern recognition, creativity and visualisation.

While each side of the brain processes information differently, some earlier assumptions about the left and right brain are outdated. Patients in whom the corpus callosum has been severed can still function in society. Interhemispheric communication does take place and allows each side of the brain to exchange information freely (McGaugh *et al.*, 1995).

Professional musicians process music in their left hemisphere – and not in their right hemisphere, as a novice would. Higher-level mathematicians and problem solvers have more right hemisphere activation during complex tasks, while beginners in those activities are usually left hemisphere active. The right hemisphere recognises negative emotions much faster; whereas the left hemisphere notices positive emotions faster (McGaugh *et al.*, 1995). Below is a diagram showing the two hemispheres with some of their main processing areas.

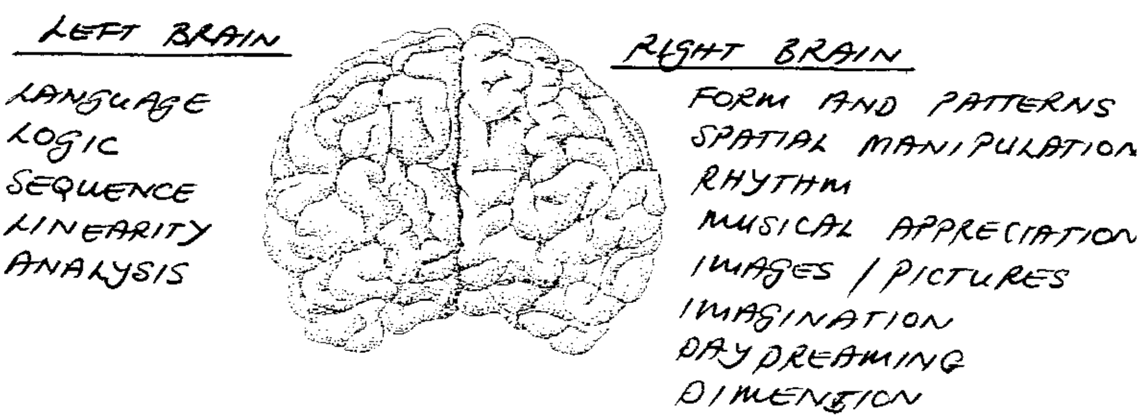


Figure 2.4: Left and Right Hemispheres
(Author's diagram)

2.2.2 Brain Asymmetry

In the last 20 years there has been a dramatic increase in research dealing with the differences in function between the hemispheres of the brain. A substantial body of literature now points to differences in the way the two hemispheres process information, as well as to anatomical, electrophysiological, and metabolic correlates of these functional asymmetries. Accompanying this research has been much speculation regarding its implications for enhancing human performance. Among the ideas that have been considered as possible ways to enhance performance, are to increase the channel capacity of the brain by presenting stimuli to each hemisphere separately, or training individuals to utilize hemispheres differentially, or selecting individuals for tasks depending on their pattern of hemispheric utilisation, or synchronising the activity of the hemispheres to enable them to work more effectively in concert (Lasley, 1997).

2.3 THE CHEMISTRY OF LEARNING

There are two kinds of brain cells: neurons and glia. While the majority (90%) of brain cells are glia, it is the remaining 10% - the neurons - that are the most studied and therefore much better understood cells. A single cubic millimetre of brain tissue has more than 1 million neurons. Each is approximately 50 microns in diameter. The adult human loses brain cells every day, but even if one lost half a million neurons per day, it would still take centuries to, literally, lose your mind (McGaugh *et al.*, 1995). Below is a sketch of some of the most common types of glial cells.

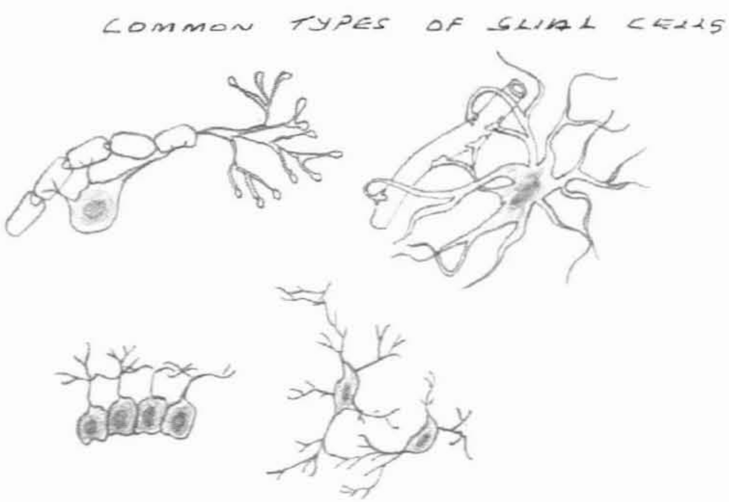


Figure 2.5: Common Types of Glial Cells
(Author's diagram)

As can be seen from the above sketch, none of the glial cells have a cell body. The role of the glial cells is supportive and may include formation of the blood brain barrier, transport of nutrients and regulation of the immune system. They also remove dead cells and give structural support that improves firmness. (McGaugh *et al.*, 1995)

Neurons are essential to performing the brain's work. Neurons consist of a compact cell body, dendrites and axons – seen on the diagram below. They are responsible for information processing, and converting chemical and electrical signals back and forth. Lasley (1997) points out that new research reveals two things which are critical about a neuron when compared with other cells in the body. The first is that some areas of the brain can and do grow new neurons, and the second is that a normal functioning neuron is continuously firing, integrating and generating information (Lasley, 1997).

NEURONS

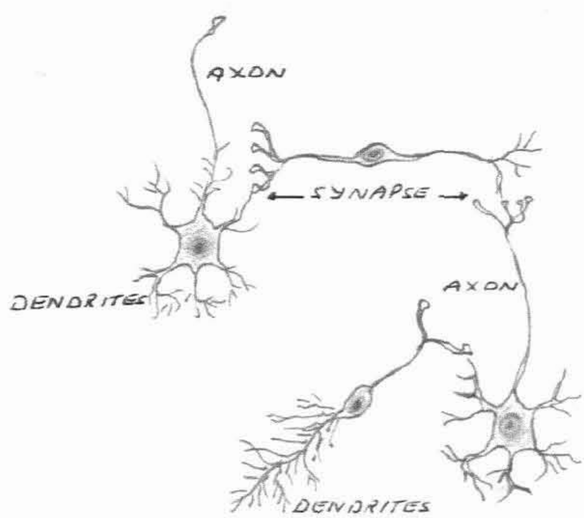


Figure 2.6: Neurons
(Author's diagram)

Many brain researchers study the brains of people who have died. They carry out detailed post-mortem examinations of the brains of a number of people of different ages. Their findings indicate that the more education that a person had in his/her life, the greater the complexity and number of branches (dendrites) there are on the neurons in the language areas of the brain (McGaugh *et al.*, 1995).

While the researchers are not able to prove which came first – complex brain neurons or relatively high education – the possibility exists that it is education that fosters the sprouting of dendrites in brain cells. Many studies have shown that education protects against the ravages of Alzheimer's disease in old age and this supports the notion that education builds brains as well as minds.

McGaugh *et al.* (1995) reminds us that education has long been regarded by Western societies as a cornerstone of civilisation. As well as growing connections in people's brains, education also 'broadens the mind' metaphorically. It could be said that education also physically rewires and sculpts people's brains. This is one important way in which culture has taken over from evolution as the main engineer of human destiny.

2.4 HOW LEARNING CHANGES THE BRAIN

What the human brain does best is learn. Learning changes the brain because it is possible for the brain to rewire itself with each new stimulation, experience and thought. A stimulus to the brain starts this process. The stimulus is then sorted and processed at several levels. Finally, there is the formation of a memory potential (Robertson, 2000).

To our brain, we are either doing something we already know how to do, or we are doing something new. If we are repeating an earlier learning, there's a good chance the neural pathways will become more and more efficient. This is done through *myelination, which is the process of adding a fatty coating to axons.* Once myelination has occurred, the brain gets more efficient (McGaugh *et al.*, 1995).

McGaugh *et al.* (1995) comments that Washington University School of Medicine researchers found that while many areas of the brain "light up" on a PET scan when a new task is initiated, the brain "lights up" less and less the better the task is learned. This quality illustrates how quickly our brain adapts and rewires itself. Robertson (2000) explained that a normal functioning neuron is continuously firing and integrating information. Although the cell body has the capacity to move, he says that most adult neurons remain stationary. They simply extend axons outward. While many dendrites, or fibres, may extend from a neuron, each has only one axon.

The axon is a thinner, longer extension that connects with other dendrites. Dendrites are branch-like extensions that grow outward from the cell body when the environment is enriched. Dendrites do not connect with one another and normally most axons connect with dendrites. The axon splits to subdivide itself and branches in two. This process repeats itself in order for axons to connect with thousands of other cells. Neurons only serve to pass information along at the end of a connection; none of them are only receivers. Information flows in one direction only. At the neuronal level information is always going from the cell body down the axon to the synapse. It never goes from the tip of the axon back up to a cell body.

One essential function of the axon is to conduct information in the form of electrical stimulation and the other is to transport chemical substances. The longest axons (running down a spinal cord) may be up to a metre long, but most are closer to a centimetre. The thicker the axon, the faster it conducts electricity and information. Myelin is a fatty substance that forms around well-used axons, and all of the larger axons are myelinated. Not only does this seem to speed up the electrical transmission (up to 12-fold), but it also reduces interference from other nearby reactions. Electrical impulses can be boosted to speeds of 120 metres per second by myelinated nodes along the axons (Robertson, 2000).

The shortest axons probably have no advantage in being myelinated. No neuron is an end point or termination for information; it only serves to pass it on. A single neuron can receive from thousands of other cells, sometimes as far as a metre away and its axon can branch repeatedly, sending signals to thousands more.

Enriched versus Impoverished Neurons

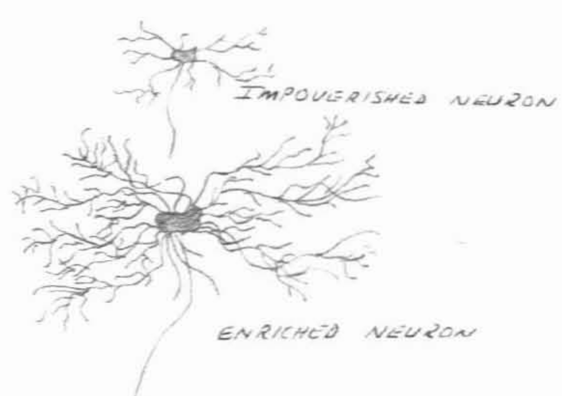


Figure 2.7: Enriched versus impoverished neurons
(Author's diagram)

The diagram above shows the difference between an impoverished and an enriched neuron. More connections make for more efficient communication. The sum total of all the synaptic reactions arriving from all the dendrites to the cell body at any moment will determine whether that cell will fire itself. If enough arriving signals stimulate the neuron, it will fire (McGaugh *et al.*, 1995).

As Gaugh *et al.* (1995) explains, information is carried inside a neuron by electrical pulses and is transmitted across the synaptic gap from one neuron to another by chemicals called neurotransmitters. Learning is a critical function of neurons, and cannot be accomplished individually – it requires groups of neurons.

Neurotransmitters are stored in the ends of the cell's axon, which nearly touches the dendrites of another cell. Typically, they will either be excitatory (like glutamate) or inhibitory (gamma-aminobutyric acid {GABA}). When the cell body sends an electrical discharge outward to the axon, it stimulates the release of those stored chemicals into the synaptic gap, which is the space between the end of an axon and tip of a dendrite (McGaugh *et al.*, 1995).

Once in that gap, the chemical reaction turns on new electrical energy in the receptors of the contacted dendrite. The process is repeated in the next cell. Repeated electrical stimulation fosters, along with an increased input of nutrients, cell growth by way of dendritic branching. These branches help to make even more connections until, in some cases, whole "neural forests" help an individual to understand better and, maybe someday, become an expert in that topic. New synapses usually appear after learning. (McGaugh *et al.*, 1995) As Roberson (2000) has also pointed out, synapses strengthen when they are given time for neural connections to solidify because they do not need to respond to other competing stimuli. Cellular resources can be preserved and focused on critical synaptic junctions.

2.5 LASTING LEARNING

The evidence of learning is memory. More than 50 years ago it was discovered that learning occurs when a cell requires less input from another cell the next time that it is activated. More recently, a research team led by Nobel laureates Kandal and Tonegawa, identified a single, specific gene that activates this critical memory formation (Kandal *et al.*, 1995). This breakthrough may explain why some people have better memory than others.

Kandal *et al.* (1995) postulate that lasting learning, or long-term potentiation (LTP), has tentatively been accepted as essential to the actual physical process of learning, and that the end result of learning for humans is intelligence.

2.6 ATTENTIVE BRAINS

The purpose of attention seems to promote survival and extend pleasurable states. Research has revealed that intentional systems are located throughout the brain and the contrasts of movement, sound, and emotion (like threat) consume most of our attention. Chemicals play the most significant role in attention, but genes may also be involved in attention (Healy, 1990).

Jensen (1998) explains that the brain generally performs poorly at continuous, high-level attention. He, amongst others, cites that genuine external attention can be sustained at a high and constant level for only a short time: on average approximately ten minutes or less. Jensen (1998) cites three reasons why constant attention is counterproductive in the classroom.

First, much of what is learned cannot be processed consciously: it happens too fast. Several researchers say that mental breaks of up to twenty minutes several times a day increase productivity. Time to process information is essential.

Secondly, in order to create new meaning, "internal" time is needed. Meaning is always generated from within and not externally.

Thirdly, after each learning experience, time for the learning to become imprinted must be allowed.

Several minutes of reflection time should therefore be allowed after each new learning experience. The essential point Jensen (1998) makes is that teachers should encourage students to have personal processing time after new knowledge has been introduced. Cramming more content per minute, or moving from one piece of learning to the next, will virtually guarantee that little will be learned or retained (Jensen, 1998).

2.7 EMOTIONS

Parenté *et al.* (1991) explains that neuroscientists are developing new knowledge with regard to mapping out the relationship between emotionality and learning. The affective side of learning is the critical interplay between how we feel, act and think. There is no separation of mind and emotions: emotions, thinking, and learning all are linked.

Brain chemicals are transmitted not only from the commonly cited axonal-synapse-dendrite reaction but are also dispersed to wide areas of the brain. According to Parenté *et al.* (1991), when an individual experiences a "gut feeling"; it is because the peptides that are released in the brain are the same as those that line the gastrointestinal tract.

Acetylcholine, adrenaline, and serotonin levels regulate memory. These active chemicals are released from areas such as the medulla, adrenals, kidneys and pons. This allows the chemicals of emotions to influence most of our behaviour. These chemicals linger and often dominate our system. That is why once an emotion occurs; it is hard for the cortex to simply shut it off. Research indicates that when emotions are engaged right after a learning experience, the memories are much more likely to be recalled and accuracy is increased (McGaugh *et al.*, 1995).

Parenté *et al.* (1991) explains that emotions engage meaning and predict future learning because they involve goals, beliefs, biases and expectations. It is possible for students to tap into this process. When students sets goals, for example, their emotions as well as intellects are engaged in creating the goal and achieving the goal.

It makes sense to integrate emotions into our curriculum as Parenté *et al.* (1991) points out. Educators can make a significant difference if they allow students to engage their emotions in the classroom. When positive emotions are engaged in solving a problem, students can learn more effectively and activate their memories, in order to recall it again at a later stage (Parenté *et al.*, 1991).

2.8 MEMORY AND RECALL

The brain stores all the information that it is exposed to during its life, but it is more likely to recall information that is charged with meaning in one way or another. Experiences involving sight, sound, touch, taste, or motion are especially vivid in our memories. And if more than one sense is involved, an experience becomes even easier to recall. As we all know from experience, repeated items are also remembered longer (Kline, 1988).

To be creative problem solvers and constructive thinkers, we must be able to draw freely and widely on the full range of our experience, which is the context of our memory. The key to effective recall is how we associate items in our memories. Some associations happen naturally; others may not be so obvious. Sometimes a conscious effort is needed to invent an association. Instead of seeing words, images that involve distinct colour, action and noise should be imagined. In this way, each association will stand out. Studies have shown that information will be remembered longer each time it is reviewed (Kline, 1988).

New research provides a powerful framework for understanding and boosting memory and recall. Memory is a process, not a fixed thing or a singular skill. Many distinct locations of the brain are implicated with certain memories. Memories of sound are stored in the auditory cortex. Researchers have found that an area of the brain called the hippocampus becomes quite active for the formation of spatial and other explicit memories, such as memory for speaking, reading, and even recall about an emotional event. Memories of names, nouns, and verbs are traced to the temporal lobe (Kline, 1988).

Robertson (2000) points out that the amygdala is quite active for implicit, usually negative, emotional events. He says learned skills involve the basal ganglia structures. The cerebellum is also critical for associative memory formation, particularly when precise timing is involved as in the learning of motor skills. Information is stored and transferred and circulated throughout the body by molecules called peptides. This awareness helps us understand why our bodies seem to recall things at times.

Many modulatory compounds, if given at the time of learning, could enhance or depress recall. Examples of these are neurotransmitters, hormones or foods. Calpain, for example, is derived from calcium and helps digest protein and unblock receptors. Researchers suspect that calcium deficiencies are linked to the memory loss of the elderly. Norepinephrine is a neurotransmitter that is linked to memories associated with stress. Phenylalanine, found in dairy products, helps manufacture norepinephrine, also involved in alertness and attention (Robertson, 2000).

McGaugh *et al.* (1995) suggests that adrenaline acts as a memory fixative, locking up memories of exciting or traumatic events. The brain uses the neurotransmitter acetylcholine in long-term memory formation. Increased levels of this neurotransmitter are linked to improved recall. Lecithin, found in eggs, salmon and lean beef, is a dietary source that raises the choline levels and has boosted recall in many studies. Choline is a key ingredient production of acetylcholine.

Schacter (1992) conducted studies that show that even the presence of household sugar in the bloodstream can enhance memory if given after a learning event. Scientists postulate that the chemistry of our body, which regulates our physiological states, is a critical element in the subsequent triggering of our recall. Learning acquired under a particular state is most easily recalled when the person is in that same state.

Semantic memory is known as explicit, factual, taxon, or linguistic memory. It is part of our declarative system and includes the names, facts, figures and textbook information that seem to frustrate us the most. Only explicit memory pathways have a short-term or a working memory (Schacter, 1992).

Much of our semantic learning is inaccessible because the original learning was trivial; it was too complex, lacked relevance or sufficient sensory stimulation, or was too cluttered with other learning. Our semantic retrieval process is affected by "when" as much as by "what" is learned. Some other researchers suggest the daily rise in levels of the neurotransmitter acetylcholine may contribute to this (Schacter, 1992).

Squire (1992) found that amnesic patients either succeeded or failed at a task simply by changing the instructions. The patients had temporal lobe damage and were given lists of words to recall. If they were instructed to recall as many words as they could from an earlier list, they did poorly. But if they were told to simply say the first word that came to mind after a cue, their memory was as good as those without brain damage.

This led researchers to conclude that our ability to recall something depends on which pathway we access to retrieve information. Much information is still in our brain; it is just a matter of finding the right pathway to retrieve the information already stored in our brains. We know it, but don't know we know it. That is the implicit memory system. Skill learning, priming and classical conditioning are all intact with temporal lobe damage, even if we cannot answer simple questions. He suggests that that is because skill learning, priming and classical conditioning also involve other areas in the brain. The implication here is that students may know more than we think they do, but the wrong pathway for retrieval has been used (Squire, 1992).

2.9 SLEEP

Lasley (1997) advocates that there are several different types of sleep. One of these is called rapid eye movement (REM) sleep. During REM sleep numerous flickering eye movements are visible behind the closed eyelids, the brain is partially active and dreams tend to occur. On average REM comprises about 20% of a normal night's sleep. The web of connected brain cells is moulded by the electrochemical impulses cascading through it, triggered by sensations, thoughts, memories and actions. Stimulation can make nets grow and this activity strengthens the learning and memories that are interwoven into the connections.

REM sleep may involve one particular type of stimulation of brain circuits that helps consolidate and strengthen the new learning and memory of the day's experience. Evidence from research indicates that during REM sleep this new learning and memory are organised and strengthened overnight – contributing to effective learning.

Researchers used a perceptual test, which showed that people's learning improved if they "slept on it". This visual test required participants to detect small differences in a complex design. If tested after a night's sleep, volunteers were found to be better at the task than when they were tested at the end of a session.

The researchers then examined what happened to this overnight learning if they interrupted REM sleep by waking up the volunteers between twenty and sixty times during the night, whenever they started to show signs of REM sleep. When deprived of REM sleep, the participants did not show the overnight learning effect. This was not just because of tiredness – for when they were woken up the same number of times during non-REM sleep, the normal overnight learning was found the next morning (Lasley, 1997).

Mice improved their learning with short training sessions punctuated by rest intervals. The rest time allows the brain to recycle CREB, an acronym for a protein switch crucial to long-term memory formation (Lasley, 1997). Research (Scroth *et al.*, 1993) also suggests that periods of purposeful processing time for "incubation for learning" may be ideal. It may be the "down" time, which we know is not really "down", that is most important for new information processing.

Hobson (1994) observes that learning can become more effective when external stimuli are shut down and the brain can link it to other associations, uses and procedures. This association and consolidation process can only occur during "down" time. This finding suggests that educators should allow for several minutes of reflection time after learning. The essential point is to encourage "personal processing time" after new learning, for material to solidify (Hobson, 1994).

2.10 THE IMPLICATIONS OF BRAIN RESEARCH FOR LEARNING

Jacobs, B., Schall, M., Scheibel, A. B. (1993) confirm that animal research on brain enrichment translates directly to human brains. In autopsy studies on graduate students, they found up to 40% more connections than in the brains of high school dropouts. The group of graduate students who were involved in challenging activities showed over 25% more overall brain growth than the control group.

Yet education alone is not enough. Frequent new learning experiences and challenges are critical to brain growth. The brains of graduate students who were "coasting" through school had fewer connections than those who challenged themselves daily (Jacobs *et al.*, 1993).

Learning changes the brain because it can rewire itself with each new stimulation, experience and behaviour. Our brain is highly effective and adaptive. The notion of narrowed standardised tests to get the right answer violates the law of adaptiveness in a developing brain. Some important action steps should be taken to encourage the exploration of alternative thinking, multiple answers and creative insights (Jacobs *et al.*, 1993).

2.11 BRAIN COMPATIBLE LEARNING (BCL)

Brain compatible learning (BCL) is an approach to teaching and learning which draws on current research and understandings of how the brain functions. It is a purposeful programme to enrich the learner's cognitive engagement with learning; it includes approaches based on in-depth learning. BCL could also be interchanged with brain-based learning. BCL uses the latest research on the brain and incorporate it in the teaching process (Jensen, 1998).

2.11.1 Enriched Environments and the Brain

Gardner (1993) advocates that when a person works in a stimulating and well-organised environment, it is much easier to develop and maintain a positive attitude, and a positive attitude is important for successful learning. Gardener (1993) points out that the goal is to create an atmosphere that induces comfort and relaxation, because it is in a state of relaxed focus that learners concentrate best and are able to learn most easily. Jensen (1998) agrees that tense muscles divert blood supply and thus reduce attention.

In 1967, Diamond (1988) conducted a series of experiments on the brain. She concluded that the more the brain is stimulated by intellectual activity and interaction with the environment, the more connections it makes between cells. She believes that human potential is virtually limitless. Her studies, and subsequent research by dozens of colleagues, have changed the way we think about our brains. The brain can literally grow new connections with environmental stimulation.

> "When we enriched the environment, we got brains with a thicker cortex, more dendritic branching, more growth spines and larger cell bodies" (Diamond, 1988).

This could mean that the brain cells communicate better with one another in an enriched environment. For Diamond (1988) and her colleagues, dendritic branching was easy to find, but the evidence of synaptic plasticity is relatively recent. We now know from various other researchers that the brain can modify itself structurally – dependent on type and amount of usage. Healy (1990) also advocates that synaptic growth varies, depending on which kind of activity is given. For novel motor learning, new synapses are generated in the cerebellar cortex.

In her research with laboratory rats, Diamond (1988) found that those that lived in an enriched environment were better learners. By enriched environment, she meant one in which the rats had positive attention from their keepers and access to toys that stimulated their thinking. She postulated that at all ages, from birth until old age, these so-called "enriched" rats were better learners in many problem-solving situations than rats who lived in impoverished environments.

Diamond (1988) comments that if she had studied human beings, she would have found similar phenomena. Her reason for conducting these experiments on rats, however, lie in the fact that she wished to study the effect of the environment on the *anatomy and physiology of the brain.* By controlling the environment, she was able to produce structural changes in the brain. Specifically, with environmental stimulation, the brain cells in the neocortex – where higher cognitive functioning takes place – became larger. By introducing environmental changes, she was able to effect this change, which she correlates to better performance. Even in rats that had already lived a good portion of their lives under unfavourable conditions, this change was noted. The best results were seen when the rats' toys were changed about twice a week, so that mastery of one thing led not to boredom but to new challenges (Diamond, 1988).

Two other scientists who worked alongside Diamond (1988) did experiments in which some rats were able to watch the enriched rats playing with toys in another cage. They found that passive observation is not enough. The observers showed no improvement in learning ability and were less curious than those who could play with the toys themselves. In order to become better learners and problem-solvers, the rats had to interact with the environment themselves. Rats are used extensively for all kinds of research because it has been found that there are many similarities in the brain physiology and body chemistry of rats and humans (Diamond, 1988).

Some researchers have found that an area of the mid-brain involved in attentional processing, the superior colliculus, grew 5 – 6 % more in an enriched environment. The single best way to grow a better brain is through challenging problem solving. This creates new dendritic connections that allow us to make even more connections. The implication here is that it is critical to expose students to a variety of approaches to solving problems. (Healy, 1990)

When students feel more capable of solving a problem, their thoughts are able to change their body's chemistry. The neural growth happens because of the process, not the solution. More intelligent people work their brains harder initially, then "coast" later on. There is also a much higher consumption of glucose while learning something new as compared to when the task is mastered. At the level of mastery, the brain is coasting (Healy, 1990).

Harman (1984) advocates that the ways in which the environment influences learning is supported by research on biofeedback. This principle states that people can learn to control previously autonomic physiological processes, such as heartbeat or brain wave production, by learning to shift attention to those processes. He says that the sensitive electronic equipment which signals changes in these functions is simply a tool for helping us learn to distinguish very minute physiological states which otherwise escape our attention.

2.11.1.1 Enriching Learning Environments with Music

Music is one way in which an enriched environment can be created. The reason music is so important to BCL is that it actually corresponds to and affects physiological conditions. During heavy mental work, pulse and blood pressure tend to rise. The brain waves speed up, and the muscles become tense. During relaxation and meditation, pulse and blood pressure decrease, and muscles relax. Normally, it is difficult to concentrate when you are deeply relaxed, and it is difficult to relax when you are concentrating intently (Druckman *et al.*, 1989).

Jensen (1998) supported other researchers who sought a way to combine strenuous mental work with relaxed physiology in order to produce excellent learners. He confirms, after intensive experimentation with students, that music was the key. He, amongst others, postulated that relaxation induced by specific music leaves the mind alert and able to concentrate.

The music found to be most conducive to this state is baroque music, such as that of Bach, Handel, Pachelbel and Vivaldi. These composers used very specific beats and patterns that automatically synchronise our minds with our bodies. Most baroque music is timed at sixty beats per minute, which is the same as an average resting heart rate. Many contemporary musicians are not able to explain how their peers of three hundred years ago were able to compose pieces with such mathematical precision (Jensen, 1998).

In experiments, plants grew lush foliage and large roots when baroque music was played to them, and they leaned toward the music, as if toward the sun. When exposed to acid rock music, these same plants shrivelled and died.

Jensen (1998) also theorised that in very left-brain situations, such as studying new material, music awakens the intuitive, creative right brain so that its input can be integrated into the whole process. It is the right brain that tends to be distracted during meetings, lectures, etc., which is why daydreaming and gazing at the view instead of concentrating sometimes takes place. Playing music is an effective way to occupy your right brain while concentrating on left-brain activities (Jensen, 1998).

2.11.1.2 Enriching Learning Environments with Art

Scientific research has not revealed much about the nature, limits and origins of creativity. The ways scientists formulate and approach their research questions are much more affected by explicit or implicit models of how the creative process takes place and what inherent limits are assured. They say that if one assumes that the new product of the creative process is a consequence of isolated or disparate or incommensurate elements coming together, it seems reasonable enough to ask questions relating to a "mechanism" of creativity. Harman (1984) found studies of highly creative people have highlighted tensions inherent in terms of such dualities as intellect and intuition, conventional and unconventional, conscious and unconscious, mental health and mental disorder, and complexity versus simplicity (Harman, 1984).

Healy (1990) refers to the implications of recent research on creativity and suggests that introducing art-based activities into the learning environment builds creativity, concentration, problem solving, self-efficacy, coordination, values attention and self-discipline. By learning and practising art, the human brain actually rewires itself to make more and stronger connections (Healy, 1990).

2.11.2 Multiple Intelligences

In the 1980s, Gardner (1985) reinforced Feuerstein's position that intelligence was flexible by advancing the theory of multiple intelligences. Like Feuerstein, Gardner (1985) challenged the traditional belief that intelligence was fixed and immutable. Multiple intelligences theory broadens the possibilities of what is understood to be a classroom. A classroom is not a place that students visit for forty minutes – it is an environment rich with materials and tools for making, doing and expanding many intelligences. Gardner (1985) support his theory by choosing rigorous criteria for proposing the existence of his proposed intelligences. Gardner defines intelligence as

> "The human intellectual competence (which) must entail a set of skills for problem solving – enabling the individual to resolve genuine problems or difficulties he/she encounters and when appropriate to create an effective product."

Gardner (1985) expand his theory and described a multiplicity of intelligences that met his criteria. He provide a strong foundation for the development of classroom environments and instructional strategies that take teachers and students well beyond traditional limits. He feels that if teachers are freed from perceived constraints on instruction, they can apply the theory in an endless array of learning opportunities that challenge students well beyond traditional expectations.

One of the largest benefits of Gardner's theory is its allowance for more authentic ways to assess student learning. In conventional assessment methods, a student's ability to answer questions in a set time period becomes the chief measure of his/her ability to learn. It is possible that under the pressures of accountability, teachers mould instruction to fit the test answers. Students, knowing the game well, decide how much time and effort they will put into memorising facts. Obviously, those with the fastest recall have the least difficulty with rote work. Many others, seeing no value in rote learning, refuse to play the game (Gardner, 1993).

Gardner's (1993) theory of multiple intelligences (MI theory) challenges the prevailing concept of intelligence as a single general capacity which equips its possessor to deal more or less effectively with virtually any situation. As described by Gardner (1983) in "Frames of Mind", MI theory proposes that people use at least eight relatively autonomous intellectual capacities – each with its own distinctive mode of thinking – to approach problems and create products. He explains that every normal individual possesses varying degrees of each of these intelligences, but the ways in which intelligences combine and blend are as varied as the characters and the personalities of individuals. Each child is a unique set of intellectual strengths and weaknesses.

Gardner's theory of MI provides a theoretical foundation for recognising the different abilities and talents of students. Approaching and assessing learning in this manner allows a wider range of students to successfully participate in classroom learning (Gardner, 1993).

2.11.3 BCL as Active Learning

Creating interest is a way of providing students with the motivation to attain their goals. Creating interest has its intrinsic rewards too. When interest is created in a subject, it will often lead to new interests in other areas. Exploring these new areas could lead to personal fulfilment as well as to other new interests. A chain reaction could thus be created (De Porter *et al.*, 1992).

De Porter *et al.* (1992) suggests that students must be encouraged to become active learners. She notes that active learners get better grades; and they learn from every situation as much as they can, using what they have learned to their advantage. An open mind absorbs and assimilates knowledge, then eagerly looks around for more. It unfolds from the introspective self and starts to venture into the world at large.

Students that are active learners learn from every situation and use what they have learned to their benefit. They realise that the more knowledge they have, the more choices they have when facing challenging situations. The more choices they have, the more personal power they have (De Porter *et al.*, 1992).

As mentioned in chapter one, two critical ingredients in enrichment are challenge and feedback. As previously pointed out, learner feedback should be maximised. Because feedback reduces uncertainty, it increases coping abilities while lowering the pituitary-adrenal stress responses (Hennessy, J. W., King, m. g., McClure, T. A. and Levine, S., 1997).

The brain is designed to operate on feedback, both internal and external. What is received at any one brain level depends on what else is happening at that level. In other words, our whole brain is self-referencing. It decides what to do, based on what has just been done. Hennessy *et al.* (1997) ventures to say that several conditions make feedback more effective. The reaction must, however, be specific and not general.

As Scroth *et al.* (1993) point out, what is challenging for one student may not be challenging for another. It therefore makes sense to have choice in the learning process, including self-paced learning, and more variety in the strategies used. Variety means that, regardless of what students choose, it's the educator's imperative to expose them to a wide variety of methodology.

This means rotating individual and group work, drama, music, presentations, self-directed work, computers, guest speakers and travel to new locations – even if merely to another classroom. The evidence is overwhelming that enriched environments do grow a better brain (Scroth *et al.*, 1993).

Robbins (1989) says that learning should incorporate a wide variety of techniques – such as suggestology, accelerated learning techniques, and neuro-linguistic programmeming (NLP). According to him, many studies have found that effective instruction is the result of such factors as the quality of instruction, practice or study time, motivation of the learner, and the matching of the training regimen to the job demands.

2.11.4 Neuro-Linguistic Programmeming (NLP), Attitude and BCL

Bandler and Grinder (1990) were the originators of Neuro-Linguistic Programmeming (NLP) in the early 1970s. They draw on brain theories and produced models of successful therapy that worked in practice and could be taught. NLP is the art and science of personal excellence. It is practical. It is a set of models, patterns, skills and techniques for thinking and acting effectively in the world. NLP deals with the structure of human subjective experience. It explores how we describe this experience in language and how we act, using language to set a BCL environment – focussing on communication (Bandler and Grinder, 1990).

Neuro – acknowledges the fundamental idea that all behaviour stems from our neurological processes of sight, hearing, smell, taste, touch and feeling. We experience the world through our five senses. Our neurology covers not only our invisible thought processes, but also our visible physiological reactions to ideas and events. It refers to how the mind works, such as preferences in thinking patterns, whether you are a "big picture" thinker or a "nuts and bolts" thinker, whether you see patterns or mismatches, etc (Andreas and Andreas, 1987).

Linguistic – suggests the use of language to order our thoughts and behaviour and to communicate with others. The word "linguistic" refers to how teachers and learners use language, how they ask questions and how they use metaphors, symbols and other figurative language in their thinking (Andreas and Andreas, 1987).

Programmeming – refers to ways we can choose to organise our ideas and actions to produce results. It refers to learning new ways of doing things by modelling others and developing effective strategies. Thus NLP is about learning through 're-programmeming' the ways in which one thinks and uses language. Or simply put – the study of how the brain organises information. It probes the relationship between language and behaviour and can be used to create rapport between students and lecturers (Andreas and Andreas, 1987).

Bandler and Grinder (1990) postulate that at the core of NLP is the belief that, when people are engaged in activities, they are also making use of a representational system. People are using some internal representation of the materials they are involved with, such as a conversation, bird singing, a spelling task. These representations can be visual, auditory, kinaesthetic or involve the other senses as well. The basic NLP assumption is that a person will be most influenced by messages involving whatever representational system is being employed at the moment.

Central to this model is the notion of the conscious mind and the unconscious mind in how we learn. NLP aims to give people more choice about what they do. Bandler and Grinder (1990) believe that having only one way of doing things is no choice at all. Sometimes it will work and sometimes it will not. In any interaction, the person who has the most choices of what to do, the greatest flexibility of behaviour, will be in control of the situation. The more choices, the more the chances of success (Bandler and Grinder, 1990).

NLP postulates six representational systems:

- Constructing visual images
- Remembering visual images
- Constructing auditory images
- Remembering auditory images
- Attending to kinaesthetic sensations
- Holding internal dialogues (Knight, 1995).

NLP maintains that, as a person uses each of these subjective representational systems, the person's eyes and posture conform to each system's requirements. Over the course of time, the NLP system has become more detailed in characterising the outward manifestations of these representational systems (Andreas and Andreas, 1987).

NLP explores the subjective experience of the processes by which people learn things. "Objective" studies usually study people who have the problem. NLP studies the subjective experience of people who have the solution. If you study reading difficulties, you'll learn a great deal about reading difficulties, but if you want to teach children how to read, it makes sense to study people who can read well (Andreas and Andreas, 1987).

To say that people have "multiple intelligences" or preferred "thinking styles" does not mean to say that people cannot develop and improve the way they think, learn and develop. People can learn to learn better. NLP is one way of help people to learn more effectively.

NLP claims that a person's language, in particular the choice of predicates, will also reflect the representational system used. Thus, a person using a stored visual image will employ phrases such as "I see a way to……"; in an auditory mode, "that sounds right to me………"; in a kinaesthetic system, "I feel we should………"; and so on. Finally, people can be asked which system they are using (Andreas and Andreas, 1987).

Knight (1995) agrees that by learning to master the techniques of NLP, the learner can learn how to manage their own learning more effectively. NLP techniques enable learners to accelerate their ability to learn and improve the quality of the way they relate to people with whom they live and work. NLP helps learners to develop flexibility so that they have more choice and therefore more influence over the learning environment and in this way to improve their ability to gain the co-operation of those around them.

The management of thoughts and feelings, so that they do not disrupt the learning , is thus an important aspect of NLP. NLP provides valuable concepts such as "modelling", "reframing" and "pacing", which help learners to clarify their goals, articulate them with conviction and thus maximise their ability to achieve them. Educators with knowledge of NLP know how to use positive language to promote positive actions – an important factor for stimulating the most effective brain functioning. Such educators also can pinpoint and make the most of each individual's best learning style (Knight, 1995).

2.11.5 BCL as Accelerated Learning

Accelerated learning methods consist of a group of techniques using unusual methods of instruction with the intent of substantially increasing the speed of learning. The techniques are referred to by various names: Suggestive Accelerated Learning and Teaching Techniques (SALTT), Suggestopedia, Suggestology and Superlearning (Druckman *et al.*, 1989).

The approach employs a combination of physical relaxation exercises, guided imagery, a suggestion of efficient learning, a belief in tapping mental reserves, and an alternation of active and passive review (generally with baroque music). The techniques have been popularised in journals such as "Psychology Today" (August 1977), "Parade magazine" (March 12, 1978) and a popular paperback, "SuperLearning", by Ostrander and Schroeder (1979). Schuster and Gritton (1986) provide a textbook for SALTT procedures that includes a review of studies supporting the approach (Druckman *et al.*, 1989).

There is an international society (Society for Accelerated Learning and Teaching), which holds an annual meeting that draws about 500 participants. The society publishes a journal, the *Journal of Society for Accelerated Learning and Teaching*, which was begun in 1975. The journal contains testimonials, evaluation studies, and reviews of SALTT techniques and research.

By dealing with the multiple aspects of instruction, SALTT techniques may enhance the educator's ability to keep students motivated to perform, to remain engaged with the task, and to provide material at an appropriate level.

A SALTT session includes three major components: preliminaries, presentations, and practice. Rather than focusing on content material for an entire session, a significant period of time is spent performing relaxation, suggestion, and exercises.

The preliminary phase (about 10 % of class time) relaxes the students and prepares them to absorb new material. This involves mild physical relaxation exercises such as stretching. Next, students perform a mental relaxation task (such as becoming aware of their breathing) to take their minds off their day-to-day problems and attend to the teacher. Thereafter teachers perform a "suggestive set-up" to convince students that the learning will be fun, easy, efficient and long lasting. Students use guided imagery to recall a pleasant learning experience (For example: Remember how you felt on your best ever-English test? Who was the teacher? How did your stomach feel?) These procedures might take three to ten minutes of an hour-long session, with more time required for the first two sessions.

The presentation phase (about 40% of the lesson) presents the material in a dramatic, dynamic way and then reviews it passively with background music. This phase has three components. The first, the preview, gives the student the big picture, providing advanced organisers as to how the current lesson fits into the entire course and the specific behaviour objectives of the lesson.

Druckman *et al.* (1989) says the preview typically requires only a few minutes. The second component, dramatic presentation, presents the material in a dynamic way. Students are strongly encouraged to make vivid images relating to the material to be learned. They generate images on their own and actively deal with the material. For example, to learn about the atom, they imagine themselves being the atom. This component might take 20 minutes of a class. The third component involves passive review with music. The instructor rhythmically repeats key material while playing baroque music in the background. The rhythm of the words and the sound of the music are assumed to produce a special mental condition that accelerates learning. This might encompass 15 minutes of an hour-long session.

Druckman *et al.* (1989) explains that the third phase of a SALTT session is practice, which entails 50% of the lesson. There are three components. The first, activation of knowledge, involves using the knowledge described in the presentation phase. For example, in a foreign language class, there might be a choral reading of the material. The second component is elaboration, which involves having the student use the material in new and different ways. In a foreign language class, students are given foreign language names and perform interactive procedures such as ordering a meal in the new language.

Error correction is often indirect (for example, the teacher does not say that a foreign phrase was wrong but rather immediately uses the phrase correctly). The third component involved the use of frequent quizzes. The questions generally assess information that has been presented more than one time. The students are provided the answers to the quizzes and scores are generally not used to determine class grades (Druckman *et al.*, 1989).

2.11.6 Mind Mapping

Buzan (1988) articulates that mind mapping is a whole brain approach where an entire subject can be fitted on one page. By using visual images and other graphic devices, mind mapping makes a deeper impression than just taking notes.

This technique of note taking was developed in the early 1970s by Buzan (1988) and is based on research on how the brain works. The brain often recalls information in the form of pictures, symbols, sounds, shapes and feelings. A mind map uses these visual and sensory reminders in a pattern of connected ideas, like a road map to use for studying, organising, and planning. It can generate original ideas and easy recall. Mind mapping activates both sides of the brain.

Mind maps are particularly effective for planning and organising. To make a mind map, a person usually starts in the middle of the page and, using different colour pens, branches out. Students' imagination and creativity are limitless, and that makes taking and reviewing notes more fun for some students.

Some of the benefits of Mind Maps are:

- That it focus attention;
- That it increases understanding;
- That it is flexible.

Mind mapping is a natural memory tool because it uses colour and symbols to create visual images. Visual associations are extremely vivid and make it possible to visually link bits of information (Buzan, 1988).

Wright (2001) points out that mind mapping as a way of taking notes, has many advantages for some students. It is however not so easy to assess. Wright (2001) came to the conclusion that in order for mind maps to be used as an assessment method, certain criteria should be met. As Buzan (1988) has confirmed, mind mapping is a skill that should be learned. Some other conditions that Wright (2001) articulates are that the assessor must explain the assessment criteria to the students and give them enough practice runs, whilst learning the rules of mind mapping (Wright, 2001).

2.11.7 Problem Solving

There are as many problem-solving models as there are theorists and researchers studying the concept, but common elements exist among all models. According to McClam and Woodside (1994), all problem solving identifies a problematic situation and seeks to resolve it by inventing hypothetical solutions and actively testing or judging the proposed solutions.

The problem solving process typically moves from understanding the problem to devising a plan to resolve it, implementing the plan, and then examining the plan for strengths and weaknesses.

McClam and Woodside (1994) suggest four general themes that characterise the problem solving process and help to define the concept.

The first is that identifiable stages may overlap and may not always occur discretely.

Secondly, they say that the process is learned. A person may acquire problem-solving skills by observing others, by experiencing the process oneself, and by actually studying the process.

Thirdly, problem solving is not always linear. Evaluation is typically a final step, but may occur throughout the whole process and appear in each step.

The fourth and last theme is that problem solving and decision making share a unique *relationship. Although the two are frequently equated,* decision-making is a unique process in which one suggests alternatives and then evaluates them as potential or possible solutions (McClam and Woodside, 1994).

One of many important steps in problem solving is the collection of books and articles on the subject, as well as talking to the authorities on the particular subject. Knowledge of the benefits when the solution or goal is achieved is important, as well as what some of the obstacles might be to accomplish this goal. The problem or goal must be stated in precise, detailed language (McClam and Woodside, 1994). Brainstorming is a problem solving technique that can be used by an individual or a group. It involves recording spontaneous ideas as they occur in a non-judgemental way. It is based on the premise that to get truly great ideas there should be lots of ideas to chose from (Knight, 1995).

Svantesson (1998) agrees that brainstorming is a well-known technique that can be used to generate new ideas in many situations. Restrictions should not be put on brainstorming; it should be the free flow of random ideas.

2.11.8 Motivation

We have all looked for solutions to the problem of how to motivate our students. According to Jensen (1998), there are various reasons why students are temporarily unmotivated. Some of the reasons could be that they have associations from their past which can provoke a negative or apathetic state, or they can feel unmotivated in the face of unsuitable learning styles, a lack of resources, language barriers, a lack of choice, cultural taboos, fears of embarrassment, a lack of feedback and a host of other possibilities. If students are visual learners, look at, and follow with their eyes, they will do better the more they can see. In other words, if the student cannot understand the lecturer's language, they will do better with strong nonverbal communication or when they work with others in a cooperative group approach. Another factor why students could be unmotivated is their relationship with the future. According to him, this includes the presence of well-defined goals, content beliefs (the student's belief in his/her own ability to learn a subject), and context beliefs - as Jensen (1998) puts it: "*the student's belief in his/her interest and resources to succeed in this* class with *this* teacher".

According to Feuerstein (1994) poor motivation is one of the common results of a feeling of incompetence. If students get two out of seven questions right, the teacher stresses the five questions that remain to be done correctly – reinforcing learners' poor self-confidence.

Inadequate mediation of feelings of competence can have more unusual psychological effects. Among learners who are not successful, or who have been encouraged to see themselves as having very limited concentration spans or poor memories, or who have been taught "down" to, a common trait is to be over-anxious to start and complete a task before the instructions have been properly grasped.

In their anxiety, they forget what the teacher told them or how they should execute the task, resulting in their own very erratic, unplanned behaviour. It is here that the learners' feelings of incompetence are often more important than any other cognitive difficulties.

Feelings of inadequacy and poor self-image represent an inevitable tendency in learners because, as they become conscious they also become aware of the number of tasks their teachers or more advanced learners can accomplish, which they cannot. Young learners may compensate for their inadequacy by "fantasising competence" in their play. While this should be encouraged, older learners should be given realistic assessments of what is and is not possible for people of their age, so that competence is seen as a process rather than an inherent possession or weakness.

Framing tasks that are achievable, and explaining the reasons for success, reinforces the idea that competence is a process of investment, time, thought and practice. The emotional reinforcement from teachers makes the student willing to cope with new and strange concepts. The excitement of success that is conveyed by the teacher when they are mediating competence to their students provokes a need in children to seek goals for themselves and to try and reach those goals (Feuerstein, 1994).

Jensen (1998) says that positive thinking and a belief in self engages the left frontal lobe that usually triggers the release of pleasure chemicals like dopamine as well as natural opiates, or endorphins. This self-reward reinforces the desired behaviour. Extended applications of projects and problem solving, where the process is more important than the answer is the real reward, not tokens or some other outside reward.

Neuroscientists explain that the brain makes its own rewards, called opiates, which are used to regulate stress and pain. The reward system is based in the brain's centre, the hypothalamus. The limbic system ordinarily rewards cerebral learning with good feelings on a daily basis. Students who succeed usually feel good, and that's reward enough for most of them (Jensen, 1998).

Jensen (1998) advocates that research done on early childhood experiences that involve violence, threat, or significant stress can rewire the brain. These brains have usually developed more receptor sites for noradrenaline in order to survive. Over arousal and aggressiveness are amongst the behaviours that could be displayed. It however, does not work to display impulsive behaviours, like threatening others in a classroom. According to the research done, these students' brains are not rewarded by the satisfaction of completing homework. They have learned to thrive just by surviving. These students will thrive when put in multiple team and cooperative roles where they can be both a leader and follower on the same day. As Jensen (1998) points out, rewards have already been studied and, to a large degree, rejected as a motivating strategy from a social and educational context.

Jensen (1998) confirms what researchers have observed on conditions that need to be present in order to foster inner drive. Amongst these conditions are compelling goals, productive emotions and positive beliefs. Neuroscientists advocate that several neurotransmitters are involved in natural, intrinsic motivation. Jensen (1998) gives five key strategies to help students uncover their intrinsic motivation:

- Eliminate threat
- Set goals – ensure that the content is relevant to them.

- Provide positive Influence – including the use of affirmations, acknowledging student successes, teamwork, positive posters, etc.
- Manage student emotions through productive use of rituals, drama, movement, celebration, etc.
- Provide feedback – specifically design learning to have dozens of methods of learner generated feedback. Druckman *et al.*, (1989) agree that peer feedback is more motivating and useful than teacher feedback in getting lasting results (Jensen, 1998).

2.11.9 Lateral Thinking Skills

De Bono (2000) is a world expert on lateral thinking. He emphasises thinking that is concerned with "what can be" rather than "what is". According to De Bono (2000) traditional thinking is largely based on judgement. Traditional thinking is concerned with recognising standard situations and applying standard solutions.

In a changing world, with increasing opportunities and increasing pressures, there is also a need for the "what can be" type of thinking. This thinking is creative and constructive. This is thinking that does not merely seek to identify "what is" but also to bring about new things that have not yet existed. De Bono (2000) like to use the term "design" to cover the thinking that brings about new thinking. Design thinking is the thinking that puts things together to deliver a value.

According to De Bono (1973) there are different levels of involvement in this kind of thinking. Some of them are:

- "We must have awareness that despite for all its excellence, our traditional thinking is not sufficient;
- We must recognise the validity, nature, importance and difference of design thinking;

- We must be willing to give time, attention and effort to this design aspect of thinking – this change in attitude should mean huge changes in education at every level;
- We must be motivated to try thinking that is constructive and creative on all occasions;
- Problem solving will always benefit from the traditional approach of finding and removing the cause of the problem. Where this is not possible, there will be an effort to design a way forward, leaving the cause in place;
- Possibilities should be generated and explored: – there is a need to create value, not just seek to find value;
- We must be willing to learn and practice these design processes. Creative and design thinking is not something only a few gifted people possess. Everyone can learn and use the skills of creative thinking."

De Bono (2000) feels that the traditional system is excellent but inadequate. Thinking should also be concerned with design rather than analysis and with value rather than with truth. You can analyse the past but you have to design the future.

2.11.10 Learning Styles

Different researchers have devised different terminologies for describing individual learning styles. According to Presseisen *et al.* (1990) researchers generally agree on two major ways of learning: first, how we perceive information most easily (modality), and second, how we organise and process that information (brain dominance).

A person's learning style is a combination of how he or she perceives, and then organises and processes information. When students are familiar with their personal learning style, they can take important steps to help themselves learn faster and more easily (Presseisen *et al.,* 1990).

Gardner's (1985) model of multiple intelligences views intelligence as more than a mere product of behaviour and more complex than one all-encompassing factor. Implied in his model is the potential for variation among individuals and for differences of development, even among persons of parallel circumstances or similar heredity. It raises issues such as, if an individual's level of functioning can be modified, then how and by how much (Gardner, 1985)?

According to Bandler and Grinder (1990) at the beginning of a learning experience, one of our first steps should be to identify a person's modality as visual, auditory, or kinaesthetic. As these terms suggest, visual people learn through what they see, auditory learners from what they hear, and kinaesthetic learners from movement and touching. Although each of us learns in all three of these modalities to some degree, most people prefer one over the other two.

Grinder (1990), author of "Righting the Education Conveyer Belt", has taught learning and teaching styles to many instructors. He notes that in every group of thirty students, an average of twenty-two are able to learn effectively enough visually, auditorily, and kinaesthetically and that they do not require special attention. Of the remaining eight students, about six prefer one of the modalities over the other two so strongly that they struggle to understand the instructions most of the time, unless special care is taken to present it in their preferred mode. For these students, knowing their best learning modality can mean the difference between success and failure. The remaining two students have difficulty learning due to external causes (Bandler and Grinder, 1990).

De Porter *et al.* (1992) says that there are many ways to categorise understanding of people and their preferences. The following lists offer some insights on the characteristics of the different modalities. The list is by no means exhaustive.

Visual People

Speak quickly
Picture what they're saying
Usually not distracted by noise
Are neat and orderly

Memorise by visual association
Are strong fast readers
Remember what was seen, rather than what was heard
Are good spellers and can actually see the words in their minds
Need an overall view and purpose and are cautious until mentally clear about an issue or project.
Doodle during phone conversations and staff meetings
Forget to relay verbal messages to others
Often answers questions with a simple yes or no
Like art more than music
Would rather do a demonstration than make a speech
Would rather see a map than hear directions

Auditory People
Speak in rhythmic patterns
Like music more than art
Is talkative, love discussion, and go into lengthy descriptions
Learn by listening, and remember what was discussed rather than seen
Find writing difficult, but are better at telling
Talk to themselves while working
Can spell better out loud than in writing
Are easily distracted by noise
Have problems with projects that involve visualisation
Are frequently eloquent speakers
Enjoy reading aloud and listening
Can repeat back and mimic tone pitch and timbre

Kinaesthetic People
Stand close when talking to someone
Touch people to get their attention
Are physically oriented and move a lot
Speak slowly
Memorise by walking and seeing

Respond to physical rewards
Have early large muscle development
Use a finger as a pointer when reading
Gesture a lot
Learn by manipulating and doing
Can't sit still for long periods of time
May have messy handwriting
Want to act things out

Recognising students' preferred learning modality is an important key in helping them to use their most effective learning style (De Porter *et al.,* 1990).

Herrmann (1989) also points out that different activities demand different types of thinking styles, so it is to a person's advantage to know, first, which is his or her predominant style, and second, what he or she can do to develop the other thinking styles in him/herself. When individuals understand their own thinking styles, they can become more balanced thinkers by occasionally forcing themselves to use the thinking and perceiving styles that they are less comfortable with.

Herrmann (1989), an expert on brain dominance, has suggested some exercises to help develop a person's less preferred quadrants. By developing the least preferred learning modalities a person can improve the ability to learn and to relate to others better.

Herrmann (1989) is an expert on how the brain functions creatively, and he has designed and led many creative thinking workshops. He believes that the first step in enhancing people's creativity is to convince them that they were in fact creative people. He collaborated with Betty Edwards, author of "Drawing on the Right Side of the Brain", to show a left-brain group of nuclear engineers how to draw. It was a successful experiment.

The ability to use learning skills is amplified by a positive attitude. Everyone has a personal learning style that can be used with great benefit in a variety of situations. It

is important to be balanced in the way information is perceived as well as in how it is ordered and processed (Herrmann, 1989).
It is clear from the literature that learning style has been viewed from several different perspectives. One approach focuses on identifying basic learning processes or stable and fundamental individual characteristics. Learning style is therefore viewed in terms of information processing strategies or personality traits. Another approach to learning style explains the differences observed in how students approach a learning task and how these affect learning (Bowden, 1986).

In a variety of educational institutions and departments, Biggs (1979) investigated the approach of students to their studying. He developed self-report inventories whose validity was examined by factor analytical techniques, amongst others. Biggs (1979) identified three dimensions of the study process. The three approaches to learning are called surface, deep and strategic. Each of the three approaches can be categorised by identifying, firstly, the predominant factors which motivate the student; secondly, the primary intention of the student; and, finally, the learning process used in carrying out these intentions.

Students who are predominantly motivated either by a desire simply to complete the work or by a fear of failure adopt the surface approach. Students, who are predominantly motivated by an interest in the subject material and/or recognition of its vocational relevance, adopt the deep approach. Students for whom the predominant motivation was the achievement of high grades, and/or a sense of competition adopt the strategic approach. Their main intention is to be successful and they are prepared to use whatever means are necessary. They might elect to use a surface or a deep approach, depending on what they feel would produce the most successful results (Biggs, 1986).

2.12 BRAIN RESEARCH AND EDUCATIONAL THEORY

In order to make effective decisions about how to use and apply particular pedagogies, facilitators must have an understanding of learning theories and their classroom applications, developmental stages, and theories of development. Learning theories are often divided into three main categories:

- Behavioural theories,
- Constructivist theories and
- Critical theories.

2.12.1 Behavioural Theories

Behavioural theorists believe that only tangible, observable behaviours or responses are worth discussing. Behaviourists believe that human behaviour can be explained as reactions or responses to stimuli. For example, a wonderful, tasty meal is put in front of you - that is a stimulus. You react or respond by eating it. So your behaviour can be seen as a reaction to a stimulus. Behaviourists' regard teaching as a "stimulus", and learning as the appropriate response to that stimulus.

The classical conditioning model explains learning on the basis of "conditioning". This means that the learner associates certain stimuli with certain responses. These responses can be reinforced with repetition. Though not a particularly useful theory for instructional design, classical conditioning is frequently used to explain the development of certain emotional responses, especially fear and anxiety. Therefore, an important implication of this paradigm for teachers is that students should experience academic learning in environments that elicit pleasant rather than unpleasant emotions.

Behaviourists define learning as a relatively permanent change in behaviour brought about as a result of experience or practice. Behaviourists believe that appropriate behaviour can be elicited by altering the stimuli. This is known as "conditioning" or "operant conditioning". For example, if the lecturer gives a talk (the stimulus), the learners might fall asleep (the response). The lecturer might feel that this is not an appropriate response, so next time she gives a talk, she might inform the learners that everyone who stays awake will get a bonus 10% for the course. This effectively adds a "reward" or "operate conditioning" element. The lecturer gives the talk (the stimulus), the learners stay awake (the desired response) and then receive the bonus mark (the reward). The lecturer has now conditioned the learners to stay awake – but only if there is a reward.

The reward system, or operant conditioning model is based on the principle that a response followed by a reinforcer is strengthened and is therefore more likely to occur again. In the operant model, reinforcement (or following a response with a positive or reinforcing consequence) is essential for learning. Additional specific components of the operant model that are important for classroom teachers include:

- Shaping - teachers should direct the learning;
- Chaining - teachers should link appropriate stimuli;
- They should include primary and secondary reinforcers so that appropriate responses are elicited from learners;
- Schedules of reinforcement are important;
- Teachers must encourage the "extinction" of inappropriate responses by learners;
- There can by negative reinforcement; and punishment (when all else fails).

2.12.2 Constructivism

Later theories about how people learn evolved out of behaviourism – and partly as a reaction against behaviourist approaches. Many educationalists feel that behaviourist theories of learning over-simplify the teaching and learning process. They believe that learning is more than a response to a stimulus. More recent constructivist educational theory is closely aligned with new ideas emanating from brain research. This is clear from the discussion that follows.

First of all, constructivists believe that learning happens in a social context. Secondly, it involves conscious intellectual effort on the part of the learner. Therefore, its focus is on the formation of concepts (or cognitive structures) and the acquisition, processing, organisation, and storing of information. This theory focuses on learning through observation and modelling. Unlike behaviourists, social learning theorists emphasise the importance of developing values, beliefs and attitudes – as well as behaviours – in the learning process (Vygotsky, 1979).

Constructivists believe that behaviour is not only a response to an external stimulus. They believe in the concept of "self-regulation", which is the human ability to change our behaviour because we ourselves want to, or because we believe something is right or important.

Some constructivists emphasise the cognitive aspects of learning. In other words, they focus on the mental processes involved in learning, such as attention, perception, encoding, storage and retrieval of knowledge. They have drawn on research on how the human brain works and how memory works.

Human memory has three levels: sensory, short-term, and long-term memory. Sensory memory involves the very short, unconscious availability of sensory data. Attending to or focusing on information from sensory memory transfers it to short-term memory, where it can be stored for up to 20 seconds. "Chunking" or combining pieces of related material can improve the capacity of short-term memory. Moving information from short-term to long-term memory requires "encoding", which involves rehearsal, elaboration, and organisation.

Other constructivists see learning as self-development, or a process of obtaining knowledge through one's own efforts. In the classroom, learning often occurs though structured or directed activities that require learners to engage in activities. For example, they may investigate and explore materials that may lead them to discover important concepts. In other words, learners are not presented with concepts and ideas in their final form; instead they are required to find these out for themselves.

These theorists believe that meaningful learning occurs when learners construct and give their own meaning to knowledge based on their prior experiences and background knowledge. They also recognise that challenging and helping students to correct their misconceptions is essential to effective learning.

Constructivism is the learning theory most closely aligned with recent brain research. A critical ingredient in any purposeful programme to enrich the learner's brain is that the learning is challenging, with new information or experiences. The degree of challenge which the learner faces in educational tasks, that is the level of difficulty of the learning task itself, affects learning.

Vygotsky (1979) claims that if a task is too easy, then the person will not learn anything from it, but if the task is much too difficult it will also be impossible for the person to learn from it. The learning task must be suited to the person's level of development - and that means it must be fairly challenging. The learning task must 'stretch' the learner; otherwise he or she will not develop. Vygotsky (1979) refers to the gap between the learners' existing skill/knowledge level and the skill/knowledge level that the learner wants to attain as the "**zone of proximal development.**"

Bloom's (1956 and 1998) attempts to classify the cognitive demands made on the learner by different learning tasks can help us in understanding the level of difficulty in different learning tasks. For example, asking students to compare two items as a learning task is, according to Bloom, a more difficult task than a straightforward analysis of a single item.

Feuerstein's (1994) theory on learning, instruction and cognitive modifiability is derived from Vygotsky (1979), who understands intellectual development as a social and dynamic process that changes with development and learning. Although genetics has some relevance, the significant factors in the development of intelligence emanate from conditioning within the school and social environment. As learners interact with other people, their learning stimulates cognitive development (Feuerstein, 1994).

As cognitive development proceeds, a "zone of proximal development" can be depicted to reflect the gap between the learner's actual developmental potential. It is this potential that enables the counsellor, psychologist, or teacher to help in the remedial and reconditioning process to raise the learner's ability to function. Testing is intentionally dynamic and geared to a remedial programme whereby cognitive gaps are apprehended and instructional procedures are designed to enhance cognitive functioning.

Feuerstein's (1994) major concern has been to assess the untapped cognitive potential of individuals, particularly disadvantaged learners, and to address any deficiencies through an active intervention process that helps the individual build a new and effective cognitive structures. The process of assessment rests on the fundamental tenet of modifiability of the cognitive structure. Linked with this is the conviction that the mediated learning experience can enhance and condition intellectual functioning.

Feuerstein's (1994) method engages both the learner and the teacher in an active modification procedure. When the student performs the task, the teacher's role is to intervene wherever necessary and to present alternative ways of perceiving, interpreting, and problem solving.

A change in the learners' approach to the task is noted, as well as the amount of intervention necessary to produce that change. The assessment process is therefore transformed from one of the neutral examiner to that of the active and involved appraiser. Assessment takes on a new meaning and becomes part of the educational process.

The test items must be clear and well sequenced to permit a starting point at the individual's level of cognitive functioning. The assessment strategies focus on the process of intellectual reasoning rather than on its product, and the emphasis is placed on change in cognitive skill.

Feuerstein (1994) distinguishes five different aspects in his contribution to psychology and education. They are:

The notion of "**Structural Cognitive Modifiability**" (SCM). Altering the development course of your cognitive system is possible. He translated this belief into a number of educational strategies regarding individuals who are facing genetic, developmental, or socio-cultural challenges. He postulated that human individuals are capable of altering their natural development course through radical restructuring of their cognitive system. Human beings are thus perceived as open systems whose future cannot be predicted on the basis of the set amount of biological, medical or psychometric data.

The concept of "**Mediated Learning Experience**" (MLE). The theory of Mediated Learning Experience (MLE) emerged from a series of studies conducted by Feuerstein since the 1950s with culturally diverse and educationally disadvantaged students. MLE is a process of mediation, which encourages a dynamic relationship between the learner and the teacher. The teacher assists the learner to interpret and gain meaning from stimuli and to develop "learning sets" which can then be applied to other situations. Independently of a teacher, the learner should then be able to optimise his/her own cognitive functions and, by exercising self-regulation, become an autonomous and independent learner.

Feuerstein's third belief system is the concept of **dynamic cognitive assessment**, proposed as a radical alternative to standard IQ tests. The individual's capacity to learn and to become modified is measured, rather than to measure the "amount", i.e. the quantitative aspects, of intelligence. The **Learning Potential Assessment Device** (LPAD) invented and developed by him and his colleagues is such a dynamic assessment procedure. In this course the individuals not only solve cognitive tasks, but also receive instruction based on the principles of MLE.

A cognitive intervention programme, **Instrumental Enrichment** (IE), called "IE", represents a systematic and practical approach to the teaching of thinking skills. As an intervention , its main purpose is to correct or redevelop cognitive functions which underlie operational thinking. Each instrument addresses a particular aspect of cognitive functioning, which is essential to the process of "learning to learn". The focus shifts from the content base of what to learn to the process-orientated approach of developing strategies of how to learn.

The shaping of a "**Modifying Environment**" (ME) involve the entire learning environment, including its physical parameters, scheduling of activities, student grouping, etc., should function as a source of modifiability.

Having studied with Piaget in France, Feuerstein developed a system of learning for the children who arrived in Israel from all parts of the world following World War II. Working in Kibbutz schools, Feuerstein faced the challenge of teaching children who were detrimentally affected by concentration camp life and the destruction, or near destruction, of their families and cultures. These children had come from the deserts of Ethiopia, from Lebanon, Europe and Asia. Very few of them brought formal learning skills with them; they were emotionally devastated and many had cognitive difficulties. Most of them lacked what Feuerstein called "the prerequisites of learning" (Feuerstein, 1994).

Piaget (1977) introduced the concept that the teacher's major role is the creation of a rich learning appropriate to the student's cognitive development. In this scenario – later expanded by Vygotsky in his early explanation of idea construction - the learner makes "meaning" from stimuli provided by the teacher in the classroom. Feuerstein (1994) also adopted the belief of Vygotsky that learning is centred in the active mental engagement of the learner with past knowledge and new experiences, but he later parted from Vygotsky. Feuerstein (1994) postulated that the best quality of learning does not occur in an environmental vacuum.

He noted how parents, siblings and other significant individuals could impact on the learner from the earliest years. He also noted that many children, denied this interaction by poverty, racism, or other negative environmental conditions, failed to develop their learning capabilities. As a consequence of his observation, Feuerstein (1994) proposed an extension of Piaget's SOR (Stimulus; Organism {Learner}; Response) model. Feuerstein (1994) added a mediator in between the learner and stimulus and the learner and the response and called it SHOHR (Stimulus {Learning condition}; Human {Mediator}; Organism {Learner}; Human {Mediator}; Response).

The mediator is a person who captures the many stimuli which bombard a learner every day, strains the stimuli and helps the child develop his/her own way of filtering those stimuli which promote learning from those stimuli that distract and in so doing assists the mediation process. Feuerstein developed a curriculum of "content-free" print materials which he called "instruments". The content of each instrument is "thinking" itself. He wanted this "content-free" approach so that the student would not be blocked by language deficiencies or by a lack of prior knowledge in any specific discipline. Such a lack, he argued, would distract from the cognitive restructuring.

The mediator helps the learner concentrate on the thinking processes he is using to solve the increasingly difficult problems on each instrument. In addition, the mediator, relying on selected open-ended questions and positive feedback, helps the learner identify how he is planning to solve the problem, how he is assessing the process for solving the problem and what tactics were most successful. Guided by additional open-ended questions from the mediator, the learner identifies the successful process and applies the critical elements to the next, more difficult problem.

Feuerstein (1994) developed ten criteria of interaction that, according to him, are fundamental for skilled mediation:

- intentionality and reciprocity
- meaning
- transcendence
- competence
- self-regulation and control of behaviour
- sharing behaviour
- individuation
- goal-planning
- challenge
- self-change

The first three criteria, Feuerstein believes, are necessary for successful mediation in any instructional situation.

The remaining seven he sees as helpful in specific situations. They teach children how to learn (Feuerstein (1994).

Feuerstein (1994) adapted traditional IQ assessment instruments to the task of discovering why these children functioned so poorly. After all, he noted, they had survived far more serious threats to life and limb before getting to Israel. He used his collection of test tools, which he later named, "Learning Potential Assessment Devices" now called "Learning Propensity Assessment Devices" (LPAD). LPAD is a dynamic assessment procedure in the course of which individuals not only solve cognitive tasks but also receive instruction based on the principles of mediated learning. In 1981 Feuerstein claimed that adhering to a psychometric conception is "an irrational endeavour." It is his belief that psychometric measurements do not provide a framework for meaningful cognitive change. Furthermore, he insisted that modifiability should be included amongst assessment standards.

Feuerstein (1994) identified fourteen cognitive functions, which he claimed were prerequisites for significant achievement. Comparing the early childhood experiences of his special students with students who were having success in school, he found that the children who were struggling lacked the prerequisites. In addition, Feuerstein (1994) found that parents were the primary providers of the "mediation" that developed these prerequisites. Because the war and the camps had destroyed their families, the children Feuerstein (1994) was attempting to assist had never experienced the necessary mediation.

Constructivist theory has many implications for classroom practice; some of the practical implications are listed below:

- Teachers should gain learners' attention at the beginning of the lesson;
- Teachers should always start a session by finding out what the learners already know, and by drawing on learners' relevant prior knowledge to build a bridge between old knowledge and new knowledge;
- Teachers need to present new information in an organised way;
- Teachers need to ensure the lesson's relevance to learners' interests and needs;
- Teachers should emphasise important aspects of the information to be learned;
- Teachers should minimise distractions;
- Teachers need to understand the effectiveness of modelling or demonstrating the new skills which learners are going to acquire;
- Teachers need to help learners to develop "self-regulatory" behaviours by teaching techniques such as goal setting, self-assessment, and other "learning how to learn" skills;

- Teachers can enhance learning by ensuring that they encourage learners to practise the new skills they are learning;
- Teachers need to make sure their explanations are meaningful and relevant;
- Teachers need to help learners to organise their work coherently;
- Teachers should help learners to 'chunk' or group related pieces of information;
- Teachers should provide opportunities for learners to elaborate on new information through active learning;
- Teachers should help learners to use mnemonic (or memory improving) techniques;
- Teachers must ensure that the learning tasks are relevant and realistic;
- Teachers should expose learners to multiple perspectives.

2.12.3 Critical Theory

Critical theorists (Freire, 1970; Rogers, 1983) disagree with the behaviourists. They believe in more "humanistic" approaches to learning and emphasise the importance of the affective (feelings and values) as well as the cognitive domain. These humanists believe that education should be holistic and enhance the total development of the person, i.e. socially, politically, emotionally as well as cognitively.

These theorists therefore believe that trainers should incorporate teaching and learning strategies that integrate feelings, values, and social skills along with knowledge. They also believe that learning should happen in a warm, trusting classroom environment, where learners are given choices and allowed to express their creativity. (Freire, 1970; 1978) Critical engagement is thus clearly aligned with brain research and its implication for learning.

Critical and humanist theorists ask very deep questions about what education should be for. Many feel that traditional education reproduces the inequalities in society. Schools and training centres, they believe, train working class people to be subservient, to obey orders and not to question the status quo.

Critical educators feel that education should transform society and make it a better place for everyone. So they try to establish democratic processes in the classroom, they encourage discussion and debate – especially around topical issues and current events. Critical education is about empowering learners to change their lives - and the lives of others.

Though all of the above descriptions of learning have merit in explaining brain compatible learning, the position taken in this research is that that the most effective learning is typically constructivist and critical in nature. Education is a self-directed and critical approach, whereas training is more behavioural – an acquisition of skills. The goal of education is the development of lifelong learners, who possess the basic skills for learning plus the motivation to pursue a variety of learning interests throughout their lives (Freire, 1970; 1978).

2.13 THE LEARNING ORGANISATION AND BCL

Argyris and Schön (1978) proposed the concept of 'organisational learning' in the late 1970s, and because of this, they are generally recognised as the pioneers of research in this field. They believed that the creation of an institutional-level learning environment would help individuals to learn. Organisational learning refers to learning behaviour in an organisation. It also means the organisation or team itself learns as an independent learning organism.

A number of articles and books on organisational learning have been published since Argyris and Schön wrote on this topic, most notably Senge (1990). According to Senge (1990), organisations that will survive in changing competitive environments cannot rely only on the ideas of top management. They must rely on the ideas of people at all levels. They must learn to reinvent themselves as learning organisations from top to bottom. They must learn to think for the long term and not in isolated boxes derived from the way the present situation might appear. This has an application to classroom based learning as well. Senge (1990) writes that:

> "...organisations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together.
>
> The basic rationale for such organisations is that in a world of rapid change only those that are flexible, adaptive and productive will excel. For this to happen organisations need to discover how to tap into people's commitment and capacity to learn at all levels.
>
> While all people have the capacity to learn, the structures in which they have to function are often not conducive to reflection and engagement. Furthermore, people may lack the tools and guiding ideas to make sense of the situations they face. Organisations that are continually expanding their capacity to create their future require employees who are also learners" (Senge, 1990).

For Senge (1990), real learning gets to the heart of what it is to be human. We become able to re-create ourselves. This applies to both individuals and organisations. For a learning organisation it is not enough to survive. "Survival learning" or what is more often termed "adaptive learning" is important and necessary, but for a learning organisation, "adaptive learning" must be joined by "generative learning", which is learning that enhances our capacity to create.

The dimension that distinguishes learning organisations from more traditional organisations is the learning organisation's mastery of certain basic disciplines. There are five disciplines that Senge (1990) identifies which characterise innovate learning organisations. They are:

- Personal mastery: this involves self-development and investing in people at the personal level so that they can align personal goals with organisational goals;

- Mental models: this involves becoming aware of the paradigms and assumptions that influence one's own thinking - and abandoning them when they are no longer useful;
- Building shared vision: this involves reaching organisational consensus on the values, mission and tasks of the organisation;
- Team learning: this involves learning how to work with others in making responsible collective decisions in strategic and operational tasks; and
- Systems thinking: this is the fifth discipline - it is what Senge refers to as the "corporate brain" and involves bringing together the other disciplines in order to direct the organisation (Senge 1990).

2.14 SUMMARY

In this chapter recent research on BCL has been reviewed. From this literature survey certain observations could be made:

- Students' needs are best met when activities allow students to learn at an individually meaningful and appropriate level
- The learning should take place in a safely challenging, interactive and discovery orientated way
- At the same time, success depends upon the degree to which the learner knows how to learn
- Learning how to learn depends upon the quality of interactions provided to assist the student's progress.

In order for learning to be successful, students must possess certain learning skills. Weir (1987) discusses several prerequisites to student success in inquiry learning activities:

- Ability to become aware of personal goals
- Ability to see formal knowledge as relevant to one's personal goals, ability to reflect on cognitive strategies
- Ability to reflect on the underlying structure of given knowledge
- Ability to understand the broad significance and implications of what one has learned to do.

To sum up, cognitive abilities are not acquired through isolated interaction with objects and symbols in the classroom, or anywhere else in the world. Instead, cognitive development depends on social interactions (Vygotsky, 1979; Feuerstein, 1994).

CHAPTER 3
RESEARCH DESIGN

Researching the curriculum entails not only the study of curriculum specifications, but also of planning and implementation processes, patterns of knowledge movement, anecdotal and systematic feedback, and the personal trajectories of individual participants. Curriculum operates within a macro socio-economic context, it operates within meso or institutional/organisational levels and it operates at the micro level of individual agents. For research to engage with and contribute to curriculum development (in the widest sense) it must connect with the intersections and constraints of these different levels.

Much of the discussion on educational research has been dominated by debates on 'methods' (rather than methodology or epistemology), in particular the binary division into quantitative and qualitative approaches (Waghid, 2000). Much educational research is thus under-theorised; it comprises investigative techniques located in a simple qualitative or quantitative framework. Perhaps because epistemological issues, like the adequacy of theories of knowledge, seem too distant from the professional concerns of practitioners, the focus on method in educational research has tended to deflect questions regarding methodology. Indeed, much educational research conflates method (techniques), methodology (the theory and analysis of how research does or should proceed) and epistemology (Harding, 1987). Critical/empancipatory educational research, on the other hand, tends to share an ontological, epistemological and value orientation. However, educational critical research has not shared a methodological theory, and criticalists have tended to see methodology as a set of research specific principles to guide research design, develop field techniques, and interpret data (Carspecken, 1996). As a result, much educational research (particularly practitioner research) been accused of 'methodological immaturity' (McTaggart, 1991).

Methodology is thus a necessary starting point for a discussion of educational research, which is directed towards positive curricular change in academic and work contexts, for it connects both downward to method and upward to epistemology.

Conducting applied research in academic and workplace settings on and with colleagues, students and outsiders brings with it a host of ethical and procedural issues, and decisions about methodological choices need to be based on ontological, epistemological, and ethical grounds. These "larger" choices precede and motivate method choices. In this regard, McWilliam et al's three part separation of research procedures and practices into (1) "field work", (2) "head work", and (3) "text work" (McWilliam, Lather, & Morgan, 1997) provides a useful framework for understanding that methodologies are plural and imply choices and decisions to be made.

The issue, then, for researchers in Education, is to investigate methodologies that promote curriculum change - with a focus on benefits to students, practitioners, and institutions. This entails developing an understanding of what it means to do post-positivist empirical research in an era of economic performativity (Usher and Solomon, 1998), and new modes of knowledge production (Gibbons et al, 1994; Nowotny et al, 2001). Lather (1991) has pointed out the inadequacies of positivist research for the production of curricular knowledge in the face of the essential "indeterminacy of human experiencing" (Lather, 1994); but there are dangers in assuming that a particular approach is inherently appropriate or inappropriate, rather than context dependent. Doing critical educational research at the macro level could draw on traditionally uncritical methods (such as statistical surveys); but it might equally entail discourse analysis of individual life histories.

Critical researchers in a postmodern era accept that critical research - what it does and how it does it - is subject to intense debate. Patai (1991) has raised a number of questions about the problems inherent in a position that effaces any distinction between 'agendas' and the 'protocols of research'. Lather (1991) finds the unsettling discourse of post modernism useful - but is wary of its tendencies to 'totalise', to present emergent, multiple-sited, contradictory movements as stable and immoveable. These issues should be raised to reflect upon what is being done so that it may be done better.

Research approaches that complement the dynamics of curriculum construction from practitioner and 'user' perspectives are favoured - and which have methodological rigour and significance in terms of research aims. Reflective researchers' central objectives include formulating criteria by which to evaluate their own research and to gain a better understanding of the socio-intellectual context within which their research is conducted.

Shifting positions along the continuum translate into choices for investigating curriculum and representing 'voices' central to curricular processes. Fine's (1994) notion of the 'voices' of the researcher - monologist, ventriloquist and negotiator – is helpful in positioning the researcher in relation to the researched along the methodological continuum (talking "to", talking "for" and talking "with").

A range of research methods - statistical, multivariate, descriptive, experimental, case study, survey, ethnographic, narrative - are available. These are not seen as inherently belonging or not belonging to epistemological positions, but as more or less useful intersections along the methodological continuum. The choice of method is thus strongly tied to research questions and research aims. The responsibility for researchers is thus both to construct the lenses through which research is accomplished, and to reflect on social roles and positions in accomplishing research.

3.1 QUALITATIVE STUDY

Qualitative researchers are concerned with understanding the context in which behaviour occurs, not just the statistical extent to which it occurs. It is descriptive in nature and the purpose of using qualitative data is to 'read between the lines' in an effort to capture the human experience underlying actions and behaviour that are not always possible to quantify (Silverman, 1998).

Silverman (1998) advocates that qualitative research offers distinctive opportunities to develop analytic perspectives that speak directly to the practical circumstances and processes of everyday life.

Garbers (1996) states that the objective of qualitative research is to promote better self-understanding and increase insight into the human condition; the emphasis is on improved understanding of human behaviour and experience.

According to Silverman (1998) the qualitative study, as one way of investigating cognitive change, has value. The specific aim of this part of the study was to investigate the possible cognitive effects on students exposed to brain compatible learning. This study is an attempt to capture the effect of brain compatible learning on the students by looking at their responses in a questionnaire, their spontaneous self-perceptions and attitudes, and their responses to input during the lessons (observation charts filled in by the lecturer). Comparison of the mean scores of the test marks for 2002 and 2003 was also analysed

The data pertaining to the process were obtained from three sources: the students, the lecturer (myself), and lesson observation charts.

3.1.1 Interviews

As Bless *et al.* (1995) point out, an interview involves direct personal contact with the participant who is asked to answer questions. The interview questions, asked by the lecturer, were open-ended, in the hope that spontaneous responses could be elicited regarding their perceptions of change in their own attitudes. The questions were all written in English, but asked in Afrikaans because all the students are Afrikaans speaking. The interviewer was mainly present to record the information, but the interviewer also directed the flow of ideas.

It seems that students sometimes gave an uncertain response which could be interpreted as a form of escapism. The students are sometimes reluctant to reveal their ignorance to the interviewer and choose the 'easy way out'.

Structured interview questions were devised to ensure the greatest possible reliability when asking open-ended questions. After the student's response was noted, the student was given an opportunity to hear the response that had been recorded. If the student was not satisfied with the interpretation of the response, the question was re-asked until the student was satisfied with the recorded response. (See interview charts with specific questions – Appendix B1.)

3.1.2 Observations

Garbers (1996) advocates that empirical observation is prominent in qualitative research, because researchers need to study actual cases of human behaviour if they are to be in a position to reflect on the human condition with more meaning and clarity.

Observations must be planned systematically and specify exactly what and how to observe (Bless and Higson-Smith, 1995). (See observation charts with specific questions – Appendix C1.)

When observing, one must remain open to discover the elements making up the markers and the tools that students mobilize in their interactions with each other (Silverman, 1998). By markers Silverman (1998) means representations of the world, or normative expectations, as well as linguistic and para-linguistic resources that are displayed in contact with the environment.

Parahoo (1997) said that when structured observations are carried out, the reliability and validity of observations depend upon the reliability and validity inherent in the observational aids and in the ability of the observer to identify and record the specified behaviours or events. When dealing with reliability, it is important to remember that researchers can be consistently right or consistently wrong.

According to Parahoo (1997) the most common error is when the same researcher faced with the same behaviour or activity interprets it differently from each other. Another error, according to him, is when, due to a lack of concentration or because the behaviour happens too quickly, observers use the wrong codes. The observers' interpretation of behaviour can be influenced by their experience and prejudices.

Observation as a method of data collection has some limitations. It is difficult to directly observe attitudes, etc. Because of this and other limitations, questionnaires and interviews were also introduced.

3.1.3 Field notes

Field notes are similar in nature to anecdotal records but including subjective impressions and interpretations. It may include descriptions on better lessons. Field notes could also record inconsiderate behaviour or petty squabbling amongst students. Like anecdotal records, attention is directed to issues thought to be of interest to begin with. Field notes should be kept on a regular basis and may contain observations, feelings, reactions, reflections and possible explanations. Issues may range from accounts of work of individual students to self-monitoring of a change in teaching method (Kemmis and McTaggart, 1988).

3.2 QUANTITATIVE STUDY

Quantitative research is usually aimed at testing theories, determining facts, statistical analysis, demonstrating relationships between variables, and prediction. A great deal of emphasis is placed on methodology; the reasoning being that the right method will lead to the truth. Quantitative designs can broadly be divided into experimental, non-experimental and non-traditional designs (Brink, 2001). In this study, participatory action research was done and according to Brink (2001) action research incorporate non-traditional quantitative designs.

3.2.1 Student Questionnaires

The structured self-administered questionnaire is designed to make it possible for the researcher to ask the same questions of each student. In this study, two types of questionnaires were used, the categorised yes/no questionnaire and the Likert statements.

The yes/no questionnaires are probably the most commonly used type of questionnaires. This type of question is usually asked to record factual information where a yes or no response indicates a clear dichotomy. It can also be used to measure attitudes. However, the result is usually an oversimplification of an attitude, as it is not always possible to record attitudes as a dichotomy (Silwerman, 1998).

According to Parahoo (1997) a questionnaire can be described as a method that seeks written responses from people to a written set of questions or statements. It is a research method when it is designed and administrated solely for the purpose of collecting data as part of a research study. It is a quantitative approach since it is predetermined – constructed in advance, standardised – the same questions in the same order are asked of all the respondents, and structural – respondents are mainly required to choose from a list of responses offered by the researcher.

Parahoo (1997) describes the validity of a questionnaire as the extent to which it addresses the research question and the objectives or hypotheses set by the researcher. The reliability of a questionnaire refers to the consistency with which respondents understand, and respond to, all the questions.

Likert statements are often used in questionnaires, since these structured questions have been designed particularly to measure the degree of a respondent's attitude towards certain matters.

Questionnaires that were completed by the 27 students at various times can be seen in Appendix C1.

3.3 METHODOLOGY

3.3.1 Participatory Action Research (PAR)

The process of action research was first conceptualised by Lewin (1952) and futher developed by Kolb (1984), Carr and Kemmis (1986) and others.

The basic assumption is that people can learn and create knowledge on the basis of *their concrete experience as well as through observing and reflecting on that* experience.

Kemmis (1982) states that action research is an alternative approach to traditional social science research in that it is practical. The results and insights gained from the research are not only of theoretical importance to the advancement of knowledge in the field, but also lead to practical improvements during and after the research process (Kemmis, 1982).

According to Kemmis (1982) action research is also participative and collaborative. The researcher is not considered to be an outside expert conducting an enquiry with "subjects", but a co-worker doing research with and for the people concerned with the practical problem and its actual improvement. Action research is interpretive. Social enquiry is not assumed to result in the researcher's positivist statements based on right or wrong answers to the research question, but in solutions based on the views and interpretations of the people involved in the enquiry.

Kemmis (1982) and his associates – amongst others - have also argued that action research is critical. The participants not only search for practical improvements in their work within the given socio-political constraints, but also act as critical and self-critical change agents of those constraints. They change their environment and are changed in the process.

Kemmis and McTaggart (1992) explain that the purpose of action research is not to test or develop a theory, but rather to find a solution to a particular problem. A theory may indeed exist that has solutions for the problem situation. That is why this study has made use of the Participatory Action Research (PAR) model. PAR is found in various forms, such as classroom based research or practitioner research. All these forms of research have a cyclical approach to research activities. The cycle, in its most basic form, consists of four stages:

- Planning (plan includes problem analysis and a strategic plan)
- Action (refers to the implementation of the strategic plan)
- Observation (includes an evaluation of the action by appropriate methods and techniques), and
- Reflection (means reflecting on the results of the evaluation and on the whole action and research process, which may lead to the identification of a new problem or problems and hence a new cycle of planning, acting, observing and reflecting.) (Kemmis and McTaggart, 1992; McNiff and Whitehead, 2002).

The cycle of Planning, Acting, Observing and Reflecting requires systematic - although flexible - methods. The full range of qualitative methodologies – such as field notes, research journals, focus group and individual interviews, small group instructional diagnosis (SGID), narratives, research memoranda, SWOT or PPESTT analyses, etc. are usually employed. PAR does not exclude a range of quantitative *methods – such as questionnaires, observation charts, schedules, and so on.* A range of these methods will be applied in this research project.

In many PAR projects, a fifth stage of 're-planning' is included and the cycle repeats itself. Kemmis and McTaggert (1992) describe PAR as 'a cyclical process, which alternates between action and critical reflection, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles'.

The purpose of a PAR project is usually to improve a process or product (in an industrial or commerce setting) or to improve a teaching, learning and curriculum development in an educational setting.

PAR enables practitioners to 'live their values in professional practice' (McNiff and Whitehead, 2002) by helping practitioners to become clear about what they are doing and why they are doing it. PAR, as McNiff and Whitehead (2002) explain, gives "Living form to an educational enquiry".

Change is more likely when those affected are involved in the change process (Fals-Borda and Rahman, 1991) and thus PAR can lead to sustainable improvement in teaching and learning because of its strongly participatory process.

PAR is an emergent process, which takes shape as understanding increases. It is an iterative process, which intends to achieve a better understanding of what happens in various contexts and communities of practice. PAR thus enables researchers to produce knowledge about teaching and learning (McNiff and Whitehead, 2002).

3.3.2 Epistemological Basis for PAR

Epistemology is the name given to the study of what we know and how we come to know it. Webster's unabridged dictionary defines epistemology as "The theory or science that investigates the origin, nature, methods and limits of knowledge." Every model has implicit epistemology. Epistemology is a set of methods for discovering and testing understandings.

As a methodology, PAR offers an alternative system of knowledge production. The location of power in the research process is with the practitioner(s) and participants, although PAR does not discount the valuable contribution of various experts. PAR has a critical ideological-ethical orientation, as its intention is to transform and improve the existing situation (Fals-Borda and Rahman, 1991).

PAR is a commonly used process to bridge the "theory-practice divide". Thus it is a "methodology for productive work" (not only research) (Schön, 1987). It is a form of "experiential knowing" (Fals-Borda and Rahman, 1991) and as such forms the epistemological and methodological basis for Total Quality Management (TQM) and Quality Assurance (QA) systems (Garvin, 1998).

3.3.3 The Nature of Action Research

Action research is more than just doing activities. It is a form of practice which involves data gathering, reflection on the action as it is presented through the data, generating evidence from the data, and making claims to knowledge based on conclusions drawn from validated evidence. The relationship between research and action, between theory and practice, is often conceived as a dichotomy. In higher education, academics consider themselves either as educational researchers/theorists or as practising teachers (Zuber-Skerritt, 1992; McNiff and Whitehead, 2002).

According to Zuber-Skerritt (1992), academics are in an ideal position; on the one side they can create and advance knowledge in higher education on the basis of their concrete, practical experience; on the other side, they can actively improve practice on the basis of their "grounded theory".

A way of describing action research is that it is a situation in which people reflect, develop, and improve their own work and their own situations. The participants themselves gather data, in relation to their own questions. They will have to do self-reflection, self-evaluation and self-management, learning progressively by doing and making mistakes in a "self-reflective spiral" of planning, acting, observing, reflecting, and re-planning, etc. (Zuber-Skerritt, 1992; McNiff and Whitehead, 2002).

According to Habermas (1978) the main benefits of action research are the improvement of practice, the improvement of the understanding of practice by its practitioners and the improvement of the situation in which the practice takes place. In order to achieve the full potential of these gains, a single loop of action research is not sufficient. What is needed is an organised process of learning or the "organisation of enlightenment" in critical communities (Habermas, 1978), that is, the use of a spiral of action research cycles by the learning community of action researchers.

The participatory and collaborative character of action research is explained by Grundy in Kemmis (1982) as follows:

> "Action research is research into practice, by practioners, for practioners.... In action research, all actors involved in the research process are equal

participants, and must be involved in every stage of the research.... The kind of involvement required is collaborative involvement. It requires a special kind of communication... which has been described as "symmetrical communication"... which allows all participants to be partners of communication on equal terms.... Collaborative participation in theoretical, practical and political discourse is thus a hallmark of action research and the action researcher" (Kemmis, 1982).

3.4 DATA COLLECTION/PRODUCTION

In this study, all data was collected by the researcher; in other words it is primary data. All the research was conducted with a sample of 27-second year Radiography students at the Peninsula Technikon.

The implementation of the programme commenced at the beginning of the 2003 academic year. The programme was monitored on a weekly basis. Reflection took place on the work done during the week, taking into account formal and informal feedback from students. When necessary, improvements were implemented the following week.

Planning of future lessons dealt with the selection of strategies, cognitive functions, principles and/or operations. The approach to teaching was to shift from being teacher-centred and product-orientated to becoming student-centred with the focus on a process approach to learning.

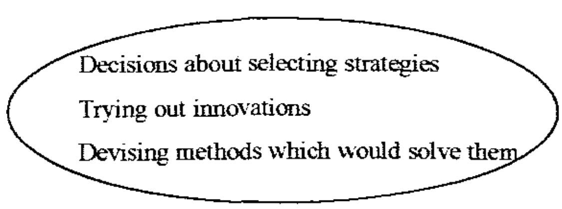
In this interactional approach to learning, (Lasley, 1997) the effects between the lecturer and the students cannot be regarded separately. The BCL programme provided a non-threatening learning climate in which students could model communication skills and where they were encouraged to express their own opinions and feelings. This encourages students to become more reflective and independent thinkers.

Lasley (1997) says the emphasis of BCL is on learning how to acquire new information more efficiently and to figure out what to do with it. This might enable students to find more adaptive ways of solving problems. The most valuable outcome is to learn how to learn. For this reason, the first few periods were spent on basic learning skills such as note taking, memory, and speed-reading. The combination of these factors, plus the focus on the whole brain, may enable students to study more effectively and absorb and recall the material faster (Lasley, 1997).

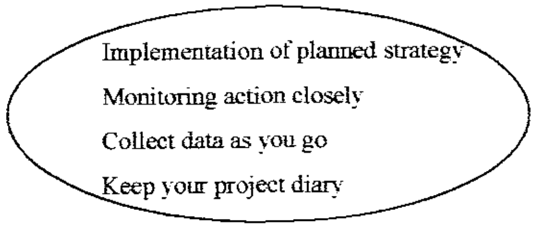
According to McNiff (2002), action research is defined as the search by higher education teachers themselves for solutions to problems in student learning and the testing of these solutions through evaluation, reflection on and review of solutions found (McNiff, 2002).

These are the cycles of Planning, Acting, Observing and Reflecting: (Kemmis and McTaggart, 1992)

Planning: **(plan includes problem analysis and a strategic plan)**
When planning, one has to deliberately ask oneself questions to decide what to do.



Action: **(refers to the implementation of the strategic plan)**



Observation: (includes an evaluation of the action by appropriate methods and techniques)

While observing one must ask questions to keep oneself alert to what is occurring and why.

Synthesis data
Collate and organise data
Try to explain what happened and
Get a clear picture of what happened
Put together narrative account of what happened

Reflection: (means reflecting on the results of the evaluation and on the whole action and research process, which may lead to the identification of a new problem or problems and hence a new cycle of planning, acting, observing and reflecting)

During this phase, one must ask oneself questions to assist in reflecting clearly on the initial plans and evaluate what has been achieved.

Time to reflect
Analyse and synthesise
Interpret across categories
Explain and draw conclusions
Review and consider opportunities and constrains
Consider consequences and draw broad conclusions
Return to initial plan,- compare it with your account of what happened.

3.4.1 Group Discussions

Meyers and Jones (1993) postulate that we cannot assume that students have all the necessary group-interaction skills at the onset. Discussion of the concepts of groups is important for students to understand. It takes some time for students to realize that they are central to the learning process, because they have learned to think of lecturers as the true source of wisdom (Meyers and Jones, 1993). In learning to rely on each other, students often need to figure out how to encourage the participation of their peers, disagree without putting each other down, actively listen to each other, and ensure that everyone gets a chance to participate meaningfully (Meyers and Jones, 1993).

Kagan (1990) advocates positive interdependence amongst students. Students need to know that the group cannot succeed unless each member contributes. Although individual students may fulfil different roles and tasks, they must depend on each other in pursuing a common goal. Students need to be individually accountable to group projects (Kagan, 1990; Meyers and Jones, 1993).

According to Kagan (1990), one great benefit of small-group interaction is the clarifying process that occurs when students explain to each other how they approached a given assignment or task. Talking things through allows students to deal with problems they may be having with a given task. It also gives the group a chance to provide valuable feedback and assistance to its troubled members (Kagan, 1990).

Meyers and Jones (1993) explain that groups need to assess their success and failure by learning to evaluate what they are doing well and what they are not doing so well. According to them and other researchers, group work can be a significant advantage to create a more congenial atmosphere for learning than traditional approaches, where students often find themselves in competition for scarce resources.

Kagan (1990) warns that the competitive environment often prevailing in traditional science classes could inhibit learning for students with a lack of self-confidence in their abilities. In this same regard, a growing body of literature supports the use of group work for teaching culturally diverse students. He also points out that group work calls on levels of ingenuity and inventiveness that many students never knew they had.

3.4.2 Format of the Lesson

There are 2 lessons for Radiation Science in a week. One lesson is 120 minutes (three 40 min. periods), and the other is 80 minutes (two 40 min. periods). The students were divided into 4 groups with 7 students in each group.

The basic framework for the 120 min. lesson was: (Baroque music plays in the background throughout the time)

2 min. quiet time – closed eyes with baroque music a bit louder
30 min. group work – music played softly
2 min. quiet time – closed eyes with baroque music a bit louder
20 min. group work
2 min quiet time – closed eyes with baroque music a bit louder
10 min. presentation by the art group (first group)
10 min. presentation by the role-play group (second group)
20 min. test (the third group set the test and the other 3 groups write the test)
10 min. for the third group to mark the test
14 min feedback, giving the summary of the prescribed work – done by the fourth group - out, handing out new homework

The basic framework for the 80 min. lesson was: (Baroque music plays in the background throughout the time)

2 min. quiet time – closed eyes with baroque music a bit louder
30 min. feedback/clarification on previous lesson – music played softly
2 min. quiet time – closed eyes with baroque music a bit louder
30 min. Video/ Interesting presentations/ Questionnaires/ Repetition of work not fully grasped in previous lesson
2 min. quiet time – closed eyes with baroque music a bit louder
12 min. Reflection time/student interviews/Work in groups on new work for next lesson
2 min. quiet time – closed eyes with baroque music a bit louder

Frequent breaks are very important and sometimes we break longer or more frequently than has been set out in the lesson plan. The reason for this is that people remember best the information that they have learned first and last (Jensen, 1998).

Jensen (1998) says people will remember more of the total information the more breaks they take. Another good reason for taking breaks is to reflect on the new information. It is a time to consolidate, to assimilate the new information and let it settle solidly into the conscious and subconscious minds.

A detailed plan of the lessons follows:
(Refer to Appendix E1.)

Table 3.1 Samples of lesson plans

ACTION	DATE	TOPIC
		MODULE 1
120 min 2 min. quiet time –closed eyes with baroque music a bit louder *30 min. group work. (4 groups)* 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark it 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**13/02/03**	**1. Concepts of Radiological Science** Describe the characteristics of matter & energy Identify the various forms of energy Define electromagnetic radiation & specifically ionising radiation State the relative intensity of ionising radiation from various sources Relate the accidental discovery of X-Rays by Roentgen Discuss examples of human injury caused by radiation List the concepts of basic radiation protection

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**17/02/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the it 14 min feedback, giving the summary of the prescribed work – done by the fourth group –to the other groups, handing out new homework	**20/02/03**	**2. Mathematics and Terminology for Radiology** Calculate problems using fractions, decimals, exponents, and algebraic equations *Identify scientific exponential notation and* the associated prefixes List and define units of radiation and radioactivity

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/ student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**24/02/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**27/02/03**	**4. The Atom** Relate the history of the atom Identify the structure of the atom Describe electron shells and instability within atomic structure Discuss radioactivity and the characteristics of alpha and beta particles Explain the difference between two forms of ionising radiation: particulate and electromagnetic

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson *2 min. quiet time –closed eyes with baroque music a bit louder* 30 min. Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/Work in groups on new work for next lesson. (Each group must work out a crossword puzzle on the atom.) 2 min. quiet time –closed eyes with baroque music a bit louder	**03/03/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. groups exchange crosswords puzzles and answers it. Afterwards the puzzles are exchanged back and were marked by group who set it *2 min. quiet time –closed eyes with baroque music a bit louder* 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder *10 min. presentation by the art group* 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the it 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**06/03/03**	**5. Electromagnetic Radiation** Identify the properties of photons Explain the inverse square law Define wave theory and the quantum theory Discuss the electromagnetic spectrum

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Video 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**10/03/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**20/03/03**	**6. X-Ray Production** Discuss the interaction between projectile electrons and the x-ray tube target Describe characteristic and brehmstrahlung x-ray production Describe the x-ray emission spectrum Explain how milliampere-second, peak kilovoltage, added filtration, target material, and voltage ripple affect the x-ray emission spectrum

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**24/03/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**24/04/03**	**7. X-Ray Emission** Define radiation quantity and its relation to intensity List and discuss the factors affecting the intensity of the x-ray beam Explain x-ray quality and penetrability List and discuss the factors affecting the quality of the x-ray beam

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**05/05/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work. (4 groups. 10 min presentation of how semi-log graphs work by peers to peers. 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark it 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**15/05/03**	**8. X-Ray Interaction with Matter** Describe each of the five x-ray interactions with matter Define differential absorption and its effect on image contrast Explain the effect of atomic number and the mass density of tissue on differential absorption Discuss why radiological contrast agents are used to image some tissues and organs Explain the difference between absorption and attenuation

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**19/05/03**	
		MODULE 2
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**28/08/03**	**2. Designing for Radiation Protection** Name the leakage radiation limit for x-ray tubes List the radiation protection features of a radiographic imaging system List the radiation protection features of a fluoroscopic imaging system Discuss the design of primary and secondary radiation barriers Describe the types of radiation dosimeters used in radiography

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**01/09/03**	
		MODULE 3
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework	**12/06/03**	**2. Fundamental Principles of Radiobiology** State the law of Bergonie and Tribondeau Describe the physical factors affecting radiation response Describe the biological factors affecting radiation response Describe the chemical factors affecting radiation response Explain dose-response relationships List and describe the types of dose-response relationships

80 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**23/06/03**	
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 80 min. group work. (each group received red and blue clay. They had to design a poster/work of art on the effects of radiation on the chromosomes. 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. presentation of work and judging by other lecturers on the winning project –(winners received a prize) 14 min feedback, on the prescribed work and handing out new homework **80 min** 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder	**07/08/03** **11/08/03**	**3. Molecular and Cellular Radiobiology** Discuss the three principal effects of in vitro irradiation of macromolecules Explain the effects of radiation on DNA macromolecules Identify the chemical reactions involved in the radiolysis of water Describe the effects of in vitro irradiation Describe the principles of the target theory of radiobiology Discuss the kinetics of human cell survival after irradiation

30 min. Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder		
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework **80 min** 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. Each student must make a mind map on radiation protection in his/her department. Mind	**04/09/03** **08/09/03**	**4. Early effects of Radiation** Describe the three acute radiation syndromes Identify the two stages leading to acute radiation lethality Define $LD_{50/60}$ Discuss local tissue damage after high-dose irradiation Explain the early radiation effects on the hemopoietic system Review the cytogenetic effects of radiation exposure

maps were taken in for evaluation. 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/Work in groups on new work for next lesson 2 min. quiet time –closed eyes with baroque music a bit louder		
120 min 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. group work. (4 groups) 2 min. quiet time –closed eyes with baroque music a bit louder 20 min. group work 2 min quiet time –closed eyes with baroque music a bit louder 10 min. presentation by the art group 10 min. presentation by the role-play group 20 min. test (one group set the test and the other 3 groups write the test) 10 min. for the group who set the test to mark the test 14 min feedback, giving the summary of the prescribed work – done by the fourth group – to the other groups, handing out new homework Mind maps were handed back to students after feedback. They have to hand back mind map with corrections or their own presentation of learning maps/notes. **80 min** 2 min. quiet time –closed eyes with baroque music a bit louder 30 min. feedback/clarification on previous lesson 2 min. quiet time –closed eyes with baroque music a	**11/09/03** **22/09/03**	**5. Radiation Protection Procedures** Discuss the units and concepts of occupational radiation exposure Indicate three ways that patient dose can be reported Describe the intensity and distribution of radiation dose in mammography and computed tomography Discuss ways to reduce occupational radiation exposure Explain occupational radiation monitors and the places where they should be positioned Discuss personnel radiation monitoring reports List the available thickness of protective apparel Discuss the principles of "as low as reasonably achievable" that are applied to patient radiation safety Identify screening x-ray examinations that are no longer routinely performed Discuss the various technical factors affecting patient radiation dose Explain when to use gonadal shields

bit louder 30 min. Questionnaires/ Repetition of work not fully grasped in previous lesson 2 min. quiet time –closed eyes with baroque music a bit louder 12 min. Reflection time/student interviews/Work in groups on new work for next lesson. Mind maps / Learning Maps/notes were taken in. 2 min. quiet time –closed eyes with baroque music a bit louder		

3.5 DATA ANALYSIS

Miller (1984) explains that the analysis of results may be subdivided into descriptive *statistics – which he calls displaying the important features of the data,- and* inferential statistics - which he calls deciding whether the results confirm the predicted effects of the independent variable (Miller, 1984).

Miller (1984) advocates that descriptive statistics involves the organisation of data in a readily comprehensible form. Re-tabulating the raw data in a systemic form, such as a frequency distribution, or using graphical methods such as the histogram and frequency polygon, may achieve this. A second function of descriptive statistics, according to Miller, (1984) is to summarise important features of the data using numerical indices. The most important features of a set of scores are the central tendency – the typical or central value, and the dispersion - the amount of spread or variability (Miller, 1984).

The function of inferential statistics is to draw inferences from the results obtained. The data are used to test the original prediction – to decide whether the independent variable is having the effect that was supposed, or whether, perhaps, there is no real difference between the performances of two groups (2002 and 2003 Radiation Science students for example) (Miller, 1984).

Miller (1984) points out that the three most commonly used measures of central tendency are the mean, which is the arithmetical average, the mode, which is the most common score, and the median, which is the middle score in the sequence from low to high. He points out that when the distribution of scores is fairly symmetrical these three measures have approximately equal values. In this case the mean is the most useful and reliable index of central tendency.

The median will give a more reasonable indication of the typical value, if the distribution of scores is markedly asymmetrical. The range may measure the dispersion in a set of scores. The range is the difference between the lowest and highest scores. The range of the middle half of the scores is called the inter quartile range.

The average deviation between each score and the mean is called the mean deviation. The average of the squared deviations between each score and the mean is called the variance. Miller (1984) points out that the most useful indices of dispersion are the variance and its square root, the standard deviation, because of their relationship to the normal distribution (Miller, 1984).

The normal curve is a symmetrical, bell-shaped frequency distribution, which is found to fit fairly closely many real distributions of psychological and other variables. Miller (1984) reminds us that the curve is completely defined by its mean and standard deviation, and the standard deviation has a special relationship to the area under the curve. A fixed proportion falls beyond any value which is expressed in terms of its deviation from the mean, measured in units of standard deviation. This property is useful both in the analysis and description of real distributions of data, and in the formulation of many of the statistical tests (Miller, 1984).

3.5.1 Significance Level

Miller (1984) reminds that it cannot be proved beyond any doubt that the independent variable is responsible for the differences between two groups, but statistical testing tells us that we can prove beyond reasonable doubt. Miller (1984) observes that by conducting a statistical test on the data it can be said how likely it is that any given difference is due to chance. If it were very unlikely that the difference could be caused by chance, then it would be concluded that the independent variable is responsible for the difference. The difference is then said to be significant. If, however, the difference between the two groups could easily have arisen by chance, then there is no reason to ascribe it to the effect of the independent variable. The findings are non-significant. According to Miller (1984), most experimental psychologists choose a significance level of 0.05. This means that a difference between two groups will be assumed to reflect chance one time in twenty, or less. In certain circumstances the significance could be set at more demanding levels, perhaps 0.01 or even 0.001 (Miller, 1984).

3.5.2 Data Analysis for this Study – One-Sample Design

The Statistical Package for the Social Sciences (SPSS) was used for quantitative analyses of this study and use was made of a one-sample test. Miller (1984) rightly points out that the one sample study is not quite so straightforward; it could be difficult to pin down the cause of any difference that is obtained. For example, a significant improvement might be due to the new method of BCL, but it could also occur if the sample contained brighter students than the population on which the norm was based. Even if the sample matched the population perfectly with regard to background characteristics, it might well have been influenced by the tendency for individuals to respond to special attention or a change in the routine. Thus the students might become more highly motivated simply because they felt themselves to be involved in something new, irrespective of the nature of the teaching method itself. Miller (1984) explains that these kinds of effects make it very difficult to achieve experimental rigour – if that is what one is looking for- in a one-sample design unless the sample and the population are properly matched in all respects – a condition which is virtually unattainable (Miller, 1984).

Miller (1984) says that problems of matching do not arise when the intention is to compare the performance of one type of subject in the sample with that of another type of subject in the population. There is no pretence here to show a causal connection between the type of subject and the response measured, but only a correlation, which could be mediated in many different ways. Miller (1984) advocates that by accepting this more modest conclusion we do not have to assume that sample and population are perfectly matched on all but one variable (Miller, 1984).

Miller (1984) points out that the most straightforward case of all occurs when we wish to compare the performance of a sample with a mean score based on a theory of some kind - in this case on various researched theories - rather than on past measurement. If the sample mean is significantly greater than the level of performance expected by chance, then the BCL teaching method might have been effective (Miller, 1984).

3.5.3 One-sample t-test

According to Miller (1984), the one-sample t-test is used to compare the mean of a sample of scores with the mean of a specified population from which the sample may have been drawn. Like the Z test, the t-test is parametric; it assumes an interval level of measurement and also that the sample has been drawn from a normal population, but this requirement can be relaxed. Unlike the Z test, the t-test does not require a large sample, nor does it assume that the standard deviation of the population is known. Thus Miller (1984) confirms that the t-test can be used when the Z test cannot, i.e. with a small sample and an unknown population standard deviation (Miller, 1984).

Miller (1984) points out that the t-test measures the probability that a sample of scores could have been obtained by random selection from a given population. The value of t increases as the difference between the sample and the population mean increases. Thus a large t value implies a large difference between the sample and population and therefore a low probability that the sample comes from the population. If the probability falls below the critical value required for significance (say 0.05) then the sample is presumed to come from a different population with a different mean (Miller, 1984).

3.6 RELIABILITY

Miller (1984) explains that reliability refers to the consistency of the measurement; in other words it is the extent to which the measure would remain constant for any particular subject if he or she were repeatedly tested under identical conditions. According to him, lack of reliability in the measurement technique will simply add to the random effects in the data and so further reduce the clarity of the experimental effect. The reliability of a measure can often be improved by taking the mean of several independent observations on the same subject (Miller, 1984).

In this study the interviews, observations and questionnaires were repeated at different times over a nine month period. The results obtained were tested for consistency. A procedure with high test-retest reliability ought to produce very similar results at each testing, whereas the results of a procedure with low test-retest reliability will vary widely. Reliability therefore asks the question 'how accurate and consistent is this instrument?' (Bless and Higson-Smith, 1995).

3.7 VALIDITY

Miller (1984) points out that validity refers to the correspondence between the operational procedures used in measurement, and the theoretical construct which is supposedly being measured. Thus the measurement of intelligence on the basis of hair colour would be perfectly reliable, but totally lacking in validity. Miller (1984) says we can measure hair colour consistently, but it simply does not reflect intelligence. According to him a test of reasoning would be more valid. When the dependent variable is something like "creativity" or "aggressiveness" the problems of measurement validity may be quite acute. He cites in these cases the idea of construct validity is important. This involves the judgement of the validity of a measure on the basis of many interrelated experimental findings. If a series of predictions are confirmed using a particular measure of creativity, then the underlying theory and the validity of the measure gain credence simultaneously. This approach is necessary when a construct has no obvious independent criterion against which its measurement may be validated. When our predictions concern directly observable characteristics such as reaction time or pupil dilation, the problem of establishing construct validity does not arise (Miller, 1984).

Bless *et al.* (1995) state that there are many different types of validity. They consider the following four the most important:

- **Content validity**

  This can be achieved by referring to literature relating to the researcher's area of study. If it can be shown that an instrument measures all the various components of the variable in question, it could be said that the instrument has high content validity (Bless and Higson-Smith, 1995).

- **Criterion-related validity**

  An instrument can be tested for validity by comparing it to another measure, which is known to be valid. This other measure is called the criterion measure. If the data collected closely match the criterion measure, it could then be concluded that the new instrument is also valid. It is, however, important to note that the two sets of data must be collected from the same group of subjects (Bless and Higson-Smith, 1995).

- **Construct validity**

  According to Bless *et al.* (1995), this is the most important and most often used type. The measurement technique should be closely linked with known theory in the area as well as with other related concepts. If that is the case then the instrument is said to have high construct validity (Bless and Higson-Smith, 1995).

- **Face validity**

  This differs somewhat from the above three. It is concerned with the way the instrument appears to the participant. The instruments need to be designed very subtly, or subjects may think that the researcher is checking up on them and react negatively to the instrument (Bless and Higson-Smith, 1995).

Validity therefore asks questions such as 'what does this instrument measure?' and 'what do the results mean?' Unless we can be sure that our techniques are actually measuring the things that they are supposed to be measuring, we cannot be certain what the results mean (Bless and Higson-Smith, 1995).

External validity does not enjoy a high priority in action research. One specific action is developed and it is not necessarily held up as a solution for any other similar situation.

3.8 RESEARCH ETHICS

According to the revised edition of ethical considerations in medical research (MRC 1987), the fundamental principle in research involving experimentation with humans, is the autonomy, independence and individuality of the person. The MRC (1987) believes that human uniqueness results in a person's right to freedom of choice and that the principle of consent and agreement protects the integrity of the patient – in this case the student - as a person.

The MRC (1987) emphasizes the importance that the researcher must respect the right of every individual to safeguard his personal integrity and that provision must be made for the confidential safekeeping of information that could be traced to, or identified with, the human subject (MRC, 1987).

Here follows a definition of informed consent, according to the MRC (1987):

"Informed consent is the agreement obtained from a subject or his legally authorised representative, to the subject's participation in an activity. The basic elements of informed consent are:

- a reasonable explanation in simple, easily understood language (if necessary using an interpreter), of the essential nature of the procedures to be followed, including identification of those procedures which are experimental;
- *a description of the essential nature of any attendant discomfort and risk;*
- a description of the benefits to be expected, as well as the known or probable permanent effects these benefits may have on the subject;
- a disclosure of possible alternative procedures which may be advantageous to the subject;

- an offer to answer any inquiries regarding the procedure;
- an instruction that the subject is free to withdraw his consent and to withdraw from the project at any time;
- that the subject should never be made to feel guilty if he is unwilling to participate in the procedure. Consent must not be obtained by force, deceit, intimidation or improper influence."

Informed consent, confidentiality and agreement to participate in the study have been gained from the participating students (see informed consent form – Appendix J). All data has adhered to the principles of ethical research. The findings of this research project will be accessible to the participating students and will be made public. Benefits will be maximised. All the research participants will receive feedback on the research findings in an appropriate manner.

CHAPTER 4
RESEARCH RESULTS

The data presented here describe students' perceptions and understandings of the processes and procedures used in BCL in Radiation Science II B, as offered in 2003. The methodology used comprised interviews, questionnaires and included an action research component, which consisted of an academic course development process, including group reflection, action, and evaluation (Limerick, 1991). The data is intended to track students' understanding of their new learning environment and the BCL approach.

The research findings confirm recent findings on brain research. The brain is known to store information in a rhythmical way, so the use of rhythm as an external aid is entirely logical. In this study the Baroque music seems to have made an impact on the students' learning outcome. As Rose (1985) points out, we know that music using certain types of rhythm, does bring about a state of relaxed alertness and physical calm. It is the predominantly alpha brain wave pattern that psychological researchres find is often associated with mediation. Music can do in minutes what weeks of meditative practice strive towards. Not only Baroque music but also the lecturer's tone of voice is very important. As Budzynski (1966) already point out in 1960s:

> "Apparently the right hemisphere processes verbal material better if it is coded in rhythm or emotion. When someone speaks in a monotone, only the verbal, dominant hemisphere is activated. If the speaker adds intonation, the nonverbal side starts to pay attention. The right hemisphere's language is not the logical content of what is said, but the emotions conveyed by how it is said. Lecturers, preachers and politicians who are famous for the oratory know intuitively what to do with their voices to generate emotion and thereby persuade their audiences"

Another positive outcome of these research findings, that of allowing reflection time, is also confirmed by Rose (1985). He, amongst others, said that reflection in the classroom is very important. The few minutes that the students close their eyes and relax with the music creating an ideal mental state (alpha) for the effortless absorption of material is very valuable. He says the whole of the lesson will bring about a coordination of left and right brain, in a synthesis that creates a quantum leap in learning speeds and retention.

The role-play that was done by students on the subject matter contribute to better retention of memory because of the involvement of emotion. Rose (1985) confirms this by saying that emotional content to learning makes it easier to remember because people remember more in a higher state of arousal. According to him the key to what we are doing is to distract the conscious mind and "click" the information in when you're not looking.

Together with the role-play, art also forms an integral part in brain friendly teaching. It's fun and will improve students' general creative ability. Rose (1985) points out that the students can relax and allow the brain to become familiar with the subject matter in a fun and creative way And gradually absorb the meaning whilst drawing.

Lozanov (1978) said the following:

> "It is well known that there is no case where the brain functions only with the cortical structure (conscious) or only with the subcortex (subconscious). The functional unity of the cortical-subcortical system is indissoluble. Teaching practice where the instruction is addressed only to the cortical structure regards the pupil as an emotionless cybernetic machine. Yet that is what most left brain teaching effectively does. Even a good teacher usually regards the teaching process in stages. You normally address the logical cortex first and then later may address the emotional subcortex. The breakthrough was to address them simultaneously, since every human operates simultaneously at both the conscious and unconscious levels."

In this study the presentation of knowledge was adapted to the way students minds really work. Feedback from students and their responses were taken into account.

4.1 QUALITATIVE DATA

The aim of this part of the study was to investigate the cognitive effects of BCL on students who were exposed to it in Radiation Science IIB. This study is an attempt to capture the effect of brain compatible learning on the students by capturing and analysing their spontaneous self-perceptions and attitudes and their responses to input during the lessons (observation charts filled in by the lecturer) and interviews conducted with them.

4.1.1 Interview Data

Ten students were interviewed (see Appendix B2 for the interview schedule). The students' responses to the interview questions were then coded and the following categories emerged from the coding process:

4.1.1.1 Students' predominantly positive feedback on the course;
4.1.1.2 Issues that the students still found difficult or 'struggled' with on the course;
4.1.1.3 Skills – particularly study skills – which the students had developed; and
4.1.1.4 Self-knowledge which the students acquired about their own learning styles and learning preferences.

4.1.1.1 Positive feedback on the course

Students' positive feedback can be further sub-divided into two additional categories, namely:

- Students' enjoyment of the course itself and the learning process involved in using brain-friendly learning;
- Students' sense of achievement and of satisfaction at the learning achieved on the course.

The above thus separates students' feedback into both 'process' issues and 'product' issues.

Process issues

In terms of process issues, students responded positively to the relaxed atmosphere of the class, the variety of the teaching and learning activities, the use of various creative, practical teaching methods – such as drawing, visualizing, and role-playing, and the background baroque music.

Some of the students' responses on process issues are listed below (translated from Afrikaans):

> "I like the background Baroque music and learn well with it in the background." (Student I 10)
> "I like the variety and alternation; it isn't boring" (Student I 01)
> "The class atmosphere is 'lekker' and relaxing" (Student I 07)
> "I enjoy it to do different things and it is very practical." (Student I 09)
> "I like the Baroque music in the background; it makes me concentrate better" (Student I 03)
> "I like the group presentations" (Student I 05)
> "I feel positive. I feel satisfied" (Student I 09)
> (Refer Appendix B)

Out of the 10 students that were interviewed, 4 experienced some difficulties with some of the aspects in this new way of presenting the subject matter. These difficulties will be further discussed in section 4.1.1.2.

The above responses appear to bear out Scroth's (1993) and Parenté's (1991) findings that a variety of strategies enhance interest and learning. As Scroth (1993) points out, it makes sense to have choice in the learning process, including self-paced learning, and more variety in the strategies used. Variety means that regardless of what students choose, it's the educator's imperative to expose them to a wide variety of teaching and learning methodologies (Scroth, 1993).

According to Parenté *et al.* (1991), neuroscientists are developing new knowledge with regard to mapping out the relationship between emotionality and learning. The affective side of learning is the critical interplay between how we feel, act, and think. Thus both mind and emotions should be taken into account in the learning process: emotions, thinking, and learning, all are linked (Parenté *et al., 1991*).

Jensen (1998) theorised that playing music is an effective way to occupy the right brain while concentrating on left-brain activities (Jensen, 1998). Although students were not conscious of this effect at the time, it does appear from the comments that they responded positively to the introduction of music in the classroom environment.

Product issues

In terms of product issues, students' claimed that they found the course 'helpful', 'relevant', and it enabled them to cope better with the academic content. They expressed their satisfaction with their level of understanding of the course.

Some of the students' responses on product issues are as follows – (translated from Afrikaans):

> "....Now I understand it" (Student I 10)
> "I like to do and see something practical" (Student I 09)
> "Now I read faster after the lectures on speed reading" (Student I 08)
> "The practical way works well for me" (Student I 02)
> "I write key words down and later build on that" (Student I 09)
> "I first do a rough framework" (Student I 10)
> (Refer to Appendix B)

Out of the ten students that were interviewed, four experienced some difficulties with some of the aspects in this new way of presenting the subject matter. These difficulties will be further discussed in section 4.1.1.2.

4.1.1.2 Difficulties still experienced on the course

Students' difficulties fall into two categories (similar to those above).

- Some students experienced difficulty with the methodology;
- Some students experienced difficulty with the academic content.

Methodological difficulties

Four out of the ten students that were interviewed expressed difficulties with some aspects of the new presentation of the content. Two students did not enjoy the 'practical', 'hands-on' activities – such as drama - and one of them plus two others did not enjoy the emphasis placed on group work. There were also three of the above students that found the baroque music uncomfortable.

Some of the students' responses to methodological issues are as follows (translated from Afrikaans):

> "I do not like drama and group work, although I learn from watching the others" (Student I 06)
> "I do not like the group work" (Student I 04)
> "I still do not manage the speed reading technique well" (Student I 02)
> (Refer to Appendix B)

Academic content difficulties

Four out of the ten students that were interviewed expressed difficulties with some aspects of the new presentation of the academic content. It must be remembered that, although the content was presented in a brain friendly way, the content itself stayed the same.

Some of the students' responses on academic difficulties are as follows (translated from Afrikaans):

> "I struggle to learn" (Student I 02)
> "I do not plan" (Student I 04)

"I do not understand exactly…." (Student I 06)
(Refer to Appendix B)

4.1.1.3 Skills learned

In their interviews many of the students make reference to new skills learned on the course – such as note taking, mind mapping.

Some of the students' responses on skills learned are as follows translated from Afrikaans):

"Knowledge on speed reading helped – I read a little bit faster now" (Student I 03)
"Lecture on note taking helped me to do mind maps – I have my own way to do that" (Student I 08)
"The background music was new for me and now I don't really hear it" (Student I 05)
"I learn a lot from the other groups" (Student I 07)
(Refer to Appendix B)

Of the 10 students that were interviewed, 8 students said that they had acquired new skills, whereas 2 students responded indifferently. One student said that she did not even do the speed reading exercises so she wouldn't know whether it would have helped her or not.

Some of the above responses appear to bear out Buzan's (1988) finding that new skills learned – such as mind mapping- enhance interest and learning. Buzan (1988) says that mind mapping is a natural memory tool because it uses colour and symbols to create visual images. Visual associations are extremely vivid and make it possible to visually link bits of information. Visually orientated learners would thus positively experience this teaching/learning method.

According to Kagan (1990), one great benefit of small-group interaction is the clarifying process that occurs when students explain to each other how they approached a given assignment or task. Talking things through allows students to deal with problems they may be having with a given task. It also gives the group a chance to provide valuable feedback and assistance to its troubled members (Kagan, 1990).

As seen from students' responses, this was the experience of some of the students in the course.

4.1.1.4 Self-knowledge gained

Self-knowledge with regard to learning styles and preferences was gained largely as a result of the consciousness-raising process of the brain-friendly methodology.

Some of the students' responses on knowledge gained are as follows (translated from Afrikaans):

> "I am a hearing person. I learn best if I can hear things" (Student I 07)
> "I am a seeing person… The brain sees pictures. Pictures are important – then the brain stores the information better if you want to recall it again"
> (Student I 10)
> "I like to see everything in pictures, then I understand it better. Once I can see something, I can learn it better" (Student I 02)
> (Refer to Appendix B)

Different researchers have devised different terminologies for describing individual learning styles. According to Presseisen (1990), there are, generally, two main processes in learning: firstly, perception of information to be learned (or the 'modality'), and secondly, organisation of that information (which has to do with brain dominance).

Three of the students interviewed favoured visual teaching, two favoured auditory teaching and the rest claimed not to have any preferences - that all the different learning styles work for them. It could thus be concluded from this that they either do not know their preferred learning style yet, or that they really do not have any dominant learning style. Learning style is a combination of how individuals perceive, and then organise and process information. When students are familiar with their personal learning style, they can take important steps to help themselves learn faster and more easily. At the beginning of a learning experience, one of an educator's first steps should be to identify a person's modality as visual, auditory, or kinaesthetic (Presseisen, 1990).

It is thus important for the lecturer/teacher/educator to assist students in identifying their particular learning modality and facilitate adopting the learning material in order to encourage implementation of the favoured learning styles. This was done by explicitly explaining the different learning styles to them.

4.1.2 Observation Charts and Field Notes

Eight observation charts were done, and, in these eight sessions, field notes were taken. The Likert scale was used for the observations charts, 1 being not engaged and 5 being extremely engaged. (See Appendix C2 for the observation schedule). The 16 questions were then grouped under the following headings:

4.1.2.1 Interest in the learning task

Students' appeared interested, lively, attentive, enthusiastic, and the background music seemed to make them more alert. For the first three observation charts, students appeared to be more interested than for the middle three observation charts. There was a rise in interest again for the last two observation charts (Average 4). Some students remained silent at first whilst others had no problem raising their voices.

4.1.2.2 Engagement with the learning task

The second category was engagement, focussing on the content. Students appeared to concentrate on the task and seemed to have understood what they were doing. They appeared focused on key points and asked relevant questions. The students were busy and engaged with the tasks assigned to them. There was a time limit on when a certain task needed to be finished and students were focussed on completing the given task in the set time (Average 4).

4.1.2.3 Participation

In this last category students were assessed according to their participation as a group. Their discussions were about related class work and the students were comfortable enough to give opinions freely. One student initially withdrew from his group: he fetched his own desk, positioning it close to the group, but at the same time on the periphery. However, after the third group session he participated fully in his group again. The groups showed creativity and their discussions involved meaningful content. The students enjoyed displaying their work – especially the more creative examples – on the wall after the presentation. Again, there was evidence of a lapse in the level of participation in the middle few sessions that were observed, but participation increased towards the end of the course (Average 4).

4.2 PROGRAMME EVALUATION

At the end of the Radiation Science II B course the students were asked to fill in an evaluation form. The following were some of the student comments:

4.2.1 Positive Comments

"I remembered the work easy through the group work and art presentations"(Student 01)

"The art partially helped a lot to present the work in another form"(Student 04)

"Another world opened up for me in terms of science" (Student 04)

"Always bring the music, it definitively works for me" (Student 04)

"There is more fun and the fact that we have to summarize the work ourselves made me remember it better" (Student 09)

"Visual aspects of the work. I learn better when there is already a picture in my head" (Student 10)

"It was more practical and easier to understand" (Student 19)

"The test questions at the end of each group discussion – I learned from that" (Student 21)

"I work better in groups and learn more" (Student 22)

"Most meaningful was the background music and the role-play" (Student 22)

"We go through the work 3 or more times before writing the test – that helped me" (Student 24)

" The most meaningful were the group work, the role-play and the fact that we made our own notes" (Student 27)

(Refer to Appendix I)

The above comments support the findings of: Kline (1988), Diamond (1980), Healy (1990), Druckman (1989), Scroth *et al.* (1993) and Bowden (1986).

As creative problem solvers and constructive thinkers, we must be able to draw freely and widely on the full range of our experience, which is the context of our memory. The key to effective recall is how we associate items in our memories. Some associations happen naturally, others may not be so obvious. Sometimes a conscious effort is needed to invent an association. Instead of seeing words, images that involve distinct colour, action and noise could be seen. In this way, each association will stand out. Studies have shown that information will be remembered longer each time it is reviewed (Kline, 1988).

In her research with laboratory rats, Diamond (1988) found that rats that lived in an enriched environment were better learners. By enriched environment, she meant one in which the rats had positive attention from their keepers and access to toys that stimulated their thinking. She postulated that at all ages, from birth until old age, these so-called "enriched" rats would be better learners in many problem-solving situations than rats who lived in impoverished environments.

Music is one way in which an enriched environment can be created. The reason music is so important to BCL is that it actually corresponds to and affects physiological conditions. During heavy mental work, pulse and blood pressure tend to rise. The brain waves speed up, and the muscles become tense. During relaxation and meditation, pulse and blood pressure decrease, and muscles relax. Normally, it is difficult to concentrate when you are deeply relaxed, and it is difficult to relax when you are concentrating intently (Druckman *et al.*, 1989).

Healy (1990) refers to the implications of recent research on creativity and suggests that introducing art-based activities into the learning environment builds creativity, concentration, problem solving, self-efficacy, coordination and self-discipline. By learning and practising art, the human brain actually rewires itself to make more and stronger connections.

As Scroth *et al.* (1993) point out, what is challenging for one student may not be challenging for another. It therefore makes sense to have choice in the learning process, including self-paced learning, and more variety in the strategies used. Variety means that, regardless of what students choose, it's the educator's imperative to expose them to a wide variety of methodology. This means rotating individual and group work, drama, music, presentations, self-directed work, computers, guest speakers and travel to new locations – even if merely to another classroom. The evidence is overwhelming that enriched environments do grow a better brain.

It is clear from the literature that learning style has been viewed from several different perspectives. One approach focuses on identifying basic learning processes or stable and fundamental individual characteristics. Learning style is therefore viewed in terms of information processing strategies or personality traits. Another approach to learning style explains the differences observed in how students approach a learning task and how these affect learning (Bowden, 1986).

4.2.1 Negative Comments

"The Baroque music not so loud or not at all played" (Student 21)
"I knew my part that I had to present well at the end of the period but I knew little the parts that the others have done" (Student 17)
"Laboratories must be provided" (Student 08)
"I do not like group work, I work better on my own, but I could adapt" (Student 06)
"Explanation of the sums must be more clear" (Student 05)
(Refer to Appendix I)

4.3 QUANTITATIVE DATA

The quantitative data in this study comprised four questionnaires, which were given to the students at various times during the course.

4.3.1 Questionnaires

Across the four questionnaires the questions can be grouped into five themes. The five main themes covered in these questionnaires are:

- Student Motivation
- Communication and feedback
- Information Gathering, Planning Strategies, Problem Solving and Task Approach
- Learning Environment
- Learning Styles, Personal Beliefs and Self-Knowledge

4.3.1.1 Student Motivation:

Across each of the four questionnaires, there was a series of statements that addressed the issue of students' motivation; students were requested to weight the value of the statement in terms of their own learning behaviours. Below are some of statements on motivation that students were required to respond to:

I try to learn at every opportunity in Radiation Science.
(First questionnaire, question 1)
I write up my own notes after the lecture. (Second questionnaire, question 3)
I know how to get myself motivated to attain my goals.
(Third questionnaire, question 16)
I read books on Radiation Science. (Fourth questionnaire, question 4)

Table 4.1 below, shows all the questionnaire statements which relate to motivation. Appendix C can be consulted for the actual statements set:

Table 4.1: Statements related to students' motivation

QUESTIONNAIRE 1	QUESTIONNAIRE 2	QUESTIONNAIRE 3	QUESTIONNAIRE 4
Question 1	Question 1	Question 1	Question 1
Question 3	Question 3	Question 3	Question 3
Question 4	Question 4	Question 4	Question 4
Question 5	Question 5	Question 5	Question 5
Question 17	Question 16	Question 16	Question 16
	Question 43	Question 43	Question 53

Table 4.2: Numerical Weightings of student motivation

		1.Perc. Student motivation
N	Valid	27
	Missing	0
Mean		65.8615
Median		69.5652
Mode		73.91
Std. Deviation		15.52268
Variance		240.95347
Skewness		-.410
Std. Error of Skewness		.448
Kurtosis		.075
Std. Error of Kurtosis		.872
Minimum		30.43
Maximum		95.65

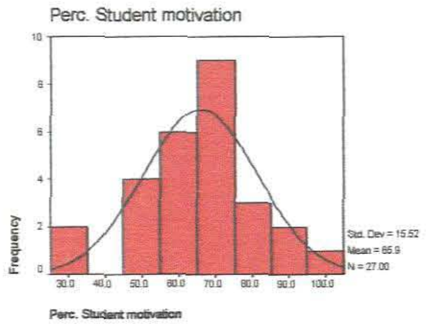
Table 4.2 shows the numerical weightings of student motivation.

Student motivation showed an 8% difference between the mean and the mode. The frequency falls between 30% and 95%. The median is 69.6% and the standard deviation is 15.5. With regards to motivation, this would suggest that the students' motivation was predominantly positive.

The maximum score for total positive motivation is 100%. 4% obtained a 100% score for motivation, 7% scored 90%, 11% scored 80%, with 33% obtained a score of 70% (highest frequency). In other words, a total of 93% of the students were 50% or more positively motivated.

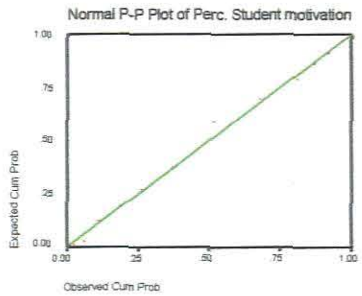
Fig 4.1 is a histogram superimposed on a normal distribution curve of student motivation. A histogram displays the data in a frequency distribution. The height of each bar is proportional to the frequency of observations; the normal distribution curve is drawn from the information on the mean and the standard deviation. From this graph, student motivation appears to follow the normal distribution and is more closely bunched around the centre. The standard deviation is 15.52 with the mean at 65.9 (N= 27). This would indicate that 21 students (78% of the total number of students) had motivational levels of 60%, nine students had motivational levels of 70%, three students had motivational levels of 80%, two students were 90% motivated and one student had motivational levels of 100% according to the results of the questionnaires.

Fig 4.1:



By looking at the pattern formed by the scatter diagram, we get a visual impression of the students' levels of motivation. In Fig 4.1 the P-Plot shows a high positive correlation, indicating that the relationship between the expected motivational outcome and the observed motivational outcome correlates positively.

Fig 4.2:



4.3.1.2 Communication and Feedback

Across the four questionnaires, there was a series of statements – such as those below – which relate to classroom communication and feedback. Students were asked to 'weight' these statements:

> I speak to the lecturer if I do not understand something.
> (First questionnaire, question 2)
> I enjoy getting feedback at the end of every chapter.
> (Second questionnaire, question 9)
> I am accurate and precise when answering a question or expressing myself in writing or in explaining the solution to problems. (Third questionnaire, question 45)
> I communicate answers clearly. (Fourth questionnaire, question 56)
> I communicate answers effectively. (Fourth questionnaire, question 57)

Table 4.3 below shows all the questions related to communication and feedback. The actual questionnaires can be found in Appendix D:

Table 4.3: Statements related to communication and feedback

QUESTIONNAIRE 1	QUESTIONNAIRE 2	QUESTIONNAIRE 3	QUESTIONNAIRE 4
Question 2	Question 2	Question 2	Question 2
Question 10	Question 9	Question 9	Question 9
	Question 25	Question 25	Question 25
	Question 42	Question 42	Question 49
	Question 45	Question 45	Question 50
	Question 46	Question 46	Question 51
			Question 52
			Question 56
			Question 57
			Question 58
			Question 59
			Question 60
			Question 61

Table 4.4: Numerical Weightings of Communication and Feedback

		2. Perc. Com & feedback
N	Valid	27
	Missing	0
Mean		75.8573
Median		81.4815
Mode		92.59
Std. Deviation		18.06774
Variance		326.44336
Skewness		-.769
Std. Error of Skewness		.448
Kurtosis		-.351
Std. Error of Kurtosis		.872
Minimum		33.33
Maximum		100.00

Table 4.4 shows the numerical weightings of communication and feedback. There is a 17% difference between the mean and the mode. The frequency falls between 33% and 100%. The median is 81.5% and the standard deviation is 18.06.This indicates that, with regard to communication and feedback, the majority of the students felt that communication and feedback were important, as the highest frequency is at the 90% level. The maximum score for total positive communication and feedback is 100%. 7% obtained a 100% score, 33% scored 90% (highest frequency), 19% scored 80%,

with 11% obtaining a score of 70%. In other words, a total of 93% of the students felt 50% or more positive about communication and feedback.

Fig 4.3:

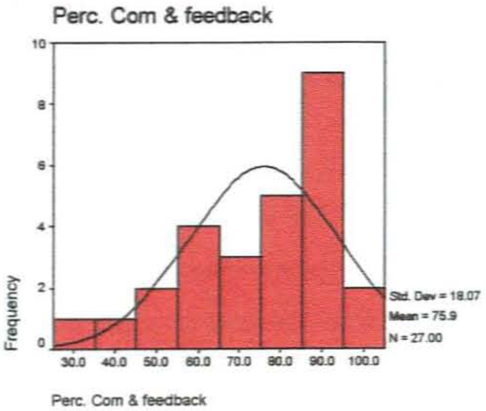
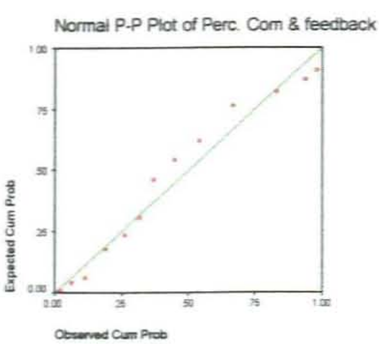


Fig 4.3 is a histogram superimposed on a normal distribution curve of classroom communication and feedback. From this graph, classroom communication and feedback is skewed towards the positive of the normal distribution, with a standard deviation of 18.07, a mean of 75.9 (N=27). This would indicate that 23 students (85% of the total number of students) weight classroom communication and feedback 60% and above – indicating that they ascribe considerable importance to communication and feedback in the learning process. (Four students weighted communication and feedback at the 60% level, three students weighted this at the 70% level, five students at the 80% level, nine students at the 90% and two students at the 100% level, according to the results of the questionnaires).

Fig 4.4:



In Fig 4.4 the P-Plot shows a high positive correlation, indicating that the relationship between the expected communication and feedback outcome and the observed communication and feedback outcome correlates positively.

4.3.1.3 Information Gathering, Planning strategies, Problem Solving and Task Approach

Questionnaire One does not address the above issues, therefore only three questionnaires were taken into account when grouping information gathering, planning strategies, problem solving and task approaching questions. The following are examples of the type of questions in this category. (Refer to Appendix D)

I generally am able to identify a problem and describe it clearly.
(Second questionnaire, question 29)
I am able to apply rules to make new associations and insights.
(Second questionnaire, question 34)
I am able to formulate a rule from a number of examples.
(Third questionnaire, question 37)
I construct a plan in order to solve problems. (Fourth questionnaire, question 45)
I think ahead before attempting an answer. (Fourth questionnaire, question 54)
I use a strategy before attempting an answer. (Fourth questionnaire, question 55)

Table 4.5 shows all the questions grouped together as they relate to information gathering, planning strategies, problem solving and task approach.

Table 4.5: Statements related to information gathering, planning strategies, problem solving and task approach

QUESTIONNAIRE 1	QUESTIONNAIRE 2	QUESTIONNAIRE 3	QUESTIONNAIRE 4
	Question 23	Question 23	Question 23
	Question 24	Question 24	Question 24
	Question 28	Question 28	Question 30
	Question 29	Question 29	Question 31
	Question 30	Question 30	Question 32

	Question 31	Question 31	Question 33
	Question 32	Question 32	Question 34
	Question 33	Question 33	Question 35
	Question 34	Question 34	Question 36
	Question 35	Question 35	Question 37
	Question 36	Question 36	Question 38
	Question 37	Question 37	Question 39
	Question 38	Question 38	Question 40
	Question 39	Question 39	Question 41
	Question 40	Question 40	Question 42
	Question 44	Question 44	Question 43
	Question 48	Question 48	Question 44
			Question 45
			Question 46
			Question 47
			Question 54
			Question 55
			Question 63

Table 4.6 Numerical Weightings of Information gathering, Planning strategies, Problem solving and Task approach.

		Perc. info gather
N	Valid	27
	Missing	0
Mean		81.5114
Median		84.2105
Mode		94.74
Std. Deviation		14.77768
Variance		218.37971
Skewness		-.458
Std. Error of Skewness		.448
Kurtosis		-1.083
Std. Error of Kurtosis		.872
Minimum		50.88
Maximum		100.00

Information gathering, planning strategies, problem solving and task approach showed a 13% difference between the mean and the mode. The frequency falls between 51% and 100%. The median is 84.2% and the standard deviation is 14.8. This would indicate that, with regard to information gathering, planning strategies, problem solving and task approaching, the majority of students responded predominantly positively towards it, as the highest frequency is at the 95% level. The maximum score for total positive information gathering, planning strategies, problem solving and task approach is 100%. 15% obtained a 100% score, 19% scored 95% (highest frequency), 15%

scored 90%, with 7% obtaining a score of 80%. In other words a total of 100% of the students felt 50% or more positive about information gathering, planning strategies, problem solving and task approach.

Fig 4.5: Percentage information gathering planning strategies, problem solving and task approach.

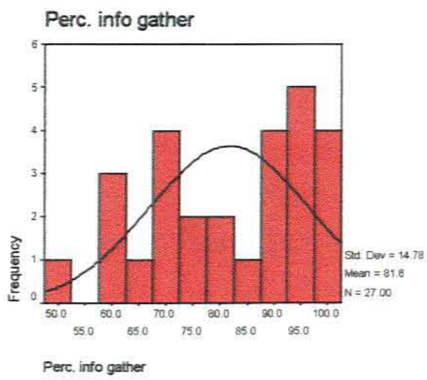
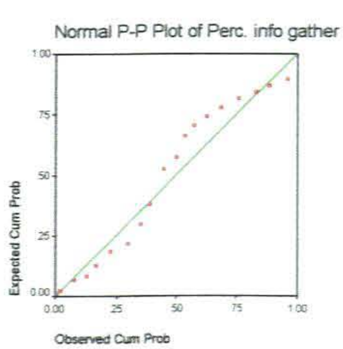


Fig 4.5 is a histogram superimposed on a normal distribution curve of information gathering, planning strategies, problem solving and task approach. From this graph it is clear that information gathering, planning strategies, problem solving and task approach are heavily skewed towards the positive of the normal distribution. This would indicate that 26 students ($\therefore$ 96% of the total number of students) were 60% and above in favour of classroom information gathering, planning strategies, problem solving and task approach: 3 students were at the 60% level, 1 student at the 65% level, 4 students at the 70% level, 2 students at the 75% level, 2 students at the 80% level, 1 student at the 85% level, 4 students at the 90%level, 5 students at the 95% level and 4 students at the 100% level, according to the results of the questionnaires.

Fig 4.6:



In Fig 4.6 the P-Plot shows a high positive correlation, the dots are closely packed around the line, indicating that the relationship between the expected information gathering, planning strategies, problem solving and task approach outcome and the observed information gathering, planning strategies, problem solving and task approach outcome, correlates positively with.

4.3.1.4 Learning Environment

Across the four questionnaires, there was a series of questions – such as those below – which relate to learning environment.

I find the classroom's atmosphere comfortable and relaxing.
(All the questionnaires, question 6)
I have a place in my home where I can make a space for work and creative thinking.
(All the questionnaires, question 7)
Baroque music in the background helps me to concentrate during a learning session.
(All the questionnaires, question 8)
(Refer Appendix D)

Table 4.7 shows all the questions grouped together as they relate to learning environment

Table 4.7: Statements related to learning environment

QUESTIONNAIRE 1	QUESTIONNAIRE 2	QUESTIONNAIRE 3	QUESTIONNAIRE 4
Question 6	Question 6	Question 6	Question 6
Question 7	Question 7	Question 7	Question 7
Question 8	Question 8	Question 8	Question 8

Table 4.8: Numerical Weightings of Learning Environment

		Perc. Learning environment
N	Valid	27
	Missing	0
Mean		76.8519
Median		83.3333
Mode		100.00
Std. Deviation		21.47516
Variance		461.18234
Skewness		-.688
Std. Error of Skewness		.448
Kurtosis		-.608
Std. Error of Kurtosis		.872
Minimum		33.33
Maximum		100.00

Table 4.8 shows the numerical weightings of the learning environment. The learning environment shows a 23% difference between the mean and the mode. The frequency falls between 33% and 100%. The median is 83.3% and the standard deviation is 21.5. This would indicate that the students' responses towards the learning environment were predominantly positive. The maximum score for total positive learning environment is 100%. 26% obtained a 100% score, 11% scored 90%, 30% scored 80% (highest frequency), with 7% obtaining a score of 70%. In other words, a total of 89% of the students felt 50% or more positive about learning.

Gardner (1993) and Jensen (1998) advocate that when a person works in a stimulating and well-organised environment, it is much easier to develop and maintain a positive attitude, and a positive attitude is important for successful learning. Gardener (1993) points out that the goal is to create an atmosphere that induces comfort and relaxation, because it is in a state of relaxed focus that learners concentrate best and are able to learn most easily. Jensen (1998) agrees that tense muscles divert blood supply and thus reduce attention.

Fig 4.7:

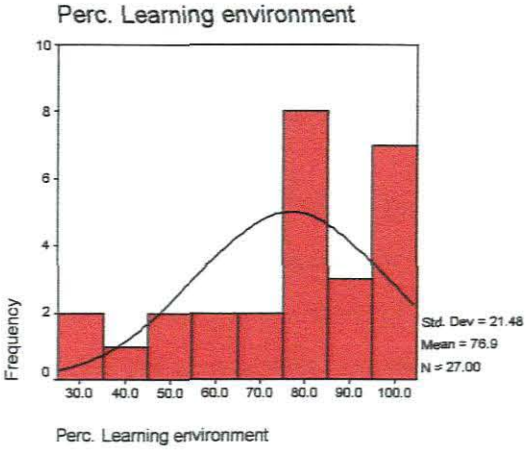
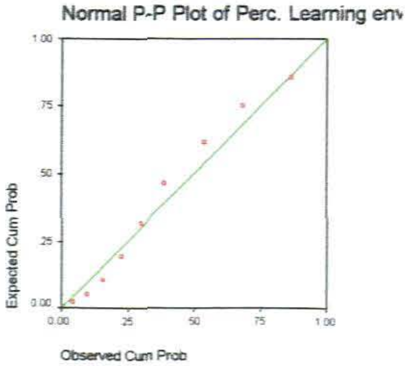


Fig 4.7 is a histogram superimposed on a normal distribution curve of the learning environments. From this graph, learning environment appears to be heavily skewed towards the positive of the normal distribution. This would indicate that 22 students (∴ 81% of the total number of students) were 60% and above positive towards a relaxed, enriched learning environment: 2 students were at the 60% level, 2 students at the 70% level, 8 students at the 80% level, 3 students at the 90% level and 7 students at the 100% level, according to the results of the questionnaire. Unfortunately, the data used for this histogram might not be sufficient for any conclusive claims.

In Fig 4.8 the P-Plot shows a high positive correlation. The dots are closely packed around the line, indicating that the relationship between the expected learning environment outcome and the observed learning environment outcome correlates positively.

Fig 4.8:



4.3.1.5 Learning Styles, Personal beliefs and Self-knowledge

Across the four questionnaires, there were series of questions – such as those below – which relate to learning styles, personal beliefs and self-knowledge.

I know what my learning style is. (First questionnaire, question 11)
I know how to focus on key points / issues. (First questionnaire, question 12)
I know what the R brain and the L brain thinking modes are.
(Second questionnaire, question 14)
I learn most with group work. (Third questionnaire, question 18)
I connect new information to prior knowledge. (Fourth questionnaire, question 12)
(Refer to Appendix D)

Table 4.9: shows all the questions grouped together as learning styles, personal beliefs and self-knowledge. The actual questionnaires can be found in Appendix D:

Table 4.9: Statements related to learning styles, personal beliefs and self-knowledge

QUESTIONNAIRE 1	QUESTIONNAIRE 2	QUESTIONNAIRE 3	QUESTIONNAIRE 4
Question 11	Question 10	Question 10	Question 10
Question 12	Question 11	Question 11	Question 11
Question 13	Question 12	Question 12	Question 12
Question 14	Question 13	Question 13	Question 13
Question 15	Question 14	Question 14	Question 14
Question 16	Question 15	Question 15	Question 15
Question 18	Question 17	Question 17	Question 17
Question 19	Question 18	Question 18	Question 18
Question 20	Question 19	Question 19	Question 19
Question 21	Question 20	Question 20	Question 20
Question 22	Question 21	Question 21	Question 21
Question 23	Question 22	Question 22	Question 22
Question 24	Question 26	Question 26	Question 26

	Question 27	Question 27	Question 27
	Question 41	Question 41	Question 28
	Question 47	Question 47	Question 29
			Question 48
			Question 62

Table 4.10: Numerical Weightings of Learning styles, Personal beliefs and Self-knowledge.

		Perc. Learning styles
N	Valid	27
	Missing	0
Mean		78.9536
Median		80.9524
Mode		90.48(a)
Std. Deviation		12.46421
Variance		155.35643
Skewness		-.830
Std. Error of Skewness		.448
Kurtosis		.304
Std. Error of Kurtosis		.872
Minimum		46.03
Maximum		96.83

Table 4.10 shows the numerical weightings of learning styles, personal beliefs and self-knowledge.

Learning styles, personal beliefs and self-knowledge showed an 11% difference between the mean and the mode. The frequency falls between 46% and 97%. The median is 81% and the standard deviation is 12.5. The maximum score for total positive learning style, personal beliefs and self-knowledge is 100%. 4% obtained a 95% score, 26% scored 90% (highest frequency), 15% scored 80% with 11% obtaining a score of 70%. In other words a total of 96% of the students felt 50% or more positive about learning styles, personal beliefs and self-knowledge. This would indicate that the students' responses towards learning styles, personal beliefs, and self-knowledge were predominantly positive, as is borne out in the literature in the findings of Jensen (1998) and Grinder (1990).

Grinder (1990) notes that in every group of thirty students, an average of twenty-two are able to learn effectively enough visually, auditorily, and kinaesthetically and that they do not require special attention. Of the remaining eight students, about six prefer one of the modalities over the other two so strongly that they struggle to understand the instructions most of the time, unless special care is taken to present it in their preferred mode. For these students, knowing their best learning modality can mean the difference between success and failure. The remaining two students have difficulty learning due to external causes (Bandler and Grinder, 1990).

Fig 4.9 below is a histogram superimposed on a normal distribution curve of the learning styles, personal beliefs, and self-knowledge. From this graph, learning styles, personal beliefs, and self-knowledge appear to be heavily skewed towards the positive of the normal distribution. This would indicate that 25 students (∴93% of the total number of students) were 65% and above positive that learning styles, personal beliefs and self-knowledge were important: 3 student were at the 65% level, 3 students at the 70% level, 2 students at the 75% level, 4 students at the 80% level, 5 student at the 85% level, 7 students at the 90% level and 1 student at the 95% level, according to the results of the questionnaires.

Fig 4.9:

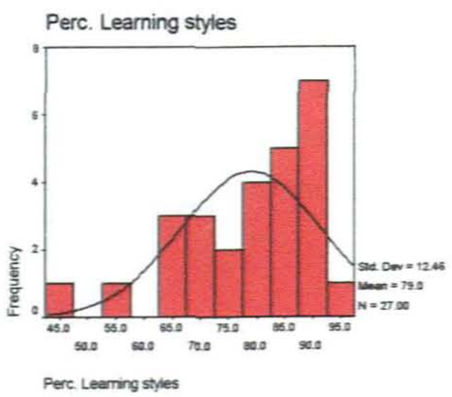
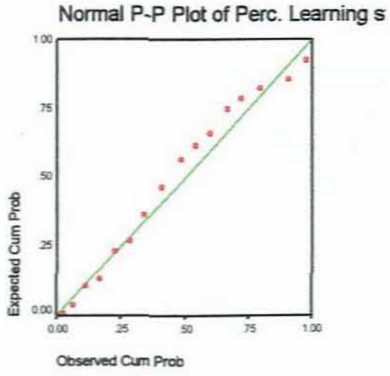


Fig 4 10:



On Fig 4.10 the P-Plot shows a high positive correlation. The dots are closely packed around the line, indicating that the relationship between the expected learning styles, personal beliefs, and self-knowledge outcome and the observed learning styles, personal beliefs, and self-knowledge outcome, correlates positively.

4.3.2 CORRELATIONS

In a correlation the investigator measures the independent variable rather than manipulating it, and looks for a relationship between these measurements and the values of the dependent variable. Correlations can yield interesting and theoretically useful findings in circumstances where experimental manipulations would be *impossible*. The Pearson *r is* the most commonly used measure of correlation. It represents the strength of the linear relationship between two variables.

Table 4.11: Pearson Correlation

		Assessment 1	Assessment 2	Assessment 3	Perc. Student motivation	Perc. Com & feedback	Perc. info gather	Perc. Learning environment	Perc. Learning styles
Assessment 1	Pearson Correlation	1	.588(**)	.446(*)	.284	.464(*)	.307	-.010	.220
	Sig. (2-tailed)	.	.001	.020	.151	.015	.120	.962	.270
	N	27	27	27	27	27	27	27	27
Assessment 2	Pearson Correlation	.588(**)	1	.385(*)	.223	.373	.263	.019	.197
	Sig. (2-tailed)	.001	.	.047	.264	.055	.185	.926	.324
	N	27	27	27	27	27	27	27	27
Assessment 3	Pearson Correlation	.446(*)	.385(*)	1	.090	.131	-.101	.015	.093
	Sig. (2-tailed)	.020	.047	.	.654	.516	.618	.942	.646
	N	27	27	27	27	27	27	27	27
Perc. Student motivation	Pearson Correlation	.284	.223	.090	1	.643(**)	.689(**)	.448(*)	.620(**)
	Sig. (2-tailed)	.151	.264	.654	.	.000	.000	.019	.001
	N	27	27	27	27	27	27	27	27
Perc. Com & feedback	Pearson Correlation	.464(*)	.373	.131	.643(**)	1	.802(**)	.181	.586(**)
	Sig. (2-tailed)	.015	.055	.516	.000	.	.000	.367	.001
	N	27	27	27	27	27	27	27	27
Perc. info gather	Pearson Correlation	.307	.263	-.101	.689(**)	.802(**)	1	.328	.696(**)
	Sig. (2-tailed)	.120	.185	.618	.000	.000	.	.095	.000
	N	27	27	27	27	27	27	27	27
Perc. Learning environment	Pearson Correlation	-.010	.019	.015	.448(*)	.181	.328	1	.672(**)
	Sig. (2-tailed)	.962	.926	.942	.019	.367	.095	.	.000
	N	27	27	27	27	27	27	27	27
Perc. Learning styles	Pearson Correlation	.220	.197	.093	.620(**)	.586(**)	.696(**)	.672(**)	1
	Sig. (2-tailed)	.270	.324	.646	.001	.001	.000	.000	.
	N	27	27	27	27	27	27	27	27

**** Correlation is significant at the 0.01 level (2-tailed).**

*** Correlation is significant at the 0.05 level (2-tailed).**

Table 4.12:Kendall's Tau and Spearman's rho Correlations

			Assess ment 1	Assess ment 2	Assess ment 3	Perc. Student motiva tion	Perc. Com & feedback	Perc. info gather	Perc. Learning environ ment	Perc. Learning styles
Kendall's tau_b	Assess ment 1	Correlation Coefficient	1.000	.419(**)	.242	.141	.373(**)	.249	-.104	.076
		Sig. (2-tailed)	.	.003	.085	.322	.009	.075	.471	.586
		N	27	27	27	27	27	27	27	27
	Assess ment 2	Correlation Coefficient	.419(**)	1.000	.366(**)	.100	.270	.185	.019	.095
		Sig. (2-tailed)	.003	.	.010	.487	.058	.187	.899	.502
		N	27	27	27	27	27	27	27	27
	Assess ment 3	Correlation Coefficient	.242	.366(**)	1.000	.061	.100	-.124	-.012	.048
		Sig. (2-tailed)	.085	.010	.	.673	.486	.378	.932	.737
		N	27	27	27	27	27	27	27	27
	Perc. Student motivation	Correlation Coefficient	.141	.100	.061	1.000	.458(**)	.523(**)	.407(**)	.535(**)
		Sig. (2-tailed)	.322	.487	.673	.	.002	.000	.006	.000
		N	27	27	27	27	27	27	27	27
	Perc. Com & feedback	Correlation Coefficient	.373(**)	.270	.100	.458(**)	1.000	.653(**)	.148	.433(**)
		Sig. (2-tailed)	.009	.058	.486	.002	.	.000	.316	.002
		N	27	27	27	27	27	27	27	27
	Perc. info gather	Correlation Coefficient	.249	.185	-.124	.523(**)	.653(**)	1.000	.221	.480(**)
		Sig. (2-tailed)	.075	.187	.378	.000	.000	.	.126	.001
		N	27	27	27	27	27	27	27	27

	Perc. Learning environment	Correlation Coefficient	-.104	.019	-.012	.407(**)	.148	.221	1.000	.510(**)
		Sig. (2-tailed)	.471	.899	.932	.006	.316	.126	.	.000
		N	27	27	27	27	27	27	27	27
	Perc. Learning styles	Correlation Coefficient	.076	.095	.048	.535(**)	.433(**)	.480(**)	.510(**)	1.000
		Sig. (2-tailed)	.586	.502	.737	.000	.002	.001	.000	.
		N	27	27	27	27	27	27	27	27
Spear man's rho	Assessment 1	Correlation Coefficient	1.000	.578(**)	.364	.183	.501(**)	.348	-.116	.107
		Sig. (2-tailed)	.	.002	.062	.362	.008	.076	.564	.594
		N	27	27	27	27	27	27	27	27
	Assessment 2	Correlation Coefficient	.578(**)	1.000	.465(*)	.169	.370	.262	.018	.140
		Sig. (2-tailed)	.002	.	.014	.398	.058	.187	.927	.485
		N	27	27	27	27	27	27	27	27
	Assess ment 3	Correlation Coefficient	.364	.465(*)	1.000	.054	.119	-.149	-.016	.071
		Sig. (2-tailed)	.062	.014	.	.787	.556	.460	.936	.726
		N	27	27	27	27	27	27	27	27
	Perc. Student motivation	Correlation Coefficient	.183	.169	.054	1.000	.609(**)	.693(**)	.590(**)	.696(**)
		Sig. (2-tailed)	.362	.398	.787	.	.001	.000	.001	.000
		N	27	27	27	27	27	27	27	27
	Perc. Com & feedback	Correlation Coefficient	.501(**)	.370	.119	.609(**)	1.000	.804(**)	.192	.564(**)
		Sig (2-tailed)	.008	.058	.556	.001	.	.000	.337	.002
		N	27	27	27	27	27	27	27	27

	Perc. info gather	Correlation Coefficient	.348	.262	-.149	.693(**)	.804(**)	1.000	.283	.598(**)
		Sig. (2-tailed)	.076	.187	.460	.000	.000	.	.153	.001
		N	27	27	27	27	27	27	27	27
	Perc. Learning environment	Correlation Coefficient	-.116	.018	-.016	.590(**)	.192	.283	1.000	.658(**)
		Sig. (2-tailed)	.564	.927	.936	.001	.337	.153	.	.000
		N	27	27	27	27	27	27	27	27
	Perc. Learning styles	Correlation Coefficient	.107	.140	.071	.696(**)	.564(**)	.598(**)	.658(**)	1.000
		Sig. (2-tailed)	.594	.485	.726	.000	.002	.001	.000	.
		N	27	27	27	27	27	27	27	27

** **Correlation is significant at the 0.01 level (2-tailed).**

* **Correlation is significant at the 0.05 level (2-tailed).**

Table 4.13 shows the results from the test marks from 2002 and 2003. It indicates the relationship between the standard deviation, median, mean and modes of the various tests. The maximum test mark and the minimum test mark obtained for each are also indicated In this table.

Table 4.13: Statistics

	N		Mean	Median	Mode	Std. Deviation	Variance	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
	Valid	Missing											
Class Test 1 2003	27	0	69.78	71.00	71	8.798	77.410	-.227	.448	-1.025	.872	54	84
Class Test 2 2003	27	0	63.81	64.00	62(a)	10.488	110.003	-.630	.448	.421	.872	36	80
Class Test 3 2003	27	0	77.78	79.00	79(a)	9.533	90.872	-.785	.448	-.486	.872	57	90
Class Test 1 2002	25	2	56.56	57.00	46(a)	17.251	297.590	-.282	.464	.049	.902	21	87
Class Test 2 2002	25	2	51.36	53.00	45	18.960	359.490	.220	.464	-.337	.902	19	94
Class Test 3 2002	25	2	68.68	73.00	53(a)	16.755	280.727	-1.844	.464	5.259	.902	10	90
Class Test 4 2002	25	2	55.16	56.00	36(a)	18.502	342.307	-.928	.464	1.713	.902	0	80

a Multiple modes exist. The smallest value is shown

4.3.2.1 Student Motivation

The Pearson correlation shows a significant correlation between motivation and learning styles, learning environment, information gathering, planning strategies, problem solving and task approaching and communication and feedback (2-tailed).

(Refer to Table 4.11 above.)

4.3.2.2 Communication and Feedback

The Pearson correlation shows a significant correlation between communication and feedback and motivation, information gathering, planning strategies, problem solving and task approach and learning styles (2-tailed).
(Refer to Table 4.11 above.)

4.3.2.3 Information Gathering, Planning strategies, Problem Solving and Task Approach

The Pearson correlation shows a significant correlation between information gathering, planning strategies, problem solving and task approach and student motivation, communication and feedback and learning styles (2-tailed).
(Refer to Table 4.11 above.)

4.3.2.4 Learning Environment

The Pearson correlation shows a significant correlation between learning environment and student motivation and learning styles (2-tailed).
(Refer to Table 4.11 above.)

4.3.2.5 Learning Styles

The Pearson correlation shows a significant correlation between learning styles and student motivation, communication and feedback, information gathering, planning strategies, problem solving and task approaching and learning environment (2-tailed).
(Refer to Table 4.11 above.)

The Kendall coefficient of concordance and Spearman's r_s are both non-parametric coefficients of correlation. The Kendall coefficient of concordance involves rankings (e.g. rankings made by independent judges regarding a particular characteristic) and hence are ordinal data. The researcher wants to determine the degree to which the rankings are similar.

Spearman's r_s is specifically designed to measure the degree of a monotonic relationship between two variables. It is used with data, which are in the form of ranks, or can be meaningfully converted to ranks. If two variables are correlated we expect those who obtain the lower scores on one variable to obtain the lower scores on the other, and those who have high scores on one variable to obtain high scores on the other. In calculating Spearman's r, all we do is to rank the subjects from low to high on both variables and then look at the differences between the pairs of ranks. In other words, we can determine the extent of the relationship between two characteristics by means of Spearman's rank order correlation. The above findings indicate that there are positive correlations between BCL and the outcome of assessment marks:

4.3.2.6 Student Motivation

Kendall's tau and Spearman's rho correlations shows significant correlations between motivation and learning styles, learning environment, information gathering, planning strategies, problem solving and task approaching and communication and feedback (2-tailed).
(Refer to Table 4.12 above.)

4.3.2.7 Communication and Feedback

Kendall's tau and Spearman's rho correlations show a significant correlation between communication and feedback and motivation, information gathering, planning strategies, problem solving and task approach and learning styles (2-tailed).
(Refer to Table 4.12 above.)

4.3.2.8 Information Gathering, Planning strategies, Problem Solving and Task Approach

Kendall's tau and Spearman's rho correlations show a significant correlation between information gathering, planning strategies, problem solving and task approach and student motivation, communication and feedback and learning styles (2-tailed).
(Refer to Table 4.12 above.)

4.3.2.9 Learning Environment

Kendall's tau and Spearman's rho correlations shows a significant correlation between learning environment and student motivation and learning styles (2-tailed).
(Refer to Table 4.12 above.)

4.3.2.10 Learning Styles

Kendall's tau and Spearman's rho correlations shows a significant correlation between learning styles and student motivation, communication and feedback, information gathering, planning strategies, problem solving and task approaching and learning environment (2-tailed).
(Refer to Table 4.12 above.)

4.3.3 CLASS TESTS: 2002 and 2003

Class tests from 2002 were used as a baseline to compare the outcome of class tests from 2003. Although the statistical analysis will be looked at, the question to be answered at the end is not "what level of significance was obtained?" Rather the question to be asked is "to what extend do these results confirm the original prediction made about BCL and throw light on the theoretical notions which gave rise to the prediction that BCL could make a difference?" The point that I wish to emphasize here is that many considerations external to the statistical analysis determine the practical and theoretical significance of the results.

Table 4.14 indicates the significance by looking at the student t-test for equality of means. From this table the 2-tailed significance level can be derived.

Table 4.14: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
MARK 1	Equal variances assumed	6.583	.013	3.519	50	.001	13.22	3.756	5.674	20.761
	Equal variances not assumed			3.439	35.075	.002	13.22	3.843	5.416	21.019
MARK 2	Equal variances assumed	7.663	.008	2.960	50	.005	12.45	4.207	4.005	20.905
	Equal variances not assumed			2.899	36.800	.006	12.45	4.296	3.749	21.161
MARK 3	Equal variances assumed	2.385	.129	2.432	50	.019	9.11	3.748	1.586	16.642
	Equal variances not assumed			2.383	37.408	.022	9.11	3.824	1.368	16.859

From Table 4.15 the standard deviation, median, mean and mode of the 2002 and 2003 tests can be seen. Mark 1 indicates the 2002 test marks (25 students) and mark 2 the 2003 test marks (27 students).

Table 4.15: Group Statistics

	COHORT	N	Mean	Std. Deviation	Std. Error Mean
MARK1	2	27	69.78	8.798	1.693
	1	25	56.56	17.251	3.450
MARK2	2	27	63.81	10.488	2.018
	1	25	51.36	18.960	3.792
MARK3	2	27	77.78	9.533	1.835
	1	25	68.66	16.777	3.355

4.3.3.1 Class Test 1 – 2003

From the Independent Samples Test (Table 4.14) and the Group Statistics (Table 4.15) and Statistics (Table 4.13), class test one 2003 shows a 1% difference between the mean and the mode. The standard deviation is 8.8. The frequency falls between 54% and 84%. The median is 71%. Using Kendall's tau and Spearman's rho correlations (Table 4.12) there is a significant correlation between communication and feedback, and class test 2 at the significant level of .01 (2-tailed). The t-test showed a value of 3.5 and a mean difference of 13.22, with a significance of .001 (2-tailed). This indicates the lowest mark obtained was 54% and the highest mark 84 %. None of the students failed this test. The mean of 70% is high.

Table 4.16: G1MARK1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	54	1	3.7	3.7	3.7
	56	1	3.7	3.7	7.4
	57	1	3.7	3.7	11.1
	58	1	3.7	3.7	14.8
	59	2	7.4	7.4	22.2
	62	1	3.7	3.7	25.9
	63	1	3.7	3.7	29.6
	66	1	3.7	3.7	33.3
	68	1	3.7	3.7	37.0
	69	1	3.7	3.7	40.7
	70	2	7.4	7.4	48.1
	71	3	11.1	11.1	59.3
	72	1	3.7	3.7	63.0
	74	1	3.7	3.7	66.7
	75	1	3.7	3.7	70.4
	77	2	7.4	7.4	77.8
	79	2	7.4	7.4	85.2
	80	2	7.4	7.4	92.6
	83	1	3.7	3.7	96.3
	84	1	3.7	3.7	100.0
	Total	27	100.0	100.0	

Fig 4.11: Percentage Class test 1 (2003)

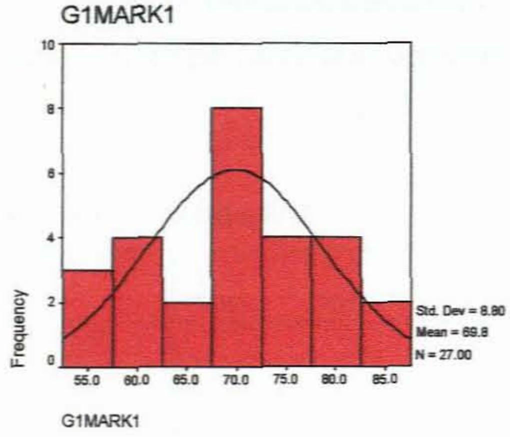


Fig 4.12: Normal P-Plot Class test 1 (2003)

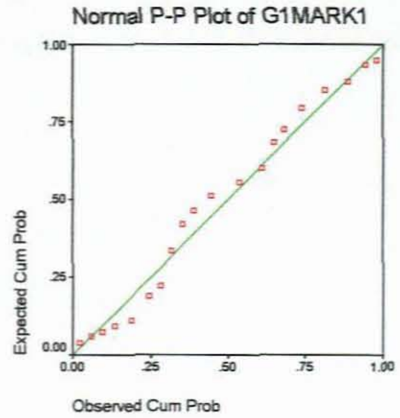


Fig 4.11 shows that class test 1 (2003) appears to follow the normal distribution, with the histogram skewed towards the positive, with the highest frequency at the 70% level. The standard deviation is 8.8 with the mean at 69.8 (N= 27). This would indicate that 24 students ($\therefore$ 89% of the total number of students) obtained a mark of 60% and above in class test 1 (2003): 4 students obtained a mark of 60%, 2 students obtained a mark of 65%, 8 students obtained a mark of 70%, 4 students obtained a mark of 75%, 4 students obtained a mark of 80% and 2 students obtained a mark of 85%.

The P-Plot (Fig 4.12) indicates high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 1 outcome and the observed class test 1 outcome, correlates positively.

The Pearson correlation (Table 4.11) shows that there is a significant (2-tailed) correlation with class test 2, class test 3 and communication and feedback. The above findings indicate that there is a positive correlation between BCL and the outcome of test marks.

4.3.3.2 Class Test 2 – 2003

From the Independent Samples Test (Table 4.14) and the Group Statistics (Table 4.15and Statistics (Table 4.13), ass test two 2003 shows a 2% difference between the mean and the mode. The standard deviation is 10.5. The frequency falls between 36% and 80%. The median is 64%. Using Kendall's tau and Spearman's rho correlations (Table 4.12 there is a significant correlation (2-tailed) between class test 1 and class test 2. The t-test showed a value of 2.96 and a mean difference of 12.45, with a significance of .005 (2-tailed). This indicates the lowest mark obtained was 36% and the highest mark 80 %. 2 students failed this test.

Table 4.17: G1MARK2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	36	1	3.7	3.7	3.7
	47	1	3.7	3.7	7.4
	50	1	3.7	3.7	11.1
	53	1	3.7	3.7	14.8
	54	2	7.4	7.4	22.2
	58	1	3.7	3.7	25.9
	59	2	7.4	7.4	33.3
	62	3	11.1	11.1	44.4
	63	1	3.7	3.7	48.1
	64	2	7.4	7.4	55.6
	68	3	11.1	11.1	66.7
	70	2	7.4	7.4	74.1
	73	2	7.4	7.4	81.5
	75	1	3.7	3.7	85.2
	76	2	7.4	7.4	92.6
	79	1	3.7	3.7	96.3
	80	1	3.7	3.7	100.0
	Total	27	100.0	100.0	

Fig 4.13: Percentage Class test 2 (2003)

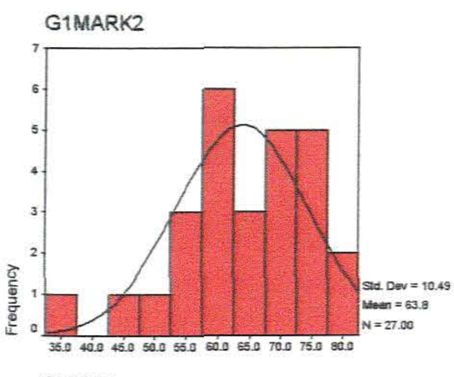


Fig 4.14: Normal P-Plot Class test 2 (2003)

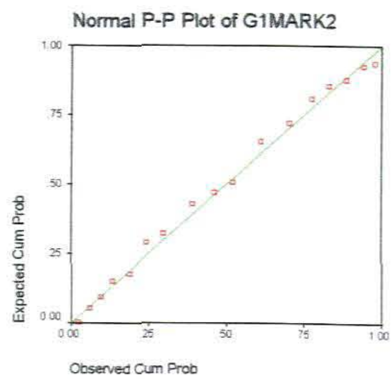


Fig 4.13 shows that class test 2 (2003) appears to follow the normal distribution, with the histogram skewed extremely towards the positive, with the highest frequency at the 60% level. The standard deviation is 10.49 with the mean at 63.8 (N= 27). This would indicate that 21 students (∴ 78% of the total number of students) obtained a mark of 60% and above in class test 2 (2003), 6 students obtained a mark of 60%, 3 students obtained a mark of 65%, 5 students obtained a mark of 70%, 5 students obtained a mark of 75% and 2 students obtained a mark of 80%.

The P-Plot (Fig 4.14) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 2 outcome and the observed class test 2 outcomes correlates positively.

The Pearson correlation (Table 4.11) shows that there is a significant (2-tailed) correlation between class test 1 and class test 3. The above findings indicate that there is a positive correlation between BCL and the outcome of assessment marks.

4.3.3.3 Class Test 3 – 2003

From the Independent Samples Test (Table 4.14) and the Group Statistics (Table 4.15) and Statistics (Table 4.13), class test three 2003 shows a 1% difference between the mean and the mode. The standard deviation is 9.5. The frequency falls between 57% and 90%. The median is 79%. Using Kendall's tau and Spearman's rho correlations (Table 4.12) there is a significant correlation (2-tailed) between class test 3 (2003) and class test 2 (2003). The t-test showed a value of 2.43 and a mean difference of 9.11, with no significance.

Fig 4.15: Percentage Class test 3 (2003)

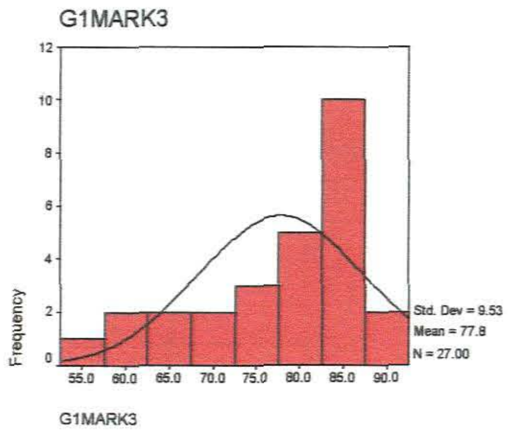


Fig 4.16: Normal P-Plot Class test 3 (2003)

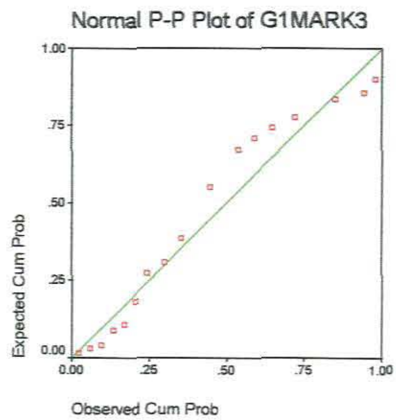


Fig 4.15 shows that class test 3 (2003) appears to follow the normal distribution, with the histogram skewed extremely towards the positive, with the highest frequency at the 85% level. The standard deviation is 9.53 with the mean at 77.8 (N= 27). This would indicate that 26 students ($\therefore$ 96% of the total number of students) obtained a mark of 60% and above in class test 3 (2003), 2 students obtained a mark of 60%, 2 students obtained a mark of 65%, 2 students obtained a mark of 70%, 3 students obtained a mark of 75%, 5 students obtained a mark of 80%, 10 students obtained a mark of 85% and 2 students obtained a mark of 90%.

The P-Plot (Fig 4.16) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 3 outcome and the observed class test 3 outcome correlates positively.

The Pearson correlation (Table 4.11) shows that there is a significant (2-tailed) correlation between class test 3 (2003), and class test 1 (2003) and class test 2 (2003). The above findings indicate that there is a positive correlation between BCL and the outcome of assessment marks.

Table 4.18 indicates that the lowest mark obtained was 57% and the highest mark 90 %. None of the students failed this test. The mean of 78% is high.

Table 4.18: G1MARK3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	57	1	3.7	3.7	3.7
	60	1	3.7	3.7	7.4
	61	1	3.7	3.7	11.1
	65	1	3.7	3.7	14.8
	66	1	3.7	3.7	18.5
	69	1	3.7	3.7	22.2
	72	1	3.7	3.7	25.9
	73	2	7.4	7.4	33.3
	75	1	3.7	3.7	37.0
	79	4	14.8	14.8	51.9
	82	1	3.7	3.7	55.6
	83	2	7.4	7.4	63.0
	84	1	3.7	3.7	66.7
	85	3	11.1	11.1	77.8
	87	4	14.8	14.8	92.6
	88	1	3.7	3.7	96.3
	90	1	3.7	3.7	100.0
	Total	27	100.0	100.0	

4.3.3.4 Class Test 1. – 2002

From the Group Statistics (Table 4.15) and Statistics (Table 4.13), class test one 2002 shows a 10% difference between the mean and the mode. The standard deviation is 17.3. The frequency falls between 21% (lowest mark) and 87% (highest mark). The median is 56.56%. 6 students failed this test.

Table 4.19: G2MARK1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21	1	3.7	4.0	4.0
	24	1	3.7	4.0	8.0
	26	1	3.7	4.0	12.0
	46	2	7.4	8.0	20.0
	47	1	3.7	4.0	24.0
	49	2	7.4	8.0	32.0
	50	1	3.7	4.0	36.0
	51	1	3.7	4.0	40.0
	52	1	3.7	4.0	44.0
	54	1	3.7	4.0	48.0
	57	1	3.7	4.0	52.0
	58	1	3.7	4.0	56.0
	59	2	7.4	8.0	64.0
	64	1	3.7	4.0	68.0
	65	1	3.7	4.0	72.0
	66	1	3.7	4.0	76.0
	70	1	3.7	4.0	80.0
	72	1	3.7	4.0	84.0
	76	1	3.7	4.0	88.0
	82	1	3.7	4.0	92.0
	84	1	3.7	4.0	96.0
	87	1	3.7	4.0	100.0
	Total	25	92.6	100.0	
Missing	System	2	7.4		
Total		27	100.0		

Fig 4.16: Percentage Class test 1 (2002)

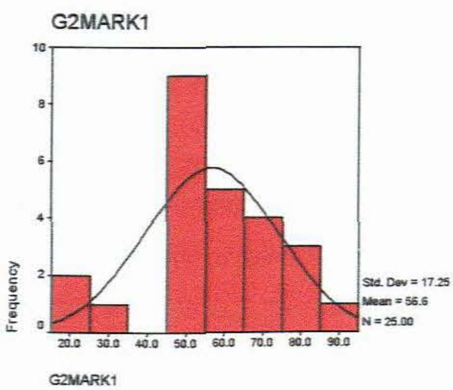


Fig 4.17: Normal P-Plot Class test 1 (2002)

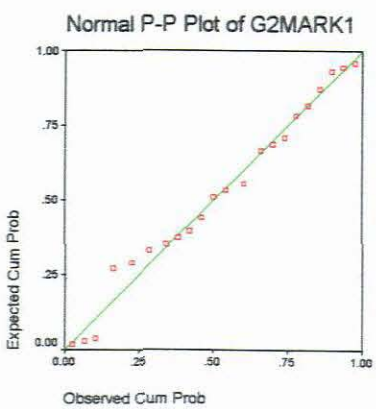


Fig 4.16 shows that class test 1 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 50% level. The standard deviation is 17.25 with the mean at 56.6 (N= 25). This would indicate that 13 students (∴52% of the total number of students) obtained a mark of 60% and above in class test 1 (2002), 5 students obtained a mark of 60%, 4 students obtained a mark of 70%, 3 students obtained a mark of 80% and 1 student obtained a mark of 90%.

The P-Plot (Fig 4.17) indicates high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 1 (2002) outcome and the observed class test 1 (2002) outcome correlates positively.

4.3.3.5 Class Test 2. – 2002

From the Group Statistics (Table 4.15) and Statistics (Table 4.13), class test two 2002 shows a 5.5% difference between the mean and the mode. The standard deviation is 18.96. The frequency falls between 19% and 94%. The median is 53%. 10 students failed this test.

Fig 4.18: Percentage Class test 2 (2002)

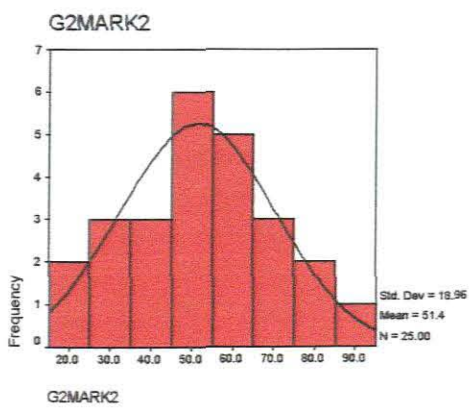


Fig 4.19: Normal P-Plot Class test 2 (2002)

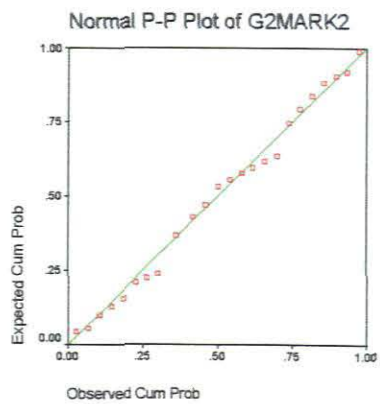


Fig 4.18 shows that class test 2 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 50% level. The standard deviation is 18.96 with the mean at 51.4 (N= 25). This would indicate that 11 students (∴44% of the total number of students) obtained a mark of 60% and above in class test 2

(2002), 5 students obtained a mark of 60%, 3 students obtained a mark of 70%, 2 students obtained a mark of 80% and 1 student obtained a mark of 90%.

The P-Plot (Fig 4.19) indicates a positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 2 (2002) outcome and the observed class test 2 (2002) outcome correlates positively.

Table 4.20: G2MARK2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	19	1	3.7	4.0	4.0
	21	1	3.7	4.0	8.0
	27	1	3.7	4.0	12.0
	30	1	3.7	4.0	16.0
	32	1	3.7	4.0	20.0
	36	1	3.7	4.0	24.0
	37	1	3.7	4.0	28.0
	38	1	3.7	4.0	32.0
	45	2	7.4	8.0	40.0
	48	1	3.7	4.0	44.0
	50	1	3.7	4.0	48.0
	53	1	3.7	4.0	52.0
	54	1	3.7	4.0	56.0
	55	1	3.7	4.0	60.0
	56	1	3.7	4.0	64.0
	57	1	3.7	4.0	68.0
	58	1	3.7	4.0	72.0
	64	1	3.7	4.0	76.0
	67	1	3.7	4.0	80.0
	70	1	3.7	4.0	84.0
	74	1	3.7	4.0	88.0
	76	1	3.7	4.0	92.0
	78	1	3.7	4.0	96.0
	94	1	3.7	4.0	100.0
	Total	25	92.6	100.0	
Missing	System	2	7.4		
Total		27	100.0		

Table 4.20 indicate the lowest mark obtained was 19% and the highest mark 94 %. 14 students failed this test.

4.3.3.6 Class Test 3. – 2002

From the Group Statistics (Table 4.15) and Statistics (Table 4.13), class test 3 (2002) shows a 16% difference between the mean and the mode. The standard deviation is 16.8. The frequency falls between 10% (lowest mark) and 90% (highest mark). The median is 73. 2 students failed this test.

Table 4.21: G2MARK3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10	1	3.7	4.0	4.0
	49	1	3.7	4.0	8.0
	51	1	3.7	4.0	12.0
	53	2	7.4	8.0	20.0
	63	2	7.4	8.0	28.0
	65	1	3.7	4.0	32.0
	67	2	7.4	8.0	40.0
	68	1	3.7	4.0	44.0
	69	1	3.7	4.0	48.0
	73	2	7.4	8.0	56.0
	75	2	7.4	8.0	64.0
	76	1	3.7	4.0	68.0
	78	1	3.7	4.0	72.0
	79	1	3.7	4.0	76.0
	81	1	3.7	4.0	80.0
	82	1	3.7	4.0	84.0
	84	1	3.7	4.0	88.0
	86	1	3.7	4.0	92.0
	87	1	3.7	4.0	96.0
	90	1	3.7	4.0	100.0
	Total	25	92.6	100.0	
Missing	System	2	7.4		
Total		27	100.0		

Fig 4.20 shows that class test 3 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 80% level. The standard deviation is 16.75 with the mean at 68.7 (N= 25). This would indicate that 20 students ($\therefore$ 80% of the total number of students) obtained a mark of 60% and above in class test 3

(2002), 2 students obtained a mark of 60%, 7 students obtained a mark of 70%, 8 students obtained a mark of 80% and 3 students obtained a mark of 90%.

Fig 4.20: Percentage Class test 3 (2002)

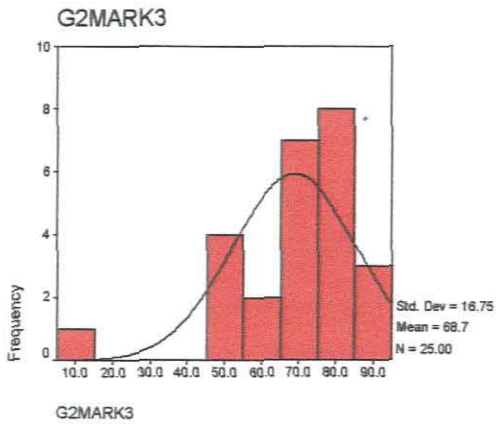
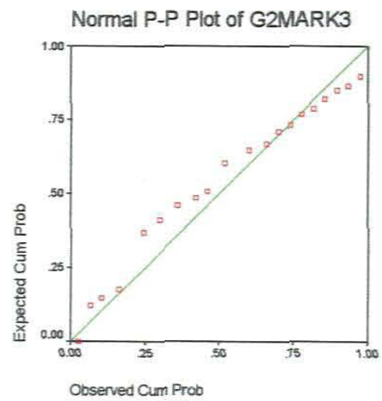


Fig 4.21: Normal P-Plot Class test 3 (2002)



The P-Plot (Fig 4.21) indicates a positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 3 (2002) outcome and the observed class test 3 (2002) outcome correlates positively with each other.

4.4 SUMMARY

The major objective of the research reported here was to study the possible connections between BCL and learning outcomes, i.e. assessment tests, motivation, task approach, communication, feedback, etc. The findings indicate a strong relationship between BCL and the various components, namely that utilizing BCL in the classroom might improve the learning outcome. The hypothesis that BCL is possible in the context of Radiation Science was substantiated.

The research described in this chapter is to be viewed as a preliminary study, and naturally opens up new channels of thought, leaving us with many questions to be investigated, so as to improve the quality of lecturer training processes, and subsequently those of teaching and education.

CHAPTER 5
INTERPRETATION OF THE RESEARCH FINDINGS

The results of this preliminary study should be viewed with caution due to the small, isolated sample. While further investigations should attempt to overcome this and other problems, these preliminary findings provide a starting point for examining lecturers' use of BCL in the classroom.

The data are predominantly qualitative, and the qualitative interpretation of the findings are thus dealt with first in this section. According to Callon (1986), situations in which innovations are introduced become unstable and events occur that can only be measured qualitatively, because they are too new and too different to track quantitatively. Once the trend has been established through qualitative investigation and then followed up, using quantitative methods, can be used. This is the approach that was taken in this research project. The innovative teaching and learning interventions were not experimentally controlled, but formed part of the naturally occurring variation in the context of learning. The lecturer systematically collected observation notes during lesson times. In addition, interviews were conducted with individual students. Interview questions were open-ended, concerning students' perceptions (Refer to Appendix B.) These perceptions were then checked quantitatively, using a series of four questionnaires over a time span of about 7 months.

5.1 QUALITATIVE ANALYSIS

Data that are analysed qualitatively are usually compared across methods, across data sources and across time (Leedy, 2001). The purpose of qualitative analysis is ultimately to gain insights into phenomena. 'Open' and 'axial' coding (Stauss & Corbin, 1996) were used for the analysis of qualitative data in this research project. Themes, patterns, and categories were coded and led to theorisation of teaching, learning and assessment in the context of Radiation Science.

5.1.1 Data From BCL Interventions in the Classroom

The first few lectures were spent explaining BCL to students. It was pointed out to students that one of the main goals of higher education is to develop a critical mind, rather than to accumulate a vast amount of factual knowledge. Rather than memorising facts, students should try to look for key concepts or ideas and learn the methods of how and where to find the facts. A video on mind mapping, as one way to take effective notes, was shown to the students. It was further pointed out to students that this process of learning obviously takes longer than rote learning, but that it has long-term effects; the learning retention rate being statistically higher. Students should also not accept the authority of a lecture or book passively and uncritically, but learn to listen and read critically and actively. (Burner, 1975) These introductory lectures also aimed at making students aware of the functions and the role of the lecturer, which has changed from lecturer to facilitator, as well as to make students understand why they will be given questions to answer and problems to solve, individually and as a group.

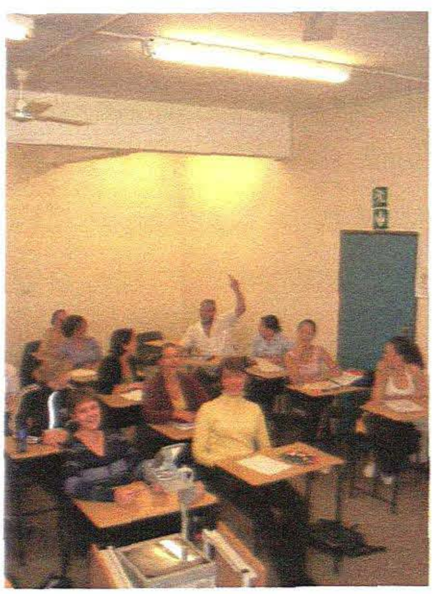
This was a new concept to some students and, from the field notes and casual conversation, it appeared that at first some of the students found this approach unfamiliar. After some time elapsed they become more open and involved and felt less threatened to express their own points of view. For example: in one lecture period, the students went to the library to research certain topics on their own and found information from various books. They compared the information in the different resources and came to the realization that different authors describe the same topic in many different and sometimes contradictory ways.

Educational research has established that the traditional lecture is an appropriate method to teach factual knowledge, but that creative, critical thinking and analytical skills are more effectively developed through discussion or exercises, workshops, problem-solving and experience-based learning activities (Blight, 1972). At first the students had to adapt to this new way of presenting the content. They had to be helped to connect the content of the lesson to other contexts or domains as well as to variables of how to learn. They are not used to being mainly responsible themselves to prepare and then present the information to their fellow students. Greenberg (1990) points out that contrary to popular belief, students do not learn how to control their approach to activities when lecturers regulate their behaviour for them by telling them exactly what to do, when to do it, and how to do it. When lecturers do this, students do not develop a need to think about their approach.

Some student comments on the new approach: (Appendix H)
(85 % of the student comments were positive, whilst 15% were negative)

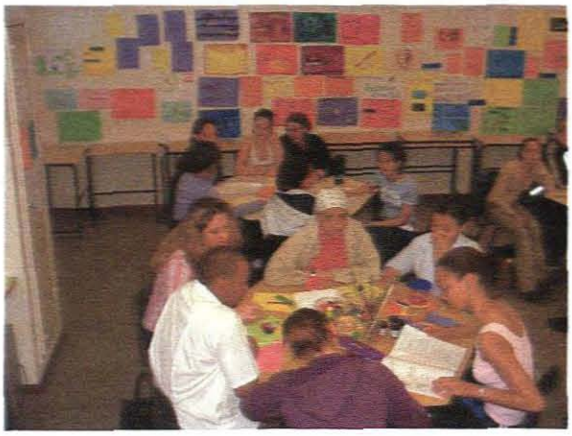
"Let students first sort out the problems on their own, then provide some help"
"The activities she allows us to do, allows us to explain and understand the work."
"The fact that we must give the class is interesting"

Photos from normal classroom environment:



The above photos are the way students used to be seated before implementation of a brain friendly environment was introduced.

Photos from 2003 Classroom – using the new approach to teaching



The above photos are showing what the classroom looks like when making use of a brain friendly environment.

5.1.1.1 Introducing Mind Mapping Techniques

Mind mapping, amongst other techniques, as a note taking method, was explained to the students in the introductory lectures. A 'student friendly' video on how to do mind mapping was also shown to the students. Students were required to produce mind maps at various points in the course. (See Appendix G1 for examples of mind maps done by students.) Sixty percent of the students made use of mind mapping and did find it a very good way to learn; the other forty percent did not like it.

Some student comments: (Appendix H)
"I learned from doing the mind maps"
"Mind mapping works for me"
"I enjoyed doing the mind maps"
"I cannot learn from a mind map. I make my own summaries in other ways"

"Mind maps don't work for me. I learn much better from my own notes"

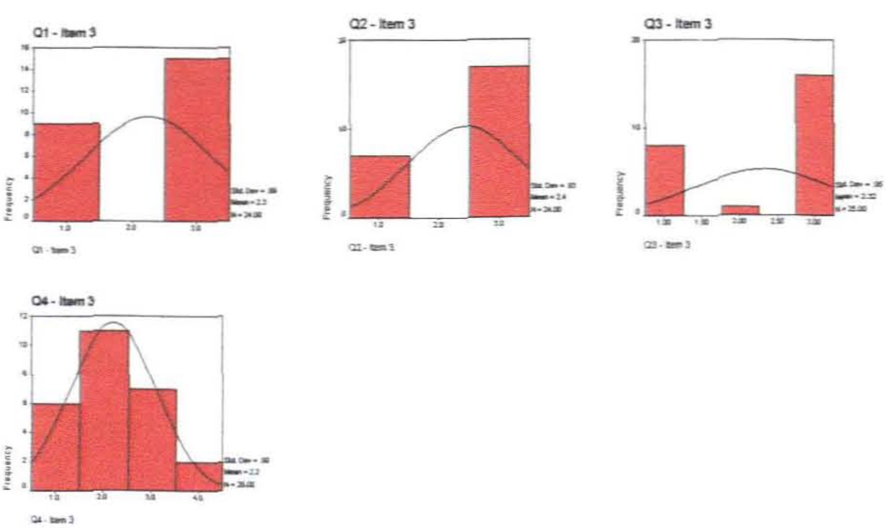
"Mind maps are time consuming"

In one of the lectures students were given written information on radiation protection in their own department. In the given time span of the lesson, they had to produce a mind map on this topic. The mind maps were handed back to them with the instruction to either correct the mind map or hand in their preferred method of note taking. (See Appendix G2 for the second corrected mind maps and some other note taking methods used by the students.)

To cross-reference the classroom data with data from questionnaires the following questions were quantified:
"I write up my own notes after the lecture."
(Question 3 in all four questionnaires)
(Refer to Appendix D.)

From the histogram below (Fig 5.1), it can be seen that there is quite a high percentage of students that do not make their own notes, even though the histogram weighs more towards the positive side.

Fig 5.1 Question 3 (in all four questionnaires)



5.1.1.1.1 Learning from Mind Maps

Mind maps should be taught to all students explicitly. If students are taught how to incorporate bridging questions (How would what you have learned now help you when…?), process questions (How else would you do that?), and challenging questions (Why is this the correct answer? What could be wrong with this answer?), into their mind maps, they might find it more useful to learn from them. At first this might be difficult for students to do, but practice might make this process worthwhile. The lecturer could help students to theorise and identify how they want to expand, enhance or change this process with their newly gained knowledge and skills regarding mind mapping. The more mind maps they do, the more sense it should make to them when they see that initially it takes a fair amount of time, but when they have to revise the work, the less time they need to spend on it. The lecturer could show them how to analyse the new content by making use of extra branches to clarify the particular content, using keywords only. It is important to bring to the students' attention, the fact that although mind maps might take long to prepare initially, the end result could be very rewarding. Time spent on practising the process of mind mapping could be time well spent, given that it has been statistically shown that mind mapping leads to longer knowledge retention (Buzan, 1988)

5.1.1.1.2 Advantages of Mind Maps

According to Greenberg (1990), advantages of mind maps are the fact that so many cognitive functions are required to accomplish a mind map. For example:

- Approach to task: Students must use exploration, systematic planning and controlled expression in a learning experience.
- Working Memory: Students must use processes effectively and clean the working memory.
- Making comparisons: Students discover similarities and differences automatically among some parts of the learning experience.

- Getting the main idea: Students must identify the basic thought that holds related ideas together.
- Thought integration: Students must combine pieces of information into complete thoughts and hold onto them while needed.
- Connecting events: students need to find relationships among past, present and future learning experiences.
- Precision and accuracy: Students need to know there is a need to understand and use words and concepts and use them correctly.
- Selective attention: Students must choose between relevant and irrelevant information needed in the learning experience.
- Problem identification: Students learn to experience a sense of imbalance automatically and define its cause when something interferes with successful learning (Greenberg, 1990).

5.1.1.1.3 Disadvantages of Mind Maps

The main disadvantage of mind maps is the initial time spent to do them correctly and meaningfully. It could also take many lecture hours to facilitate the correct way to do mind maps. Some students do not have the necessary cognitive skills for this process and, according to Greenberg (1990), should be taught some or all of the following:

- Inner meaning: students need to seek deep personal value in learning experiences that energise thinking and behaviour and lead to greater commitment and success.
- Feeling of challenge: Students need to energise learning in new and complex experiences by focussing on the learning process rather than fear and anxiety.
- Awareness of self-change: Students need to recognise and understand feelings related to personal growth and to learn to expect and welcome change and development.
- Feeling of competence: Students need to energise their feelings, thoughts and behaviours by developing beliefs about being capable of learning and doing something effectively.

- Self-regulation: Students need to reflect on thoughts and actions as they occur to energise, sustain and direct behaviour toward successful learning and doing.
- Goal orientation: Students need to take purposeful action in consistently setting, seeking and reaching personal objectives.
- Self-development: Students need to appreciate qualities in everyone and to enhance personal potential.
- Sharing behaviour: Students need to energise life and learning for everyone by sharing thoughts and actions through effective interdependent learning skills.
- Feeling of belonging: Students need to experience positive feelings of belonging somewhere, to a group, etc. (Greenberg, 1990).

5.1.1.2 Group work

Kagan (1990) and Meyers *et al.* (1993), amongst others, believe that group work can enhance student learning In structured group discussions with colleagues, Kagan (1990) found out that there are certain characteristics, problems and solutions which are common in learning and studying, but that learning can also vary from individual to individual, depending on each student's existing knowledge and strengths. Students can thus become a learning resource for one another. Group work is based on a philosophy of education that assumes that the aim of education is to provide conditions in which the natural curiosity, intelligence and expressiveness of students will emerge and develop. The emphasis in this philosophy is on bringing out and nourishing what are assumed to be naturally intelligent, creative and expressive tendencies among students.

According to Kagan (1990) it is an approach quite in contrast to traditional approaches, which assumes that the student is a void into which educators must pump facts, theories and methods. Group work is based on the assumption that following one's curiosity, having new experiences that modify one's conception of oneself and the world, and sharing these experiences – especially with one's peers – are inherently satisfying, and that no extrinsic reward is needed to get students to engage in these activities, which are the most important forms of learning. In group work students cooperate within their small teams to produce something of benefit to share with the whole class.

Some student comments on the group work in Radiation Science: (Appendix H)
(90% of the 10 students interviewed experienced group work positively while the remaining 10% said that they learn better on their own)

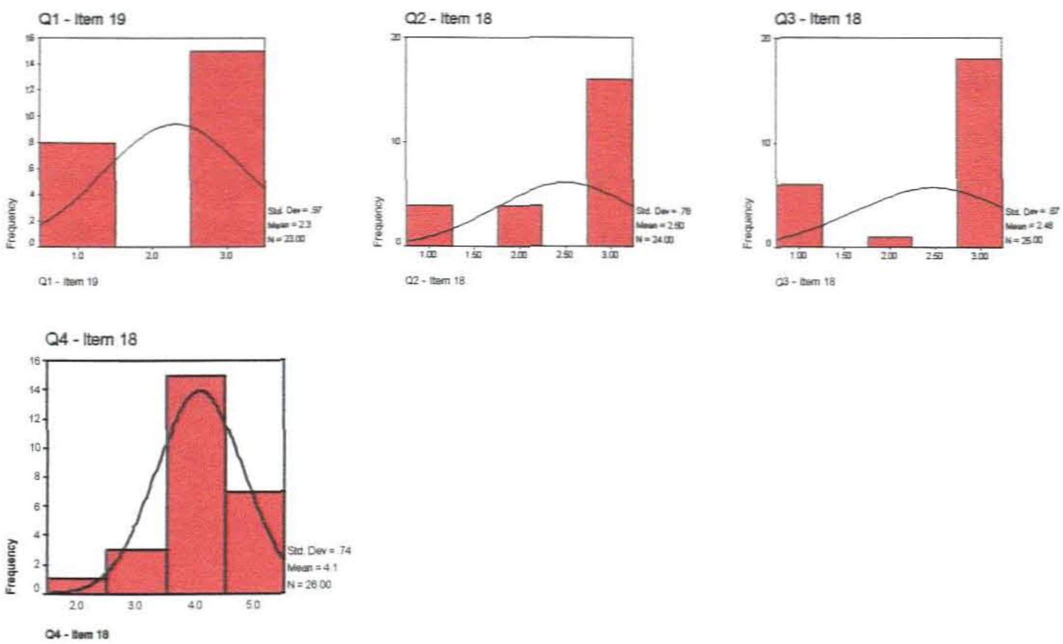
> "The group work was very nice, thank you."
> "The new way of introducing different learning styles in the classroom. The group activities and fun way of learning"
> "The technique to make the classes so interesting by doing group work"
> "The fact that we work in groups makes the learning so much easier, thank you!"
> "I don't like group work too much, I learn better on my own"

For meaningful learning to occur, students must fully understand and integrate new knowledge into their existing knowledge networks. Students become more confident and motivated to learn how to learn when they experience, through discussion, that they can gain insight into their own learning, and that they can develop skills and methods that are best suited to their personal cognitive systems in acquiring knowledge or in solving problems (Zuber-Skerritt, 1992).

5.1.1.2.1 Learning from Group work

[f we cross reference Fig 5.2 with question 19 in questionnaire 1 (I learn with group vork) and the corresponding question in the other three questionnaires –18, we can see he change that took place. In the first questionnaire 35% of students did not like group vork whereas in questionnaire 2 only 17% did not like group work and another 17% vere unsure. In questionnaire 3 there were 24% of the students who did not like group vork, with 4% who were unsure. In the case of Questionnaire 4, only 4% did not like roup work, with 12% being unsure. It could thus be argued that the students' attitude towards group work has changed over time. One reason might be that they could see the positive results that came from working with their peers on certain tasks.

Fig 5.2 Question 19 (in questionnaire 1) and Question 18 (in the other three questionnaires)



5.1.1.2.2 Possible Advantages of Group work

We know we continually learn more about the topics we teach in the process of teaching others. As we tutor, even simple questions from the tutee make us look at our subject matter freshly. As we try to determine the easiest way to convey understanding or overcome a learning block, we ourselves gain a deeper understanding of our topic. Students who tutor peers learn more than the academic content, they learn leadership skills, gain self-esteem, and learn conflict resolution skills as well as role-taking abilities (Kagan, 1990).

For this research project group activities were structured in such a way that no individual student could solely rely on the efforts of his/her teammates. Each student in the group has a mini-topic for which he/she alone is responsible. Learning is individually assessed and students are individually accountable for their own learning gains.

5.1.1.2.3 Possible Disadvantages of Group Work

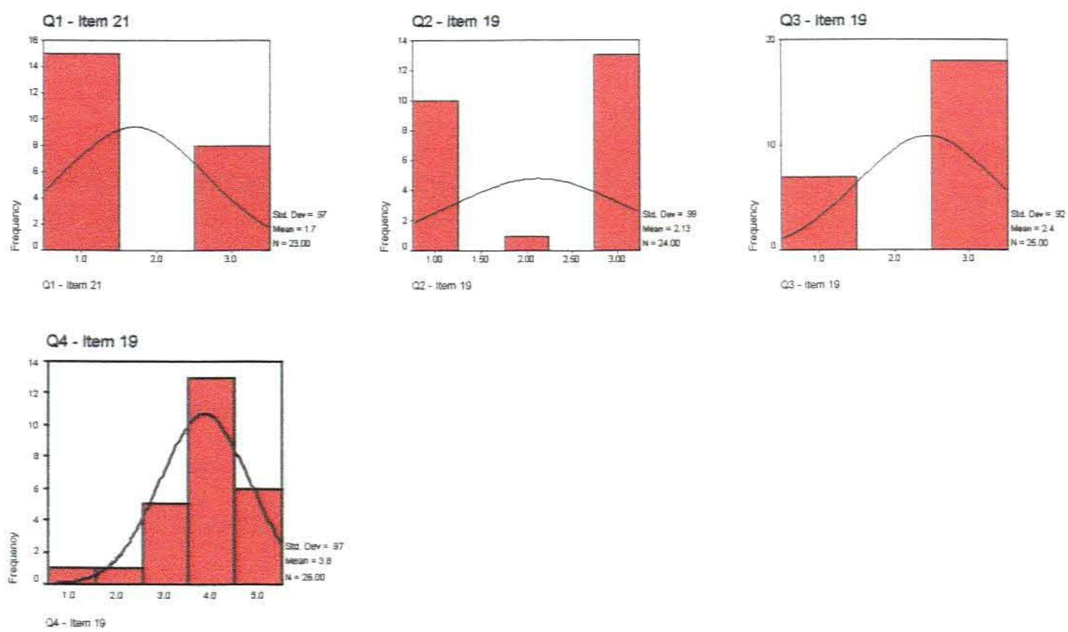
When there is group talk, the lecturer can intervene to facilitate. But the lecturer may also intervene in such a way as to decouple the student from interaction with the balance, and at that point assimilation and accommodation are interrupted. If the lecturer tries to explain, while the underlying conceptual, operational structure is still fragile, the language being used will not couple with the operational structure and reinforce it, but may instead disconcert and bewilder. The accommodative learning process can be facilitated by informal talk in context, but talk cannot be a substitute, and can destroy, as it frequently does (Kagan, 1990).

5.1.1.3 Role-play

Role-play is a very natural mode of learning. It is a chance to explore behaviours, to try them on, to practise. Close observations of play reveals it is often practice of roles for later use. Structured role-play in the classroom is the same thing, with the exception that the teacher points the students in the direction of the content. The role-play in the class addresses the content in a completely different way. When asked about role-play in the questionnaires some students said directly that they do not enjoy role-play (see Appendices D and Fig 5.3 below). What was interesting is the fact they commented in casual conversation that they had learned a great deal from watching the other groups acting out some of the subject content. From the field notes, it was clear these students use language (their own or slang language) to bring certain aspects of the work out very clearly and creatively. Some of the groups put effort into their role-play but others did not give it enough thought to bring out the main idea of the lesson. It could be for a number of reasons, for example they did not like the role-play, or perhaps they did not prepare their homework well enough, or the fact that are shy/have low self-confidence/fear of criticism/are introverted/or have had previous negative experiences.

We can cross reference the classroom data with questionnaire data (refer to Appendix D and Fig 5.3). Question 21 in the questionnaire 1 reads: 'I learn with role-play/acting' (the corresponding question appears in the other three questionnaires). From their responses, we can see how the students' attitude towards role-play has changed over the course of the BCL intervention. In the beginning 65% of the students did not like it and felt negative about role-play. From the second questionnaire 42% of the students still felt negative. Responses to the third questionnaire indicated 28% felt negative and from the fourth questionnaire only 8% of the students felt negative with another 19 % being neutral. It could thus be argued that the students started to benefit from role-play.

Fig 5.3 Question 21 (in questionnaire 1) and Question 19 (in the other three questionnaires)



5.1.1.3.1 Learning from role play

At first students were a little resistant to do role-play. It was a new concept to them therefore they had to work through their own feelings of competence, sharing behaviour and feelings of challenge. That is why it is so important to create a safe classroom environment. As soon as they realise that it is allowed and encouraged to share their own ideas and challenge the ideas of others in a non-threatening atmosphere, they also became more open to role-play themselves.

Kagan (1990) cites Kohlberg, (1973) and Piaget (1932) who postulated that role-play and group work interaction opportunities have theoretically been related to the development of higher levels of morality. Experiences in situations in which bilateral and multilateral communication are necessary probably increase the general sense of interdependence among students which, in turn, increases their understanding of the experience of others.

As Kagan (1990) points out, students who are engaged in role-play are more active, self-directing, and expressive, all of which may be associated with achievement gains. Students take direct responsibility for teaching each other and receiving help from each other. There is structural support for peer involvement in the learning process.

5.1.1.3.2 Advantages of role-play

Some advantages of role-play could be the fact that it encourages students to listen to others carefully. It could teach students effective exploration, to search carefully, not impulsively. Students learn to gather all the necessary information, not all available information or just some information. Students could also learn to use strategies for gathering information systematically in order to role-play the content best (Meyers *et al.*, 1993).

Another possible advantage of role-play might be that students could learn effective planning. They should think about the goal and decide on the steps of the plan and their order and make changes to the plan, when needed (Meyers, *et al,* 1993).

Role-play also encourages students to communicate thoughts and actions carefully and with controlled expression in the learning experience. Focus is here on the process used to achieve effective expression. Role-play could help students to understand and use information about space and time that is important in almost all learning (Meyers *et al.*, 1993).

The whole class is involved in role-play, each student gets a turn to assume different roles as they act out a prescribed scenario. These scenarios incorporate specific rules and activities designed to teach a concept or have students put a theory into practice (Meyers *et al.*, 1993).

5.1.1.3.3 Disadvantages of role-play

A disadvantage of role-play is that it is easier for some students to handle than others. We need to acknowledge that role-play is not value-free and might undercut some of the goals we hope active learning will achieve. It could go too far and encourage too much competition among students. In such instances, students may miss an academic point entirely. Role-play can also be overused in the classroom and the danger here is that students can get caught up solely in the novelty and fun of an activity and, in the process, fail to see the learning goals that should be achieved (Meyers *et al.*, 1993).

5.1.1.4 Setting questions for peers

According to Kagan (1990) peer questioning results in positive outcomes. A meta-analysis of 65 objective studies of peer tutoring concluded that peer tutoring was effective in producing positive academic and social outcomes.

In this study one group of students were required to set questions on the assigned work for that particular session, after the other groups had done the role-play, art work and summarisation of the specified content. They could only ask short questions due to the time constraint. It meant that they had to make use of various skills in order to do so. Firstly, they had to get the main idea of the content in order to decide what were the most important and relevant questions to ask. Secondly, they had to use thought integration to combine pieces of information into complete thoughts. Thirdly, they had to use selective attention to choose between relevant information, and to focus on the information needed. The informal feedback was that students enjoyed doing this. It helped them to focus on what is relevant and important about the content. They also enjoyed marking the answers their peers had given, and gave feedback immediately. However, from the data from the questionnaires not all the students like to set questions for their peers or thought that they could learn from that, although none of students who were interviewed, verbalised this.

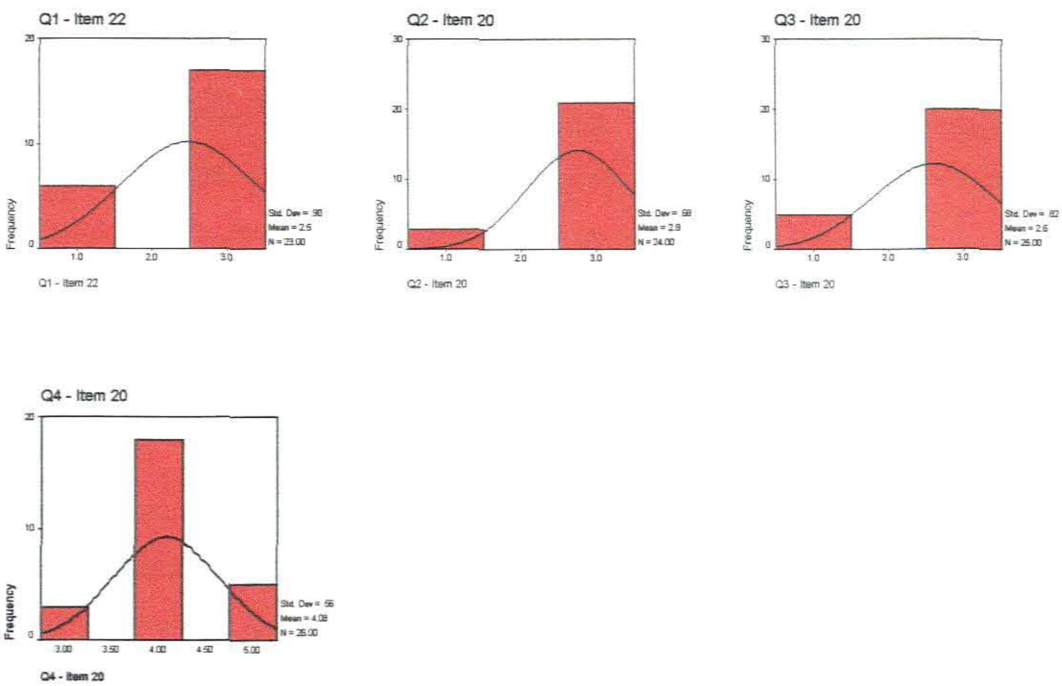
These are some student comments from the field notes:

> "I learned a lot from setting the questions myself"
> "Now I understand what is important to know and what not"
> "I like the marking part, it makes me see how easy it is to make a mistake by asking an ambiguous questions, then the marking is not so easy anymore"

By letting students set some questions themselves emphasis of the learning process shifts from knowing to understanding. Hence the primary focus is on the process of learning instead of on the product.

If we cross reference question 22 in questionnaire 1 (I learn most when I have to set questions for my peers on the work done) and the corresponding question 20 in the other three questionnaires with Table 5.4, we can see that once again for questionnaire one 26% of the students did not learn from setting questions for their peers, but for questionnaire 2 only 8% of the students felt negative. For questionnaire 3, 16% felt negative and for questionnaire 4, 12% of the students felt that they did not gain anything from setting questions for their peers. It could thus be argued that there was an improvement in their feeling towards peer questioning.

Fig 5.4 Question 22 (in questionnaire 1) and Question 20 (in the other three questionnaires)



5.1.1.5 Learning with Baroque Music

Meyer *et al.* (1993) promotes that an active learning classroom is one that excites students' interests and encourages their participation. De Porter *et al.* (1992) supported other researchers who sought a way to combine strenuous mental work with relaxed physiology in order to produce excellent learners. She confirmed, after intensive experimentation with students, that music was the key. She, amongst others, postulated that relaxation induced by specific music leaves the mind alert and able to concentrate.

The music found most conductive to this state is baroque music, such as that of Bach, Handel, Pachelbel and Vivaldi. These composers used very specific beats and patterns that automatically synchronise our minds with our bodies. Most baroque music is timed at sixty beats per minute, which is the same as an average resting heart rate. Many contemporary musicians are not able to explain how their peers of three hundred years ago were able to compose pieces with such mathematical precision (Jensen, 1998).
De Porter *et al.* (1992) also theorised that in very left-brain situations, such as studying new material, music awakens the intuitive, creative right brain so that its input can be integrated into the whole process. It is the right brain that tends to be distracted during meetings, lectures, etc., which is why daydreaming and gazing at the view instead of concentrating is sometimes taking place. Playing music is an effective way to occupy your right brain while concentrating on left-brain activities.

In the evaluation form (see Appendix H) at the end of the course, 16% of the students said that background baroque music was new to them and that they did not like it. They preferred it to be quiet in the class, whereas the other 84% either liked the music or were indifferent towards it.

These were some student comments on the Baroque music played in the class (Appendix H):

"Keep the Barok-Music"

"I find the Bach music useful"

From the field notes:

"You did not play the music today? I missed it."

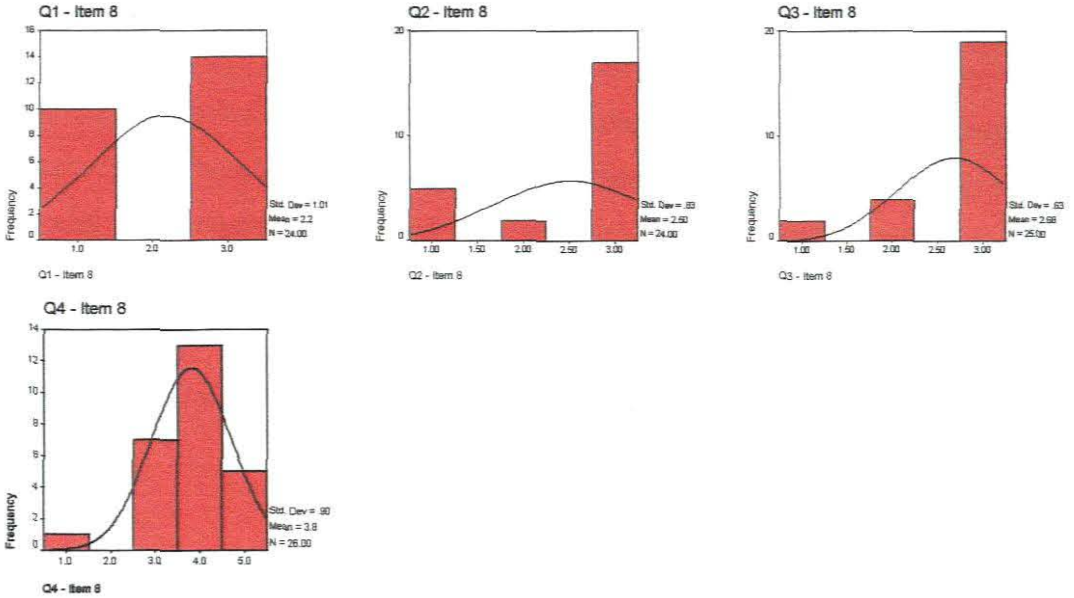
"I enjoy the background music, it helps me to concentrate."

"In the beginning I wasn't sure about the music, but now I got used to it and even like it."

One of Diamond's (1988) studies departed intriguingly from rat brains. She studied Einstein's brain. His brain had been preserved after his death, but no one had yet studied it when Diamond requested four special tissue samples. She was particularly interested in comparing two sections from each hemisphere with the same areas in more average male brains. By the intricate technique of staining cells and counting them under a microscope, she discovered that the brain of this genius was different. In small but critical areas of frontal and parietal lobes, Einstein's brain contained significantly more glial cells per neuron. Diamond (1988) believes this ratio is associated with more vigorous use of these particular areas for higher thinking and reasoning. While the number of neurons does not increase after birth, the support systems grow in response to cognitive demands. What is interesting is that one of Einstein's preferred hobbies was to listen to classical music while working.

If we cross reference question 8 in all the questionnaires (Baroque music in the background helps me to concentrate during a learning session), with Fig 5.5 we can see that in the first questionnaire 42% of the students said the background music was new to them and that they did not like it. In questionnaire 2, 21% felt negative, in questionnaire 3, 8% felt negative with only 4% of the students being negative towards the music played in the classroom in questionnaire 4. It could be argued that more of the students felt positive about the music towards the end of the course than in the beginning.

Fig 5.5 Question 8 (in all four questionnaires)



5.1.1.5.1 Advantages of Baroque Music

Baroque music in the background might keep students alert as well as relaxed as seen from the literature on studies on baroque music in the classroom. According to De Porter *et al.* (1992), there are both beta and alpha brain waves present in Baroque music. The beta brain waves keep the mind highly active and able to concentrate on complex projects, while the alpha brain waves, on the other hand, keep the mind in a state of relaxed alertness. This helps students to concentrate on the task in the class, while at the same time they can be relaxed to maximise the intake of relevant content knowledge. As Healy (1994) points out, melody, processed by the right hemisphere, is a catalyst for creativity in many people, although whether music actually “turns on” or helps integrate parts of the brain has not been proven. A background of baroque music has been claimed to facilitate creative learning and memory. Formal musical training develops more analytical, left-hemisphere abilities.

5.1.1.5.2 Disadvantages of baroque music

When Baroque music was first introduced to the students, it seemed as though they either adapted to it immediately or found it a little disturbing at first. It could also be that the novelty might take their attention away from what was being presented in class at first. This novelty was only preliminary and later wore off, as can be seen from the answers to the questionnaires (Appendix D). More objective research studies need to be conducted on the effect Baroque music has in the classroom in order to see how meaningful it really is.

5.1.1.6 Reading

According to Healy (1994) comprehension must go hand in hand with decoding for good reading. Students without a good base of language and thinking skills have trouble understanding and applying what they read. She also says that some intelligent people do not easily remember words by sight. They need to depend on phonics in order to learn to read, and they learn them best through methods that incorporate all the senses. Reading comprehension is built on mental networks formed throughout childhood from real experiences with the world. Good reading requires intellectual risk taking. A perfectionist environment where mistakes are barely tolerated may inhibit a child's reading development.

The second year students were giving information on speed-reading along with exercises to do to improve their reading times. Some of the students did the exercises and reported an improvement in their reading speed. Other students did not do the exercises and as a result did not improve their reading skills. (38% of the students did not do the reading exercises, 63% did do the exercises and benefited from that.)

Some students' comments on the interview questions (Appendix B) follow:

"The speed reading notes have helped to read a little faster"

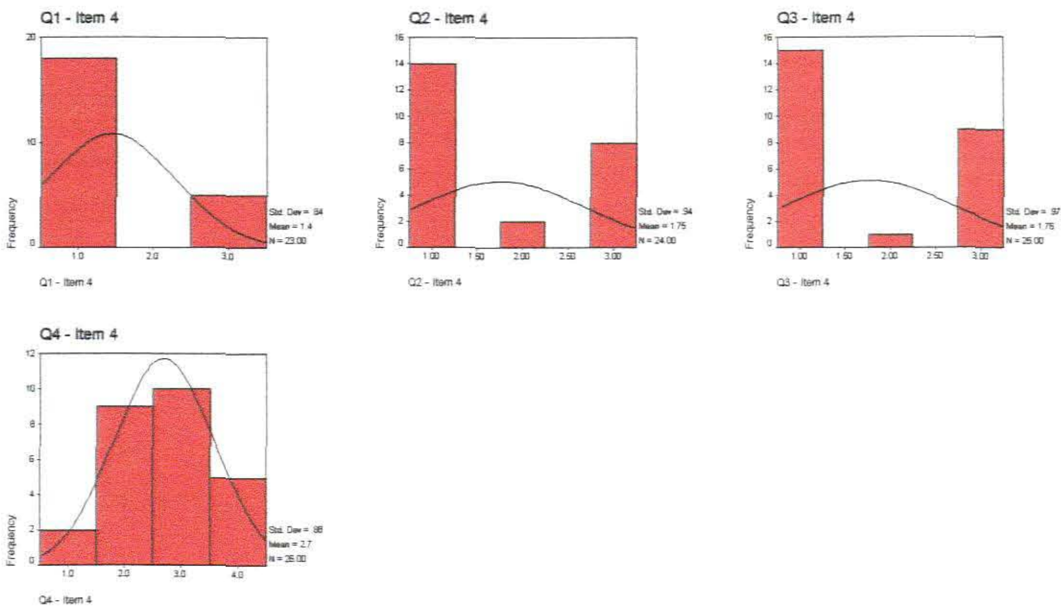
"*I did not really do the speed reading exercises*"

"My reading has improved slightly after the speed reading exercises, but I still need to practise more."

In this subject – Radiation Science II B – students are required to do a great deal of reading on their own. From field notes, interviews and questionnaires it could be seen that they do not like reading very much and definitely do not read beyond what is required of them. Approximately 71% students did not have a well-planned study system, and were not motivated to read actively beyond that which they were instructed to do.

If we cross reference question 4 in all the questionnaires (I read books on Radiation Science) with the histogram – Table 5.6, we can see from questionnaire 1 that a very low percentage (22%) of the students actually read any books on the subject beyond what is required of them. For questionnaire 2 only 33% of the students did extra reading. For questionnaire 3, 36% of the students did extra reading and for questionnaire 4, 42% of the students did extra reading. In the first three questionnaires, the value of 3 is positive and in the fourth questionnaire the value of 1 is strongly agree.

Table 5.6 Question 4 (in all four questionnaires)



Meyers *et al.* (1993) says that preparing students to read effectively should preface active learning strategies. Many students lack basic reading comprehension skills, such as identifying, summarising, and contrasting. Lecturers may have to review these skills, particularly in the first two weeks of class. One significant step toward that goal will be to have good study questions ready.

5.1.1.7 Student-lecturer communication

Communication is an integral part of any classroom, and even more so in a brain friendly environment. Communication is encouraged at every possible opportunity. Taking time to create an interesting physical environment can have the added benefit of settling students down and focusing them on the tasks at hand. Lecturers convey as much to students nonverbally as through their words. Students quickly sense if a lecturer respects their contributions to class or not.

Knowing that students pick up on both our verbal and nonverbal messages can guide us in creating a positive active learning environment. There are many ways to personally communicate a positive classroom tone, and the small investment in time we make for our students will benefit all concerned (Meyers *et al.*, 1993).

These were some student comments (Appendix H) and field notes on communication experiences:

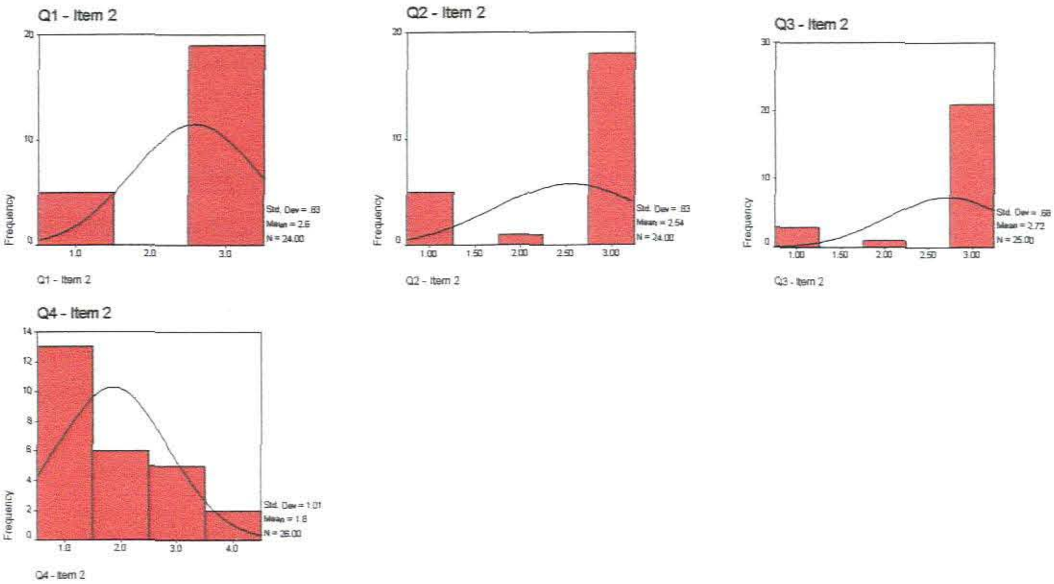
"Much better communication and more student involvement"
"I ask when I do not understand in the class"
I like talking to my friends in the group to sort out problems"

This is a student comment from the interview (Appendix B):

"I talk to the lecturer if I do not understand something"

If we cross reference question 2 in all the questionnaires in Table 5.7, (I speak to the lecturer if I do not understand something) it can be seen from questionnaire 1 that only 17% of the students do not communicate well. In questionnaire 2 it is 21% of the students, for questionnaire 3, 12% and for questionnaire 4 it is 8% of the students. In the first three questionnaires, the value of 3 is positive and in the fourth questionnaire the value of 1 is strongly agree.

Table 5.7 Question 2 (in all four questionnaires)



As Meyers *et al.* (1993) rightly points out, small groups work because they incorporate the key elements of active learning and lend themselves to a variety of purposes. Therefore, we should know what we want students to get out of an exercise – such as practice in summarizing, generating ideas, or comparing and contrasting points of view and how we expect them to interact. We also need to tell them why we are using groups. By talking and listening to one another, and by reflecting in small group discussions, students can clarify their thinking and appreciate the perspectives of others.

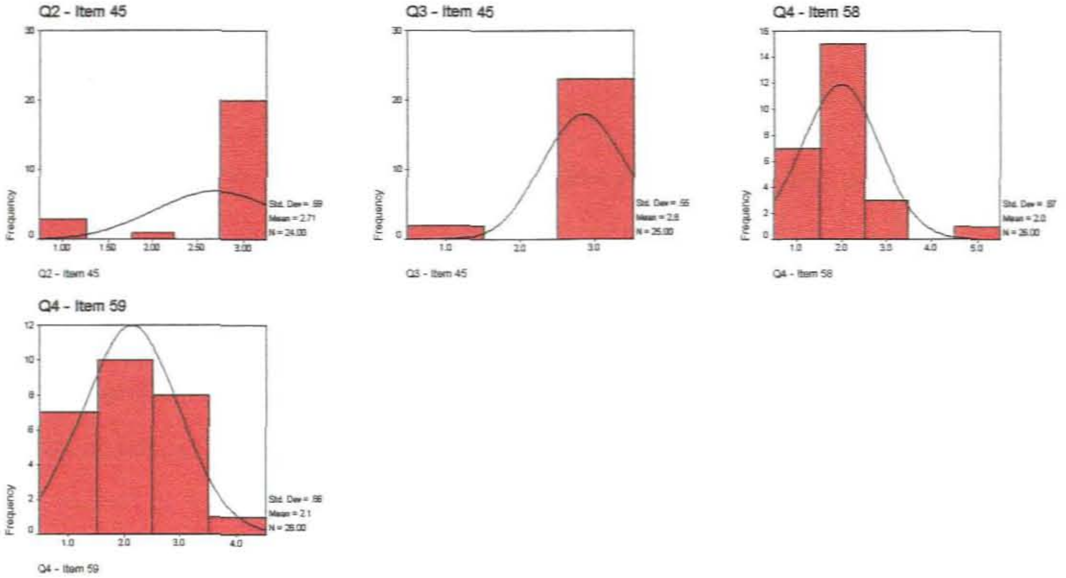
5.1.1.8 Classroom and homework task

The format of the lessons in Radiation Science is such that it is essential for all students to be prepared. They have to prepare the content that will be discussed in the group work lesson. If some students do not prepare well, the load on their peers will be so much harder. In this lesson assessment marks are allocated to the various groups on certain tasks and marks are also allocated for individual students. The group dynamics force the students to a degree to be prepared in order not to let their fellow students down. It is also important for them individually to be prepared, as they have to write a peer set test at the end of the session. In this way students are taught various important building blocks of thinking. Some of these building blocks have been mentioned already under mind mapping. To recapture:

- Approach to task
- Working Memory
- Making comparisons
- Getting the main idea
- Thought integration.
- Connecting events.
- Precision and accuracy.
- Selective attention.
- Problem identification (Greenberg, 1990).

If we look at question 45 in questionnaires 2 and 3 (I am accurate and precise when answering a question or expressing myself in writing or in explaining the solution to problems) and the corresponding questions 58 and 59 in questionnaire 4, it is clear from Table 5.8 that in questionnaire 2, 83% of the students responded positively towards the above question. In questionnaire three, 92% of the students responded positively and in questionnaire 4 for questions 58 and 59, 68% and 92% of the students respectively responded positively to the above question. The value of 3 is positive and in the fourth questionnaire the value of 1 is strongly agree.

Table 5.8 Question 45 (in questionnaires two and three) and Questions 58 and 59 (in questionnaire four)



Some student comments (directly translated from Afrikaans) (Appendix G):

> "Her method (way) she explains the lesson. The atmosphere of the class during class and lessons. The activities she allows us to do to explain and understand the work."
> "Enjoy class very much"

5.1.2 Interviews with students

The student interviews indicate clear patterns of response. The majority of students were keen and committed and generally said complimentary things about Radiation Science. These general responses must be seen in the context of comments students made about their expectations of the course and their attitudes towards study in general. Students expected and wanted advice that would help them. There are obviously students whose comments are at variance with the general trend of responses, but these students are not in the majority.

Ten students were interviewed (see Appendix B2 for the interview schedule). The students' responses to the interview questions were then coded and the discussion below shows the categories which emerged from the coding process.

5.1.2.1 Students' predominantly positive feedback on the course

There are many possible reasons for the students' predominantly positive attitude towards the course; most of these reasons can be grouped together under the head of 'Process issues' (or students' satisfaction with the experience of being on the BCL course) and 'Product issues' (or students' satisfaction with their achievements on the BCL course).

Process issues

For most students, the experience of being in a class where BCL techniques were used was overwhelmingly positive. The BCL is a caring class in which students' well-being and enjoyment of their learning are seen to be important parts of the learning process. Critical theorists believe that lecturers should incorporate teaching and learning strategies that integrate feelings, values, and social skills along with knowledge (Freire, 1970; Rodgers, 1983).

In BCL, the lecturer plays an important role in ensuring that learning is fun and that learning activities are varied. It is not surprising that students should look forward to a class in which they might do a painting of a particular subject-related concept, work through some subject content by putting on a short play, or testing their own skills by setting an assessment task for other students in the class.

Some student comments were (Appendix H):

"Loves to motivate"
"Interesting way of presenting the class"
"She has always new study methods and information processing"

"The lecturers' guidance in improving the creative and learning skills of students."

It could be argued that the variety and alternation kept students' attention span longer, Frequent breaks allowed students to concentrate better and retain the information given better (see Appendix E for lesson plan). As Healy (1990) reminds us, the purpose of attention seems to promote survival and extend pleasurable states. Research has revealed that intentional systems are located throughout the brain and the contrasts of movement, sounds, and emotions consume most of our attention. Chemicals play the most significant role in attention. Healy (1990) in Jensen (1998) explain that the brain generally performs poorly at continuous, high-level attention. Healy and Jensen amongst others, claim that genuine external attention can be sustained at a high and constant level for only a short time, on average it approximately ten minutes or less (Jensen, 1998).

As Scroth (1993) points out, it makes sense to have choice in the learning process, including self-paced learning, and more variety in the strategies used. Variety means that regardless of what students choose, it's the educator's imperative to expose them to a wide variety of methodology (Scroth, 1993). This means rotating individual and group work, drama, music, presentations, self-directed work, computers, guest speakers, and travel to new locations – even if merely to another classroom. According to Scroth (1993) the evidence is overwhelming that enriched environments do grow a better brain (Scroth, 1993).

When a person works in a stimulating and well-organized environment, it is much easier to develop and maintain a positive attitude, and a positive attitude is important for successful learning (Gardner, 1993). Gardener (1993) points out that the goal is to create an atmosphere that induces comfort and relaxation, because it is in a state of relaxed focus that learners concentrate best and are able to learn most easily. Jensen (1998) agrees that tense muscles divert blood supply and thus reduce attention.

In 1967, Diamond (1988) conducted a series of experiments on the brain. She concluded that the more the brain is stimulated by intellectual activity and interaction with the environment, the more connections it makes between cells. She believes that human potential is virtually limitless. Students who participate in BCL will find that learning in this environment become more effective, and therefore more satisfying.

With regard to environmental stimulation, Diamond (1988) believed that the brain cells in the neocortex – where higher cognitive functioning takes place – became larger when environmental changes were introduced in her experiments with rats, which she then correlated to better performance. We can similarly assume that students in the highly stimulating environment of the BCL classroom also achieve enhanced performance.

Product issues

Students' satisfaction with the course extended beyond satisfaction with the process issues; they were also generally satisfied with their performance.

Some student comments were (Appendix H):

"....give homework – keep students on their toes"
"The way the class is divided. (practical part)"
"It is interesting – not so dead. Bach music"

In terms of product issues, students claimed that they found the course 'helpful', 'relevant', and it enabled them to cope better with the academic content. They expressed their satisfaction with their level of understanding of the course. Their overwhelming positive response could be due to the fact that, as borne out by Freire (1970; 1978), learning happens best in a warm, trusting classroom environment, where learners are given choices and allowed to express their creativity. Critical engagement is clearly aligned with brain research and its implication for learning.

Perceived increased understanding of the course could be due to the fact, as borne out by Presseisen's (1990) research, that a person's learning style is a combination of how he or she perceives, and then organises and processes information. When students are familiar with their personal learning styles, they can take important steps to help themselves learn faster and more easily. At the beginning of a learning experience, one of our first steps was to identify the students, learning modality as visual, auditory, or kinaesthetic. Many of the students commented on how the course helped them to know themselves as learners better and thus learn more effectively.

5.1.2.2 Difficulties still experienced on the course

Students' difficulties fall into two categories. There were students who did not enjoy the BCL approach or method – these students are said to have experienced 'methodological difficulties'. There were also students who, despite the BCL techniques employed, continued (for a variety of reasons) to experience difficulty with the content of Radiation Science.

Methodological difficulties

Students, whose personal learning styles are well matched to the teachers' presentation style, learn much more effectively than those who are mismatched. It can be seen from some of the comments that students made (such as not liking the role-play, drama or group work) that there was in some cases a 'mismatch' between teaching style and learning style. (9% of the students responded negatively towards teaching style used)

These were some student comments (Appendix B):

"I do not like role-play"

"I learn from watching the others act, but I do not like doing it myself"

"I learn better on my own – not in a group"

They were obviously more comfortable with other methods of instruction, perhaps more conventional methods of teaching. Gardener (1993), however, claims that it is important to 'challenge' one preferred learning style – which can easily result in sinking into a 'comfort zone'. It is important to cater for different approaches to learning, but equally important to train students to adapt to different styles in order to facilitate development across all the 'multiple intelligences'.

Academic content difficulties

7% of the students interviewed experienced difficulties with the academic content.

These were some student comments from field notes and interviews (Appendix B):

"I find radiation Science hard to learn"
"Radiation science is a lot of work for me"
"There is so much to know and learn – it is quite difficult"

From these and other comments it is clear that this subject is perceived as being difficult for some students. Although they comment positively on the way it is being presented to them, they realise that they still need to cover the content. It could be argued that more research is needed to address this problem adequately. It might be advisable to spend much more time on mind mapping and study skills in the beginning of the year in order for these students to really be able to master the content with more ease - possibly more individual feedback to students and assistance in identifying problems and resolving them in creative ways.

5.1.2.3 Skills learned

In their interviews many of the students make reference to new skills learned on the course – such as note taking, mind mapping, and recognising their preferred learning style.

These were some student comments on skills learned (Appendices B and H):

> "The group work was very nice, thank you."
> "I enjoyed the new way of introducing different learning styles in the classroom. The group activities and fun way of learning"
> "The technique to make the classes so interesting by doing group work"
> "The fact that we work in groups makes the learning so much easier, thank you!"
> " The mind maps helps me to sum my work up"

It would appear that mind mapping works to some extent for some of the students. Buzan (1988) says that mind mapping is a natural memory tool because it uses colour and symbols to create visual images. Visual associations are extremely vivid and make it possible to visually link bits of information (Buzan 1988). The brain often recalls information in the form of pictures, symbols, sounds, shapes and feelings. A mind map uses these visual and sensory reminders in a pattern of connected ideas, like a road map for studying, organising, and planning. It can generate original ideas and easy recall. Mind mapping activates both sides of the brain (Buzan, 1988).

5.1.2.4 Self-knowledge gained

Self-knowledge with regard to learning styles and preferences was gained largely as a result of the consciousness raising process of the brain-friendly methodology. Gardner's (1993) theory of multiple intelligences (MI theory) challenges the prevailing concept of intelligence as a single general capacity which equips its possessor to deal more or less effectively with virtually any situation. As described by Gardner (1983) in *Frames of Mind*, MI theory proposes that people use at least eight relatively autonomous intellectual capacities – each with its own distinctive mode of thinking – to approach problems and create products. He explains that every normal individual possesses varying degrees of each of these intelligences, but the ways in which intelligences combine and blend are as varied as the characters and the personalities of individuals. Gardner's theory of MI provides a theoretical foundation for recognising the different abilities and talents of students. Approaching and assessing learning in this manner allows a wider range of students to participate successfully in classroom learning (Gardner, 1993).

Different researchers have devised different terminologies for describing individual learning styles. According to Presseisen (1990) they generally agree that there are two major ways of learning: first, how we perceive information most easily (modality), and second, how we organise and process that information (brain dominance) (Presseisen, 1990). Presseisen (1990) ventures that a person's learning style is a combination of how he or she perceives, and then organises and processes information. When students are familiar with their personal learning style, they can take important steps to help themselves learn faster and more easily. A detailed plan of a summary of some of the students' comments follow:

Table 5.9 Summary of Students' Comments

THEMES	**SELECT STUDENT STATEMENTS** Students' responses – translated from Afrikaans:	**ANALYSIS OF STATEMENTS**
5.1.2.1 Students'	**Process Issues** "I like the background Baroque music and learn well with it in the	**Process Issues** The background music did not seem to disturb most of the students. They enjoyed the class

predominantly positive feedback on the course;	background." (Student I 10) "I like the variety and alternation; it isn't boring." (Student I 01) "The class atmosphere is 'lekker' and relaxing." (Student I 07) "I enjoy it to do different things and it is very practical." (Student I 09) "I like the Baroque music in the background; it makes me concentrate better." (Student I 03) "I like the group presentations." (Student I 05) "I feel positive. I feel satisfied." (Student I 09)	atmosphere and that might explain the overall improvement of their feeling of positiveness towards the subject. The variety in content presentation could also explain the predominantly positive feedback. Some students even noticed spontaneously when on one occasion there was an absence of baroque music in the background.
	Product Issues "... now I understand it." (Student I 10) "I like to do and see something practical." (Student I 09) "Now I read faster after the lecturers on speed reading." (Student I 08) "The practical way works well for me." (Student I 02) "I write key words down and later build on that." (Student I 09) "I first do a rough framework." (Student I 10)	**Product Issues** It could be argued that some students have gained from the speed reading and that had an overall positive effect on their reading abilities. The practical component has definitely benefited some students. There were many student comments on the practical presentations.

5.1.2.2. Issues that the students still found difficult or 'struggled' with on the course;	**Methodological** "I do not like drama and group work, although I learn from watching the others." (Student I 06) "I do not like the group work." (Student I 04) "I still do not manage the speed reading technique well." (Student I 02) "The Baroque music not so loud/or not at all" (Student S21 Appendix H) **Academic** "I struggle to learn." (Student I 02) "I do not plan" (Student I 04) "I do not understand exactly…." (Student I 06)	**Methodological** There was an overall tendency that most of the students did not particularly enjoy the drama. What did emerge was that they enjoy watching their peers present and felt that they learned from that. There were students who did not work optimally in a group situation. All the different learning styles were accommodated, so it is a given that everybody would not gain from everything. There were also students who found the baroque music interfering with their concentration. **Academic** Despite the brain friendly environment some students still struggle with the content and expressed difficulties with the new presentation of the content.
5.1.2.3 Skills – particularly study skills – which the students had developed;	"Knowledge on speed reading helped – I read a little bit faster now." (Student I 03) "Lecture on note taking helped me to do mind maps – I have my own way to do that" (Student I 08) "The background music was new for me and now I don't really hear it." (Student I 05) "I learn a lot from the other groups" (Student I 07)	Certain skills learned did improve students' perception on what they are capable of.

5.1.2.4 Self-knowledge which the students acquired about their own learning styles and learning preferences	"I am a hearing person. I learn best if I can hear things." (Student I 07) "I am a seeing person… The brain sees pictures. Pictures are important – then the brain store the information better if you want to recall it again." (Student I 10) "I like to see everything in pictures, then I understand it better. Once I can see something, I can learn it better." (Student I 02)	Some of them mentioned that the new knowledge gained on their preferred learning style really made a difference for them. There seems to be a sense of achievement and of satisfaction at the learning achieved on the course.

5.1.3 Observation Charts

The lecturer and independent observers used schedules and free form field notes to record the responses of students during the BCL interventions in class. After studying the schedules and field notes, the following categories emerged, which describe students' responses to BCL techniques in the classroom. The first category is an initial stage of involvement, which is implied by the term 'Interest'. In such a state, the student shows some interest in the task set. A second stage of involvement is termed 'Engagement', which indicates that the student and his/her group have set about engaging with the task and interacting with each other in a learning process. The final, and most intense stage of learning is 'Participation', in which the student is fully involved with the learning task or activity. A detailed plan of a summary of some of the students' comments follows:

5.1.2.4 Self-knowledge which the students acquired about their own learning styles and learning preferences	"I am a hearing person. I learn best if I can hear things." (Student I 07) "I am a seeing person… The brain sees pictures. Pictures are important – then the brain store the information better if you want to recall it again." (Student I 10) "I like to see everything in pictures, then I understand it better. Once I can see something, I can learn it better." (Student I 02)	Some of them mentioned that the new knowledge gained on their preferred learning style really made a difference for them. There seems to be a sense of achievement and of satisfaction at the learning achieved on the course.

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Table 5.10 Summary of Students' Comments

THEMES	FIELD NOTES / OBSERVATIONS	ANALYSIS OF OBSERVATION CHARTS AND FIELD NOTES
Interest in Task	Students' appear interested, lively, attentive, enthusiastic, and the background music seemed to make them more alert. (Average 4). Some students remain silent at first whilst others had no problem raising their voices.	It could be argued that the variety used in presenting the content could have contributed to the interest shown by students. However for the first few observation charts, students appear to be more interested than for the middle charts. There was a rise in interest again for the last few observation charts. To sum up, it would appear that the initial interest levels of the students fell off after a time lapse but that they rose again after another time lapse. This could be due to various reasons.
Engagement with Task	The second category was engagement, – focussing on the content. Students appear to concentrate on the task and seemed to have understood what they were doing. They appeared focused on key points and asked relevant questions. The students looked busy with task assigned to them. (Average 4).	It would appear that the brain friendly environment and the way in which the content was presented, had a positive effect on the students' engagement. They seemed to be able to stay focussed and concentrated on key points. It could be argued that the fact that they only had a certain time period in which the work had to be finished, before presenting it to their peers, influenced their engagement with the task.
Participation	In this last category students appear to be participating as a group. They seem	It could be argued that framing tasks that are achievable, and explaining the reasons for

	to talk about related class work and appeared comfortable enough to give opinions freely. One or two students pulled away from the group a little. They fetched their own desk, putting it close to the group, but at the same time on the periphery. The groups appeared to show creativity and their discussions appeared to involve meaningful content. The students put all the works of art up on the wall after the presentation. (Average 4)	success, reinforce the idea that competence is a process of thought and practice. Participation makes the student willing to cope with new and strange concepts. The excitement of success that is conveyed by participating in a group must not be underestimated. By participating in a group each student are in a way challenged to do better.

5.2 QUANTITATIVE ANALYSIS

The quantitative data generally supports the qualitative findings in terms of students' satisfaction with the course; as well as with their difficulties. The questionnaire data also shed some new light on possible reasons for students' performance in tests or why they enjoyed or did not enjoy particular aspects of the course.

5.2.1 Questionnaires

5.2.1.1 Student Motivation

The quantitative data (refer 4.3.11, p 117) indicates that students were positively motivated about the BCL method of presenting Radiation Science II B. Jensen (1998) says that positive thinking and a belief in self engages the left frontal lobe that usually triggers the release of pleasure chemicals like dopamine as well as natural opiates, or endorphins. This self-reward reinforces the desired behaviour. Jensen (1998) also postulates that extended applications of projects and problem solving, where the process is more important than the answer, is the real reward, not tokens or some other outside reward.

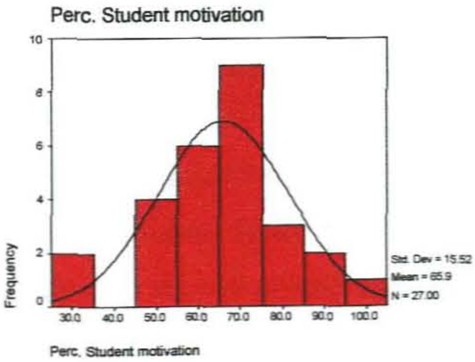
In the class context, the following methods were used to improve self-confidence and develop a positive attitude, in an attempt to increase student motivation:

- When students answer a question – whether the answer is wrong or right – the student is always asked how he/she arrived at this particular answer. Recognition is given for anything relevant that the student says. The student is never put down, ridiculed or told right out that it is the wrong answer.
- Students are encouraged to share their views in a relaxed, friendly atmosphere.
- Students are made to feel that, no matter what they say, their opinion is valued.
- Their art works are put up on the walls of the classroom – giving them a feeling of belonging and giving them a feeling that what they do is important enough to be exhibited.
- The students are allowed to be creative and express their points of view in different forms e.g. art, summarising (getting the main idea), role-play, etc.

De Porter (1992) points out that creating interest is a way of providing students with the motivation to attain their goals. She postulates that creating interest has its intrinsic rewards too. When interest is created in a subject, it will often lead to new interests in other areas. Exploring these new areas could lead to personal fulfilment as well as to other new interests. A chain reaction could thus be created (De Porter, 1992).

Table 5.11 is a histogram superimposed on a normal distribution curve of student motivation. A histogram displays the data in a frequency distribution. The height of each bar is proportional to the frequency of observations. From this table it can be seen that 6 students were 60% motivated, 9 students were 70% motivated, 3 students were 80% motivated. 2 students were 90% motivated and 1 student was 100% motivated according to the results of the questionnaires. From this information it could be argued that 78% of the students were motivated 60% and above by this new approach to teaching Radiation Science.

Table 5.11 Percentage Student Motivation



5.2.1.2 *Communication and Feedback*

In any conversation, in either oral or written form, partners in the communication process decide and plan what they will convey to each other. Speakers and listeners continually adapt as the conversation proceeds. Meanings are derived from the way in which speakers assign attributes or emphasis (Kozulin *et,al.,* 2000).

According to the NLP theorists (Andreas and Andreas, 1987. Bandler, 1990) getting and receiving feedback in a supportive way is the key to learning. Receiving feedback on one's work is always difficult, and it is to be expected that students would not generally appreciate feedback that is critical. It is a mark of the BCL approach that students on the Radiation Science course regarded feedback in a positive light.

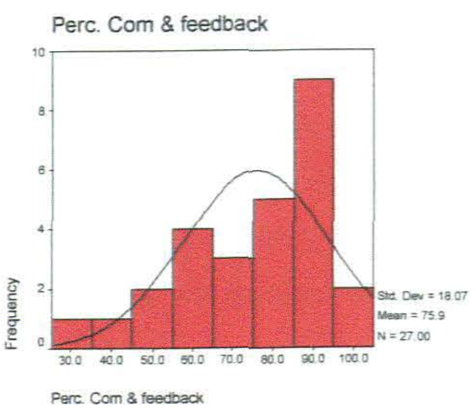
These are some of the questions that were grouped as communication and feedback (Refer to Appendix D):

> I speak to the lecturer if I do not understand something.
> (First questionnaire, question 2)

I enjoy getting feedback at the end of every chapter.
(Second questionnaire, question 9)
I am accurate and precise when answering a question or expressing myself in writing or in explaining the solution to problems.
(Third questionnaire, question 45)
I communicate answers clearly. (Fourth questionnaire, question 56)
I communicate answers effectively. (Fourth questionnaire, question 57)

Table 5.12 is a histogram superimposed on a normal distribution curve of classroom communication and feedback. From this graph, classroom communication and feedback appears to be skewed towards the positive of the normal distribution. This indicates that 23 students ($\therefore$85% of the total number of students) felt 60% and above, that classroom communication and feedback were important: 4 students at the 60% level, 3 students at the 70% level, 5 students at the 80% level, 9 students at the 90% and 2 students at the 100% level according to the results of the questionnaires). It is clear from this data that feedback is very important to students, and that it stayed positive throughout. (In the first three questionnaires, the value of 3 is positive and in the fourth questionnaire the value of 1 is strongly agree). The SPSS programme was used to do the statistical analysis.

Table 5.12 Percentage Communication and Feedback



From the information in Table 5.12 it could be argued that students feel strongly about feedback and effective communication. As previously pointed out, learner feedback should be maximised to enable quality learning. Because feedback reduces uncertainty, it increases coping abilities while lowering the pituitary-adrenal stress responses (Hennessy *et al.*, 1997).

Hennessy *et al.* (1997) argue that the brain is designed to operate on feedback, both internal and external. What is received at any one brain level depends on what else is happening at that level. In other words, our whole brain is self-referencing. It decides what to do, based on what has just been done. There are several conditions that make feedback more effective. The reaction must, however, be specific and not general (Hennessy *et al.*, 1997).

In a practical context, this was achieved in the following way in the classroom situation:

- Feedback was constructive
- Feedback was meaningful to the students
- Feedback was given as soon as possible
- Feedback was also given by peers on certain tasks

5.2.1.3 Information Gathering, Planning Strategies, Problem Solving and Task Approach

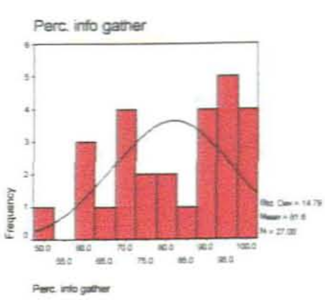
Some students make a slow start, and became distracted from the main focus, but overall looking at the quantitative data in Table 5.12, it seems that the students have gained some insight into problem solving skills by working with their peers in groups. It can thus be argued that the new approach could have a positive influence on the students' information gathering and planning strategies.

The following are examples of the type of questions in this category:

> I generally am able to identify a problem and describe it clearly.
> (Second questionnaire, question 29)
> I am able to apply rules to make new associations and insights.
> (Second questionnaire, question 34)
> I am able to formulate a rule from a number of examples.
> (Third questionnaire, question 37)
> I construct a plan in order to solve problems. (Fourth questionnaire, question 45)
> I think ahead before attempting an answer. (Fourth questionnaire, question 54)
> I use a strategy before attempting an answer. (Fourth questionnaire, question 55)
> (Refer to Appendix D)

Table 5.13 is a histogram superimposed on a normal distribution curve of information gathering, planning strategies, problem solving and task approach. From this graph, information gathering, planning strategies, problem solving and task approach appear to be heavily skewed towards the positive of the normal distribution. This indicates that 26 students (∴96% of the total number of students) were 60% and above in favour of classroom information gathering, planning strategies, problem solving and task approach: (3 students at the 60% level, 1 student at the 65% level, 4 students at the 70% level, 2 students at the 75% level, 2 students at the 80% level, 1 student at the 85% level, 4 students at the 90% level, 5 students at the 95% level and 4 students at the 100% level, according to the results of the questionnaire).

Table 5.13 Percentage Information Gathering, Planning Strategies, Problem Solving and Task Approach



As borne out by Healy (1990), some researchers have found that an area of the mid-brain involved in attentional processing, the superior colliculus, grew 5 – 6 % more in an enriched environment. The single best way to grow a better brain is through challenging problem solving. This creates new dendritic connections that allow us to make even more connections. The implication here is that it is critical to expose students to a variety of approaches to solving problems (Healy, 1990).

When students feel more capable of solving a problem, their thoughts are able to change their body's chemistry. The neural growth happens because of the process, not the solution. More intelligent people work their brains harder initially, then they don't have to work so hard later on. There is also a much higher consumption of glucose while learning something new as compared to when the task is mastered. At the level of mastery, the brain is coasting (Healy, 1990).

5.2.1.4 Learning Environment

The quantitative data support the qualitative data in showing that the students appreciated the rich learning environment that was created through the BCL activities.
Across the four questionnaires, there were a series of questions – such as those below – which relate to learning environment.

> I find the classroom's atmosphere comfortable and relaxing.
> (All the questionnaires, question 6)
> I have a place in my home where I can make a space for work and creative.
> (All the questionnaires, question 7)
> Baroque music in the background helps me to concentrate during a learning session. (All the questionnaires, question 8)
> (Refer to Appendix D)

Table 5.14 below indicates that the students' responses towards the learning environment were predominantly positive, as the highest frequency is at the 80% level. Thus confirms the findings of Gardner (1993) and Jensen (1998). They advocate that when a person works in a stimulating and well-organised environment, it is much easier to develop and maintain a positive attitude, and a positive attitude is important for successful learning. Gardener (1993) points out that the goal is to create an atmosphere that induces comfort and relaxation, because it is in a state of relaxed focus that learners concentrate best and are able to learn most easily. Jensen (1998) agrees that tense muscles divert blood supply and thus reduce attention.

Table 5.14 Percentage Learning Environment

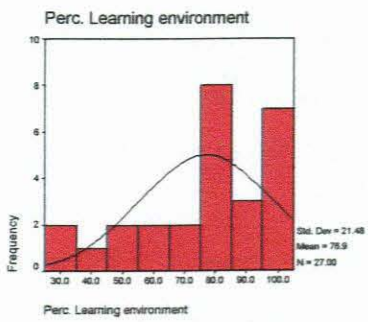


Table 5.14 is a histogram superimposed on a normal distribution curve of the learning environments. From this graph, learning environment appears to be heavily skewed towards the positive of the normal distribution. This indicates that 22 students ($\therefore$ 81% of the total number of students) were 60% and above positive towards a relaxed, enriched learning environment: (2 students at the 60% level, 2 students at the 70% level, 8 students at the 80% level, 3 students at the 90%level and 7 students at the 100% level according to the results of the questionnaires).

The students had put all their art work on the classroom walls, as borne out by Healy, (1990) who says that the implications of recent research on creativity suggests that introducing art-based activities into the learning environment builds creativity, concentration, problem solving, self-efficacy, coordination and values attention and self-discipline. By learning and practising art, the human brain actually rewires itself to make more and stronger connections (Healy, 1990). Analysing the collected data in table 5.14, it is clear that taking the time to create an interesting physical environment can have the added benefit of setting students at ease / relaxing them in order to focus on the tasks at hand.

5.2.1.5 Learning Styles, Personal Beliefs and Self-Knowledge

The quantitative data supports the qualitative findings with regard to how students developed self-knowledge. We can thus argue that BCL could have a positive influence on students' learning styles.

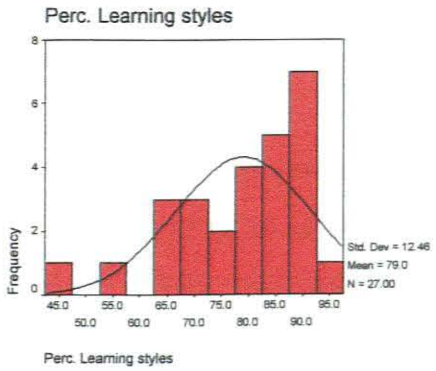
From the histogram (Table 5.15 below) it can be seen that the category on learning styles, self-knowledge and personal believes has a positive outcome, as a direct result of the BCL programme employed.

Across the four questionnaires, there were a series of questions – such as those below – which relate to learning styles, personal beliefs and self-knowledge.

I know what my learning style is. (First questionnaire, question 11)
I know how to focus on key points / issues. (First questionnaire, question 12)
I know what the R brain and the L brain thinking modes are.
(Second questionnaire, question 14)
I learn most with group work. (Third questionnaire, question 18)
I connect new information to prior knowledge. (Fourth questionnaire, question 12)
(Refer to Appendix D)

From the graph (Table 5.15) learning styles, personal beliefs, and self-knowledge appear to be heavily skewed towards the positive of the normal distribution. This indicates that 25 students (∴ 93% of the total number of students) were 65% and above positive that learning styles, personal believes and self-knowledge were important: (3 student at the 65% level, 3 students at the 70% level, 2 students at the 75% level, 4 students at the 80% level, 5 student at the 85% level, 7 students at the 90%level and 1 student at the 95% level, according to the results of the questionnaire).

Table 5.15 Percentage Learning Styles, Personal Believes and Self-Knowledge



Rose (1985) said that within the last 5 – 6 years a number of researchers have established the importance of three principle forms of communication between human beings, and demonstrated that these communication styles are mirrored by learning styles.

Grinder (1990) has been one of the principle researchers of learning styles. His main conclusion was that each person has a dominant sensory system. At first sight the analysis may seem obvious – but the implications are significant. Grinder (1990) said if you want to communicate with someone who is highly visual, he/she would find a lesson that consists only of an audiotape tedious and unsatisfying. Conversely, an auditory learner will benefit less from a presentation that relies purely only with your preferred sense. How you present something is often as important as what you say – and indeed may determine whether it is understood at all. Nonverbal influence has an actual influence of up to 55%.

Rose (1985) says that by matching the teaching approach with the preferred learning approach, we are able to establish a more direct, sympathetic and clear communication. In a real sense, the teacher and pupil are "speaking the same language."

5.2.2 Class Test Marks 2002 and 2003

Three outcome marks were available. The marks for 2003 showed that students performed significantly better compared to the previous years' students.

In previous years, the students wrote 3 formal tests, covering the whole syllabus, and two assignments on certain aspects of the syllabus. The two marks obtained from the assignments were combined and resulted in the fourth mark. In this study, only the 3 formal test marks of 2002 were used. They were compared to the first three marks obtained in 2003. The weighting of all the marks was exactly the same. Each marks weighs 25% of the year-end mark. However, the marks for 2003 were obtained slightly differently.
An assessment mark (still weighing 25%) was obtained in the following way:

70% was a mark for a written test on the course work.
10% was a mark given for group work
10% was a mark given for homework done, in other words how prepared they were for the group sessions.
10% was a combination of all the written class tests, set by their peers.

The lecturer felt that this flexibility is important as students often have some difficulties and anxieties associated with a particular form of expression. In this way, more learning styles can be accommodated.

The curriculum objectives for Radiography reflect a desire that students should develop certain intellectual skills above and beyond those associated with the accumulation of

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The curriculum objectives for Radiography reflect a desire that students should develop certain intellectual skills above and beyond those associated with the accumulation of factual knowledge. These would include the ability to integrate knowledge and to use it for effective, clinical problem solving. BCL might enhance the development of such skills.

The 2003 results could offer tentative support for further experimental interventions which adopt a BCL approach to improving learning and teaching in Radiation Sciences. Such an approach could entail attention to teaching and assessment and recognition that activities designed to improve student learning are properly seen as part of the process of teaching academic content.

5.2.2.1 Class Test 1 2003

There was a significant improvement from class test 1 2002 (mean: 57%) and class test 1 2003 (mean: 70%).

Table 5.16 Class test 1 2003

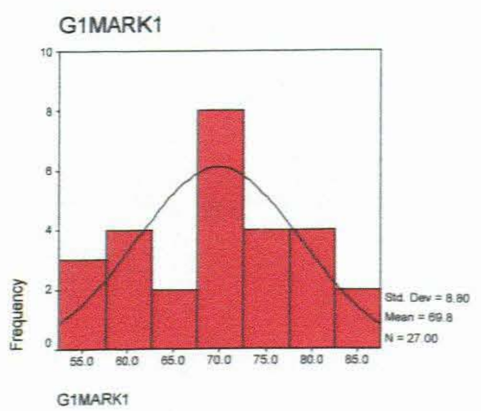


Table 5.17 Normal P-Plot of Class test 1

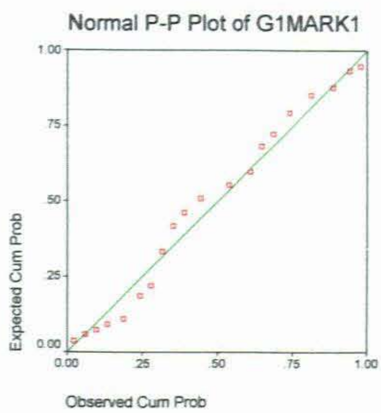


Table 5.16 shows that class test 1 (2003) appears to follow the normal distribution, with the histogram skewed towards the positive, with the highest frequency at the 70% level. The standard deviation is 8.8 with the mean at 69.8 (N= 27). This would indicate that 24 students ($\therefore$ 89% of the total number of students) obtained a mark of 60% and above in

class test 1 (2003): 4 students obtained a mark of 60%, 2 students obtained a mark of 65%, 8 students obtained a mark of 70%, 4 students obtained a mark of 75%, 4 students obtained a mark of 80% and 2 students obtained a mark of 85%.

The P-Plot (Table 5.17) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 1 outcomes and the observed class test 1 outcomes, correlates positively.

5.2.2.2 Class Test 2 2003

There was a significant improvement from class test 2 in 2002 (mean: 51%) to class test 2 in 2003 (mean: 64%).

Table 5.18 Class test 2 2003

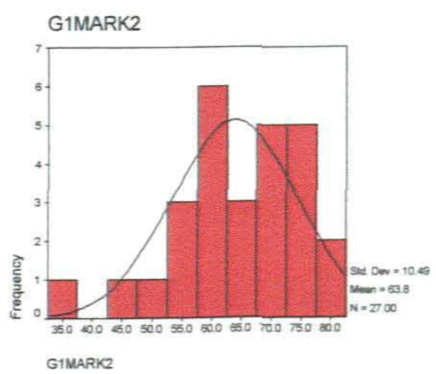
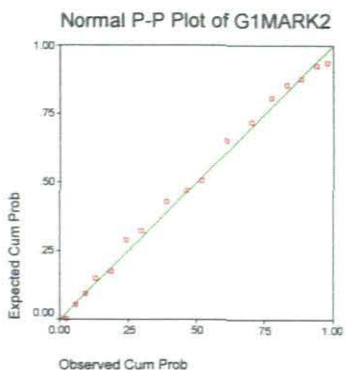


Table 5.19 Normal P-Plot of Class test 2



We can thus argue that BCL techniques had a positive influence on class test 2. Class test two 2003 shows a 2% difference between the mean and the mode. The standard deviation is 10.5. The frequency falls between 36% and 80%.

Table 5.18 shows that class test 2 (2003) appears to follow the normal distribution, with the histogram skewed extremely towards the positive, with the highest frequency at the 60% level. The standard deviation is 10.49 with the mean at 63.8 (N= 27). This would indicate that 21 students (∴ 78% of the total number of students) obtained a mark of 60% and above in class test 2 (2003): 6 students obtained a mark of 60%, 3 students obtained a mark of 65%, 5 students obtained a mark of 70%, 5 students obtained a mark of 75% and 2 students obtained a mark of 80%.

The P-Plot (Table 5.19) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 2 outcomes and the observed class test 2 outcomes correlates positively.

5.2.2.3 Class Test 3 2003

There was a significant improvement from class test 3 in 2002 (mean: 69%) to class test 3 in 2003 (mean: 78%).

Table 5.20 Class test 3 2003

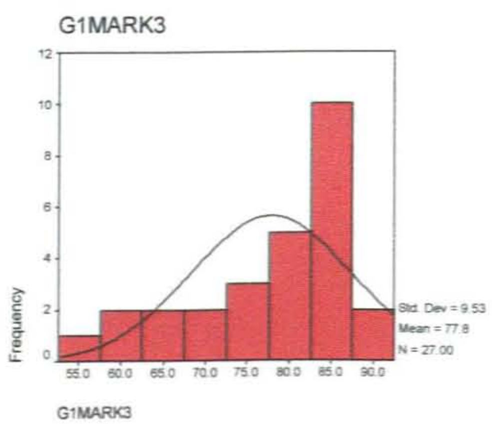
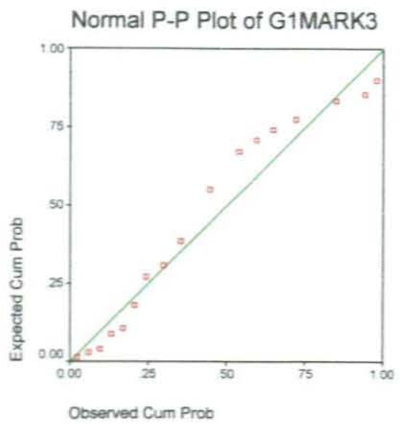


Table 5.21 Normal P-Plot of Class test 3



We can thus argue that BCL techniques had a positive influence on class test 3. Class test 3 in 2003 shows a 1% difference between the mean and the mode. The standard deviation is 9.5. The frequency falls between 57% and 90%.

Table 5.20 shows that class test 3 (2003) appears to follow the normal distribution, with the histogram skewed extremely towards the positive, with the highest frequency at the 85% level. The standard deviation is 9.53 with the mean at 77.8 (N= 27). This would indicate that 26 students (∴96% of the total number of students) obtained a mark of 60% and above in class test 3 (2003): 2 students obtained a mark of 60%, 2 students obtained a mark of 65%, 2 students obtained a mark of 70%, 3 students obtained a mark of 75%, 5 students obtained a mark of 80%, 10 students obtained a mark of 85% and 2 students obtained a mark of 90%.

The P-Plot (Table 5.21) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 3 outcomes and the observed class test 3 outcomes correlates positively.

5.2.2.4 Class Test 1 2002

Class test one 2002 shows a 10% difference between the mean and the mode. The standard deviation is 17.3. The frequency falls between 21% and 87%.

Table 5.22 Class test 1 2002

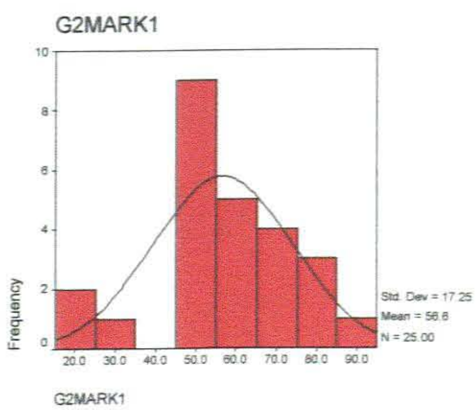


Table 5.23 Normal P-Plot of Class test 1

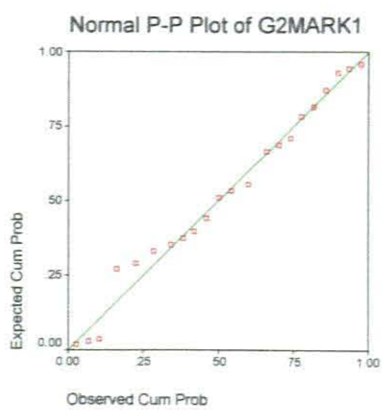


Table 5.22 shows that class test 1 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 50% level. The standard deviation is 17.25 with the mean at 56.6 (N= 25). This would indicate that 13 students (∴52% of the total number of students) obtained a mark of 60% and above in class test 1 (2002): 5 students obtained a mark of 60%, 4 students obtained a mark of 70%, 3 students obtained a mark of 80% and 1 student obtained a mark of 90%.

The P-Plot (Table 5.23) indicates a high positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 1 (2002) outcomes and the observed class test 1 (2002) outcomes correlates positively.

5.2.2.5 Class Test 2 2002

Class test two 2002 shows a 7% difference between the mean and the mode. The standard deviation is 17.3. The frequency falls between 19% and 94%.

Table 5.24 Class test 2 2002

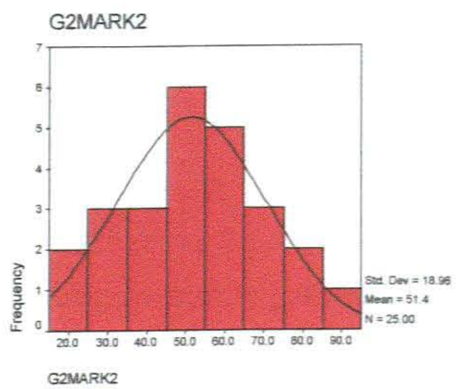


Table 5.25 Normal P-Plot of Class test 2

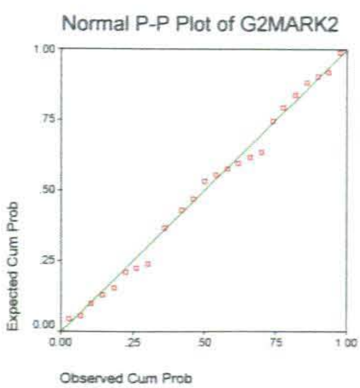


Table 5.24 shows that class test 2 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 50% level. The standard deviation is 18.96 with the mean at 51.4 (N= 25). This would indicate that 11

students (∴44% of the total number of students) obtained a mark of 60% and above in class test 2 (2002): 5 students obtained a mark of 60%, 3 students obtained a mark of 70%, 2 students obtained a mark of 80% and 1 student obtained a mark of 90%.

The P-Plot (Table 5.25) indicates a positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 2 (2002) outcomes and the observed class test 2 (2002) outcomes correlates positively.

5.2.2.6 Class Test 3 2002

Class test 1 in 2002 shows a 16% difference between the mean and the mode. The standard deviation is 16.8. The frequency falls between 10% and 90%.

Table 5.26 Class test 3 2002

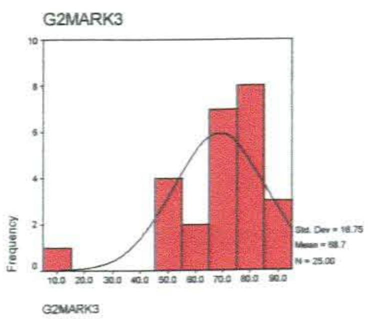


Table 5.27 Normal P-Plot of Class test 3

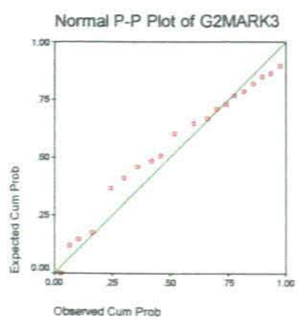


Table 5.26 shows that class test 3 (2002) appears to follow the normal distribution, with the histogram skewed positively, and the highest frequency at the 80% level. The standard deviation is 16.75 with the mean at 68.7 (N= 25). This would indicate that 20 students (∴80% of the total number of students) obtained a mark of 60% and above in class test 3 (2002): 2 students obtained a mark of 60%, 7 students obtained a mark of 70%, 8 students obtained a mark of 80% and 3 students obtained a mark of 90%.

The P-Plot (Table 5.27) indicates a positive correlation; the dots are closely packed around the line, indicating that the relationship between the expected class test 3 (2002) outcomes and the observed class test 3 (2002) outcomes correlates positively.

5.3 PROGRAMME EVALUATION

The analysis of this study involved the impact that BCL might have on both subject matter knowledge and cognitive knowledge. The overall perspective of learning and teaching should always be considered when providing BCL in the classroom. Without it BCL will have little meaning.

This study of a BCL environment seems to have a positive outcome, given that the following were among some of the outcomes achieved:

- Improved motivation
- Improved self-confidence
- Improved academic performance, etc.

Learning to think creatively is a process of making links. Healy (1994) reminds us that this process of making links is between movement and the senses, then between ideas, and finally between the human mind's most sophisticated achievements – inspiration and evaluation. At the heart of the system are the chains of neurons, which make the connections. Although we have a great deal yet to learn about the brain's role in creativity, the gradual development of neurons' ability to "talk" among themselves probably explains a great deal about all intellectual talents.

Additional studies might offer new perspectives as to the lecturer's role in BCL and lecturer training processes. Teaching is a highly complex activity.

CHAPTER 6

CONCLUSION

BCL may provide a programme that could fulfil the function of setting up a learning environment which is conducive to effective learning for individual students, as well as for groups of students. The responsibility for the effectiveness of learning, from discussions in the group activities, amongst others, lies with the students, rather than with the teaching team. It could be argued that those interested in student learning should be ready to exert their own influence on the institutional context and be willing and ready to create a favourable environment for the sorts of activities believed to be *beneficial for high quality in student learning.*

6.1.1 Recommendations

This study raises several questions regarding issues for further research. More comprehensive assessment procedures need to be followed up and implemented. Follow-up studies of classroom applications and infusion of BCL thinking skills into the curriculum need to be done on a bigger scale, i.e. in other subjects and/or courses in order to assess its implications more fully.

In the future more time could perhaps be spend on the following:

- Planning and preparing students for the different learning styles in order for students to really get to know their preferred learning style.
- Creating space for student reflection on the new brain friendly learning approach
- Feedback and monitoring from lecturer on students' progress
- Feedback from peers

Language is a vital and integral component of cognitive development. The issue of introducing thinking skills in multi-lingual settings should therefore also be an area for further research.

The BCL programme provides a framework for lecturers to think about their own teaching and apply BCL techniques and principles in teaching. This observation suggests the need for follow-up studies of classroom applications which were not provided for in this study. Ongoing research could provide an opportunity to focus on process variables. This would require keeping records of exactly what happens and an analysis of how interactions occur in the classroom.

6.1.2 Limitations

There are situations where action research would be too time consuming compared to other methods that lead to the same results. For example, if the answers to a problem are already known and are either right or wrong; if knowledge is programmable (e.g. computer packages) or if it can be obtained faster by other means.

Thus action research is not the panacea for all problems, but it is appropriate in an uncertain environment for solving problems in complex situations in which the answers are not simple or not known to be right or wrong (Zuber-Skerritt, 1992).

Other limitations might be perceived by lecturing staff who argue that collaborative enquiry into learning and teaching problems is disadvantageous because of time constraints and a lack of institutional rewards for educational action research activities. However, this argument is bureaucratic and self-defeating. Zuber-Skerrit (1992) argues that lecturers in higher education need to control their own practice as true professionals, this they do by displaying a critical, enquiring attitude, and by researching and justifying the academic value of their practice through continuing self-evaluation and professional development. Unless they do these things, their own existence and that of their institution could be jeopardised (Zuber-Skerritt, 1992).

6.2 FUTURE RESEARCH

It is apparent that there is a need for more comprehensive assessment procedures for assessing cognitive change. Although interpretations from the data have proved useful, there is a need to further explore and devise better techniques which could be more sensitive or more finely-tuned to changes in cognitive processing.

BCL might therefore provide a framework for lecturers on which to base their own ideas and thereby it might enable them to develop their own solutions to particular teaching and/or learning problems.

6.3 SUMMARY

There is a need and scope for further research in BCL and continuing development in the area of improving practice in higher education. I hope that this study will stimulate many academics and staff developers to follow a similar path.

Possible conclusions drawn from this study are:
There might be considerable strengths in the BCL.
The range of teaching methods could be considered as imaginative and provide a variety of learning opportunities.
BCL might succeed generally in providing students with both the thorough grounding in core areas and the practical and analytical skills that are at the heart of this revised programme in Radiation Science II B.

In broad terms, it appears that the curriculum might be planned so that not only does it define the structure and content of the course, but it also provides opportunities for students to participate in activities which encourage and enhance the development of a deep versatile approach.

BCL might fulfil the function of setting up a learning environment which could be conducive to effective learning for individual students as well as for groups of students, and in which the responsibility for the effectiveness of learning from discussion in group activities lies with students, rather than the lecturer.

To summarise what Rose (1985) said:

> "Learning is maximised when all the elements are focussed on the learning process. Since possibly up to 90% of communication is at the subconscious level, the greater the number of subconscious stimuli that are orchestrated to aid learning, the faster and more effective is that learning. Such learning has been characterised as intuitive learning. Some ways this can be achieved are:
>
> - By using a side-by-side presentation of text which takes advantage of peripheral vision.
> - By incorporating background music. This appeals to the subconscious through rhythm and through emotive associations.
> - By acting out roles, which distract your attention and allows information to be indirectly and subconsciously assimilated.
> - By providing information on cards and posters around the room which is subconsciously noted and stored.
> - By teaching in stories, the subject content can be indirectly absorbed.
>
> Imaging and articulation of new material is a powerful memory creating device. Presenting each lesson to the student in the tree sensory channels – Visual. Auditory and Kinaesthetic – ensures that the presentation is in a style which the student learns best, and that all three senses are coordinated to make learning highly effective. It also enables the student to deliberately extend the use of his senses."

"The aim of education shall be to teach the youth to love their people and their culture, to honour human brotherhood, liberty and peace;
Education shall be free, compulsory, universal and equal for all children:"

The Freedom Charter

As adopted at the Congress of the People on 26 June 1955

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APPENDICES

APPENDIX A

MODULE 1

SPECIFIED OUTCOME	ASSESMENT CRITERIA
1. Concepts of Radiological Science	Describe the characteristics of matter & energy Identify the various forms of energy Define electromagnetic radiation & specifically ionising radiation State the relative intensity of ionising radiation from various sources Relate the accidental discovery of X-Rays by Roentgen Discuss examples of human injury caused by radiation List the concepts of basic radiation protection
2. Mathematics and Terminology for Radiology	Calculate problems using fractions, decimals, exponents, and algebraic equations Identify scientific exponential notation and the associated prefixes List and define units of radiation and radioactivity
3. Fundamentals of Physics	Discuss the derivation of scientific systems of measurement List the three systems of measurement Identify nine categories of mechanics
4. The Atom	Relate the history of the atom Identify the structure of the atom Describe electron shells and instability within atomic structure Discuss radioactivity and the characteristics of α and β particles Explain the difference between two forms of ionising radiation: particulate and electromagnetic

5. Electromagnetic Radiation	Identify the properties of photons Explain the inverse square law Define wave theory and the quantum theory Discuss the electromagnetic spectrum
6. X-Ray Production	Discuss the interaction between projectile electrons and the x-ray tube target Describe characteristic and bremstrahlung x-ray production Describe the x-ray emission spectrum Explain how milliampere-second, peak kilovoltage, added filtration, target material, and voltage ripple affect the x-ray emission spectrum
7. X-Ray Emission	Define radiation quantity and its relation to intensity List and discuss the factors affecting the intensity of the x-ray beam Explain x-ray quality and penetrability List and discuss the factors affecting the quality of the x-ray beam
8. X-Ray Interaction with Matter	Describe each of the five x-ray interactions with matter Define differential absorption and its effect on image contrast Explain the effect of atomic number and the mass density of tissue on differential absorption Discuss why radiological contrast agents are used to image some tissues and organs Explain the difference between absorption and attenuation

MODULE 2

SPECIFIED OUTCOME	**ASSESMENT CRITERIA**
1. Health Physics	Define health physics List the cardinal principles of radiation protection and discuss the ALARA concept Explain the purpose of the National Council on Radiation Protection and Measurements Name the recommended dose limits observed for radiation workers and the public Discuss the radio-sensitivity of the stages of pregnancy Describe the recommended management procedures for pregnant radiation workers and for the pregnant patient
2. Designing for Radiation Protection	Name the leakage radiation limit for x-ray tubes List the radiation protection features of a radiographic imaging system List the radiation protection features of a fluoroscopic imaging system Discuss the design of primary and secondary radiation barriers Describe the types of radiation dosimeters used in radiography
3. Radiation Protection Procedures	Discuss the units and concepts of occupational radiation exposure Indicate three ways that patient dose can be reported Describe the intensity and distribution of radiation dose in mammography and computed tomography Discuss ways to reduce occupational radiation exposure Explain occupational radiation monitors and the places where they should be positioned Discuss personnel radiation monitoring reports List the available thickness of protective apparel

	Discuss the principles of "as low as reasonably achievable" that are applied to patient radiation safety Identify screening x-ray examinations that are no longer routinely performed Discuss the various technical factors affecting patient radiation dose Explain when to use gonadal shields

MODULE 3

SPECIFIED OUTCOME	ASSESMENT CRITERIA
1. Human Biology	Discuss the cell theory of human biology List and describe the molecular composition of the human body Explain the parts and function of the human cell Describe the processes of mitosis and meiosis Evaluate the radio sensitivity of tissues and organs
2. Fundamental Principles of Radiobiology	State the law of Bergonie and Tribondeau Describe the physical factors affecting radiation response Describe the biological factors affecting radiation response Describe the chemical factors affecting radiation response Explain dose-response relationships List and describe the types of dose-response relationships
3. Molecular and Cellular Radiobiology	Discuss the three principal effects of in vitro irradiation of macromolecules Explain the effects of radiation on DNA macromolecules Identify the chemical reactions involved in the radiolysis of water Describe the effects of *in vitro* irradiation Describe the principles of the target theory of radiobiology Discuss the kinetics of human cell survival after irradiation

4. Early effects of Radiation	Describe the three acute radiation syndromes Identify the two stages leading to acute radiation lethality Define $LD_{50/60}$ Discuss local tissue damage after high-dose irradiation Explain the early radiation effects on the hemopoietic system Review the cytogenetic effects of radiation exposure
5. Late effects of Radiation	Define the late effects of radiation exposure Identify the radiation dose needed to produce late effects Discuss the results of epidemiological studies of people exposed to radiation List the local tissue effects of low-dose radiation to the skin, chromosomes, and cornea Explain the estimates of radiation risk Analyse radiation-induced leukaemia and cancer Review the risks of low-dose radiation to fertility and pregnancy
6. Biological effects of Ultrasound	Define the biological effects of ultrasound

APPENDIX B1

INTERVIEW

1. What do you enjoy most about radiation science?
2. What do you enjoy least about radiation science?
3. How would you describe your attitude towards radiation science?
4. How would you describe your learning style? (e.g. do you like music to work by, silence, working in team/individually….etc)
5. Does radiation science suit your particular learning style? Why/why not…
6. Do you have a quiet work environment?
7. Do you know what interferes with your concentration and eliminate it?
8. Did the new knowledge on speed-reading help you to read faster?
9. Do you know how to take effective notes?
10. Do you think this way of learning radiation science can also be implemented in other radiography subjects?
11. How do you organize and process information the most easily:
    - Through seeing (visual) (follow the illustrations?)
        - Do you doodle when you talk on the phone?
        - Do you speak quickly?
        - Would you rather see a map than hear directions?
    - Through hearing (auditory) (have someone talk you through it?)
        - Do you talk to yourself?
        - Do you prefer a lecture or seminar to reading a book?
        - Do you like talking more than writing?
    - Through moving, doing, and touching (kinesthetic) (start putting it together yourself?)
        - Do you think better when you are moving and walking around?
        - Do you gesture a lot while speaking?
        - Do you find it hard to sit still?
12. How do you plan your projects, assignments, etc?
13. What helps you to learn a topic in radiation science?
14. Describe the process that you go through when you want to solve a problem (eg.----)
15. Describe to me how you think the brain works in the learning process…
16. Do you make use of what you know about how the brain works…?
17. Do you take many breaks when studying?
18. How many times do you review your material?
19. If you have to do some reading for an assignment, describe how you read,
20. Do know what lateral thinking is?
21. Do you know what outcome thinking is?
22. Do you know what creative thinking is?
23. Do you know what vertical thinking is?
24. Do you know what critical thinking is?
25. Do you know what strategic thinking is?
26. Do you know what analytical thinking is?
27. Do you know what it means to be 'stuck in a paradigm'?

APPENDIX B2

INTERVIEW SCHEDULE

DATE	STUDENT
17.02.03	Student I 01
17/02/03	Student I 02
24/02/03	Student I 03
24/02/03	Student I 04
24/03/03	Student I 05
19/05/03	Student I 06
19/05/03	Student I 07
01/09/03	Student I 08
01/09/03	Student I 09
01/09/03	Student I 10

APPENDIX C1

OBSERVATION CHART

QUESTIONS	No/or not engaged 1	2	3	4	Yes/or extremely engaged/active 5
The students appear interested.					
The students appear to be concentrating on the task.					
The students appear lively.					
The students appear distracted					
The students appear to be attentive.					
The students appear to be participating.					
The students ask relevant questions.					
The students seem to understand what they're doing.					
The students seem to talk about related class work.					
The students appear to be comfortable enough to give opinions freely.					
The students appear to show creativity					
The students appear to be focused.					
The students' discussions appear to be involving meaningful content.					
It appears that this way of learning is generating enthusiasm and interest.					
The students appear to focus their attention on key issues/points.					
The background Baroque music makes the students more alert					

APPENDIX C2

OBSERVATION SCHEDULE

DATE	LESSON
13.02.03	Concepts of Radiological Science
20/02/03	Mathematics and Terminology for Radiology
27/02/03	The Atom
*27/02/03	The Atom
06/03/03	Electromagnetic Radiation
20/03/03	X-Ray Production
24/04/03	X-Ray Emission
05/06/03	X-Ray Interaction with Matter

*Different Observer

APPENDIX D

FIRST QUESTIONNAIRE

BIOGRAPHICAL QUESTIONNAIRE

Please complete the following biographical questions to guide us in the assessment of this project on brain compatible learning.
Information will be treated as strictly confidential and will only be used by the Peninsula Technikon research team for purposes of this project.
NAME:
ADDRESS:
DATE OF BIRTH:
AGE AS AT 01/01/03
GENDER
HOME LANGUAGE

QUESTIONNAIRE

	YES	NO
1. I try to learn at every opportunity in Radiation.Sciences.		
2. I speak to the lecturer if I don't understand something.		
3. I write up my own notes after the lecture.		
4. I read books on Radiation Science.		
5. If you take every opportunity to learn, it will benefit you personally.		
6. I find the classroom's atmosphere comfortable and relaxing.		
7. I have a place in my home where I can make a space for work and creativity.		
8. Music helps me to concentrate during a learning session.		
10. I enjoy getting feedback at the end of every chapter.		
11. I know what my learning style is.		
12. I know how to focus on key points/issues.		
13. I know how to connect new information to prior knowledge.		
14. I believe that my brain has the same potential as Albert Einstein's.		
15. I know what the R brain and the L brain thinking modes are.		
16. I believe that what one person can do, another person has the potential to do.		
17. I know how to get myself motivated to attain my goals.		
18. I know that different tasks on a rotation basis help me to accommodate my specific learning style.		
19. I learn most with group work.		
20. I learn most with role-play.		
21. I learn most with acting the work out.		
22. I learn most when I have to set questions for my peers on the work done?.		
23. I learn most when I make compact notes of the key elements in the work.		
24. I learn most when group work, role-play, acting, worksheets, and keynotes are all combined.		

SECOND AND THIRD QUESTIONNAIRES

BIOGRAPHICAL QUESTIONNAIRE

Please complete the following biographical questions to guide us in the assessment of this project on brain compatible learning.

Information will be treated as strictly confidential and will only be used by the Peninsula Technikon research team for purposes of this project.

NAME:

ADDRESS:

DATE OF BIRTH:

AGE AS AT 01/01/03

GENDER

HOME LANGUAGE

QUESTIONNAIRE

	YES	NO
1. I try to learn at every opportunity in radiation sciences.		
2. I speak to the lecturer if I don't understand something.		
3. I write up my own notes after the lecture.		
4. I read books on Radiation Science.		
5. I believe that if you take every opportunity to learn, it will benefit you personally.		
6. I find the classroom's atmosphere comfortable and relaxing.		
7. I have a place in my home where I can make a space for work and creativity.		
8. Baroque music in the background helps me to concentrate during a learning session.		
9. I enjoy getting feedback at the end of every chapter.		
10. I know what my learning style is.		
11. I know how to focus on key points/issues.		
12. I know how to connect new information to prior knowledge.		
13. I believe that my brain has the same potential as Albert Einstein's.		
14. I know what the R brain and the L brain thinking modes are.		
15. I believe that what one person can do, any other person has the potential to do.		
16. I know how to get myself motivated to attain my goals.		
17. I know that different tasks on a rotation basis can help me to accommodate my specific learning style.		
18. I learn most with group work.		
19. I learn most with role-play / acting		
20. I learn most when I have to set questions for my peers on the work done?.		
21. I learn most when I make compact notes of the key elements in the work.		
22. I learn most when group work, role-play, acting, worksheets, and keynotes are all combined.		
23. When I am faced with a problem, I gather the necessary information in a careful manner (i.e., is thorough and attend to details)		
24. I am able to understand new verbal information adequately (i.e., understand what is said; can identify objects or events if their names or descriptions are given)		
25. I know left from right, top from bottom, as well as being able to relate to (locate) objects and events in my world (e.g., next to, around the corner, etc.).		
26. I have a sense of time and understands and differentiate among time concepts such as one hour's time, 8 o'clock, yesterday, tomorrow, next week, last year, etc.		
27. When I begin a task, I make sure that my information is precise and accurate (e.g., checks that copying from board / OHP are accurate).		

	YES	NO
28. When I am confronted with a problem, I am able to consider two or more sources of information that might be used together in solving the problem (e.g., in plotting a graph, both the x and the y axes need to be considered; in working out an area, length and width must be considered).		
29. I generally am able to identify a problem and describe it clearly (i.e., am able to see what the task requires me to do).		
30. I am able to choose and use the correct and appropriate information needed to attempt a problem (i.e., can decide what aspects of the given information will be useful).		
31. I make comparisons when approaching tasks and problems (e.g., see similarities and differences between different types or aspects of problems and approaches, compare different characters in a story, etc.).		
32. I can solve problems mentally, without using concrete aids (i.e., am able to think abstractly; can argue about possibilities, future outcomes, alternatives approaches).		
33. I actively try to sequence and summarize new information and events in order to organize them (e.g., when explaining an event or telling a story, it is clear that I can extract or summarise the main idea).		
34. I am able to apply rules to make new associations and insights.		
35. I actively look for explanations to problems and are able to argue logically to support possible answers (i.e., use logical evidence to support arguments or conclusions).		
36. I am able to link new information to knowledge previously acquired in order to solve a problem (i.e., can build on experiences or past learning).		
37. I am able to formulate a rule from a number of examples.		
38. I am able to construct and follow a plan in order to solve problems (i.e., can develop a logical plan).		
39. When I am solving a problem, I am able to explain in detail what I am doing.		
40. I have a good understanding of how things are connected and related in my world (i.e., do not see things as isolated and episodic; see a relationship between what has been done and the present, or what is being done now, and the future outcomes).		
41. My answers, verbal or written, are clear, precise, and easy to understand.		
42. I show an interest in attempting to solve new problems.		
43. I think ahead and use a strategy before attempting an answer (i.e., do not use trail-and-error responses; think about or plan an answer carefully).		
44. I am able to communicate answers clearly and effectively (i.e., use appropriate language; have good vocabulary).		
45. I am accurate and precise when answering a question or expressing myself in writing or in explaining the solution to problems.		
46. I am able to think about a problem in my own head without having to constantly refer back to the given example.		
47. My answers and actions are planned and controlled (i.e., do not answer or act impulsively; think before I act).		

FOURTH QUESTIONNAIRE

BIOGRAPHICAL QUESTIONNAIRE

Please complete the following biographical questions to guide us in the assessment of this project on brain compatible learning.
Information will be treated as strictly confidential and will only be used by the Peninsula Technikon research team for purposes of this project.

NAME: ....
ADDRESS: ....
DATE OF BIRTH: ....
AGE AS AT 01/01/03 ....
GENDER ....
HOME LANGUAGE .... **Office use only**

QUESTIONNAIRE

Statement	Strongly agree	Agree	Neutral	Dis-agree	Strongly disagree	
I try to learn at every opportunity in radiation sciences.	1	2	3	4	5	
I speak to the lecturer if I don't understand something.	1	2	3	4	5	
I write up my own notes after lectures.	1	2	3	4	5	
I read books on Radiation Science.	1	2	3	4	5	
If you take every opportunity to learn, it will benefit you personally.	1	2	3	4	5	
The classroom's atmosphere is comfortable and relaxing.	1	2	3	4	5	
I need a place in my home where I can make a space for work and creativity.	1	2	3	4	5	
Baroque music in the background helps me to concentrate during a learning session.	1	2	3	4	5	
I enjoy getting feedback at the end of every chapter.	1	2	3	4	5	
I know my learning style.	1	2	3	4	5	
I know how to focus on key points/issues.	1	2	3	4	5	
I connect new information to prior knowledge.	1	2	3	4	5	
My brain has the same potential as Albert Einstein's.	1	2	3	4	5	
I know what the R brain and the L brain thinking modes are.	1	2	3	4	5	
What one person can do, any other person has the potential to do.	1	2	3	4	5	
I can motivate myself to attain my goals.	1	2	3	4	5	
Different tasks on a rotation basis help me to accommodate my learning style.	1	2	3	4	5	
I learn with group work.	1	2	3	4	5	

I learn with role-play/acting	1	2	3	4	5	
I learn when I have to set questions for my peers on the work done?	1	2	3	4	5	
I learn when I make compact notes of the key elements in the work.	1	2	3	4	5	
I learn when group work, role-play, acting, worksheets, and keynotes are all combined.	1	2	3	4	5	
When faced with a problem, I gather the necessary information in thorough detail.	1	2	3	4	5	
I approach new information in a controlled, systematic way.	1	2	3	4	5	
I am able to understand new verbal information adequately.	1	2	3	4	5	
I know left from right.	1	2	3	4	5	
I know top from bottom.	1	2	3	4	5	
I can locate objects and events around me.	1	2	3	4	5	
I understand time and time differences.	1	2	3	4	5	
At the beginning of a task I make sure that my information is precise.	1	2	3	4	5	
I consider two or more sources of information together in solving problems.	1	2	3	4	5	
I can identify a problem clearly.	1	2	3	4	5	
I can describe a problem clearly.	1	2	3	4	5	
I choose the appropriate information needed to attempt a problem.	1	2	3	4	5	
I use the appropriate information needed to attempt a problem.	1	2	3	4	5	
I make comparisons when approaching problems.	1	2	3	4	5	
I solve problems mentally without using concrete aids.	1	2	3	4	5	
I ***sequence*** new information and events in order to organize them..	1	2	3	4	5	
I ***summarise*** new information and events in order to organize them.	1	2	3	4	5	
I apply rules to make new associations and insights.	1	2	3	4	5	
I look for explanations to problems.	1	2	3	4	5	
I argue logically to support possible answers.	1	2	3	4	5	
I link new information to knowledge previously acquired in order to solve a problem.	1	2	3	4	5	
I formulate a rules from a number of examples.	1	2	3	4	5	
I ***construct*** a plan in order to solve problems.	1	2	3	4	5	

I ***follow*** a plan to solve problems.	1	2	3	4	5	
When solving a problem, I explain in detail what I do.	1	2	3	4	5	
I understand how things are related in my world.	1	2	3	4	5	
My ***verbal*** answers are precise.	1	2	3	4	5	
My ***verbal*** answers are easy to understand.						
My ***written*** answers are precise.	1	2	3	4	5	
My ***written*** answers are easy to understand.						
I show an interest in solving new problems.	1	2	3	4	5	
I ***think ahead*** before attempting an answer.	1	2	3	4	5	
I ***use a strategy*** before attempting an answer.	1	2	3	4	5	
I communicate answers ***clearly***.	1	2	3	4	5	
I communicate answers *effectively*.	1	2	3	4	5	
I am precise when ***answering*** a question ***in writing*** to the solution of problems.	1	2	3	4	5	
I am precise when ***expressing*** myself ***in writing*** to the solution of problems.	1	2	3	4	5	
I am precise when ***answering*** a question ***in explaining*** the solution to problems.	1	2	3	4	5	
I am precise expressing myself ***in explaining*** the solution to problems.	1	2	3	4	5	
I think about a problem in my own head without referring back to the given example.	1	2	3	4	5	
I react impulsively.	1	2	3	4	5	

APPENDIX E

FRAMEWORK 120 MIN LESSON

2 min QUIET TIME - BAROQUE MUSIC

30 min WORK IN YOUR GROUP- Baroque music in background

2 min QUIET TIME - BAROQUE MUSIC

20 min WORK IN YOUR GROUP - Baroque music in background

2 min QUIET TIME - BAROQUE MUSIC

10 min PRESENTATION BY 2 GROUPS - Baroque music in background

20 min TEST (answering of worksheet questions by 3 groups) - Baroque music in background

10 min - MARKING OF QUESTIONS BY GROUP - Baroque music in background

14 min FEEDBACK AND HANDING OUT OF NEW HOMEWORK. - Baroque music in background

FRAMEWORK 80 MIN LESSON

2 min QUIET TIME - BAROQUE MUSIC

30 min FEEDBACK/CILARIFICATION ON PREVIOUS SESSION - Baroque music in background

2 min QUIET TIME - BAROQUE MUSIC

30 min - VIDEO/ INTERESTING PRESENTATIONS/ QUESTIONNAIRES - Baroque music in background

2 min QUIET TIME - BAROQUE MUSIC

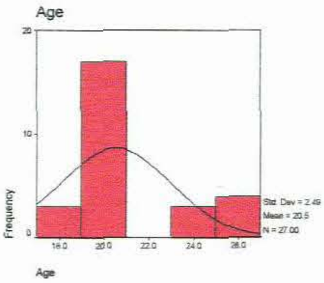
12 min STUDENT INTERVIEWS/ WORK IN GROUPS ON NEW WORK - Baroque music in background

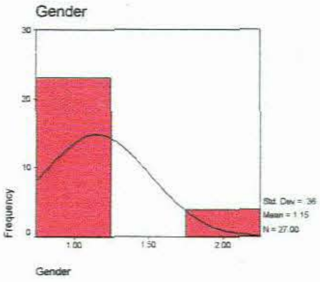
2 min QUIET TIME - BAROQUE MUSIC

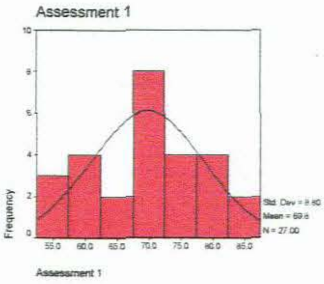
APPENDIX F

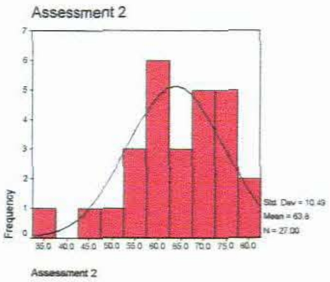
Questionnaire Statistics

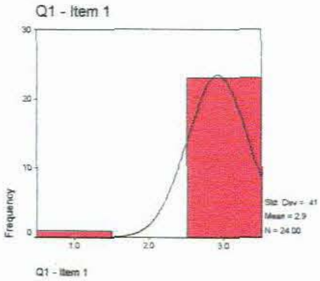
Histograms Questionnaire one

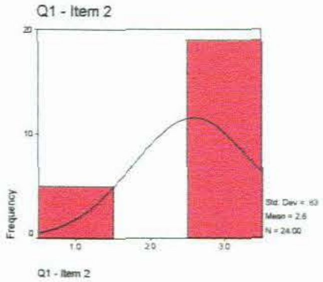


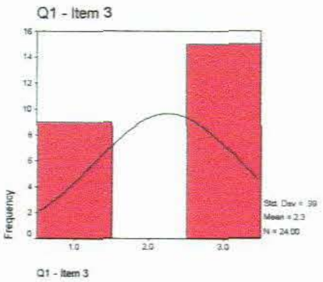


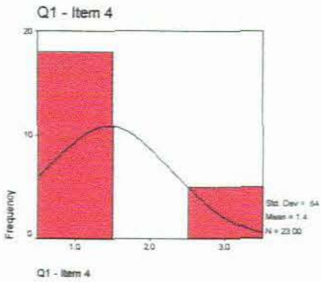


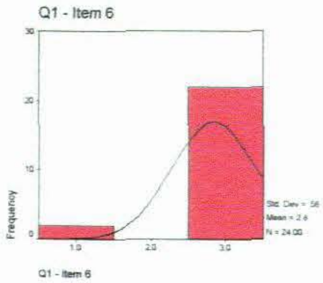


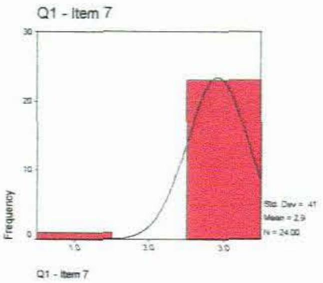


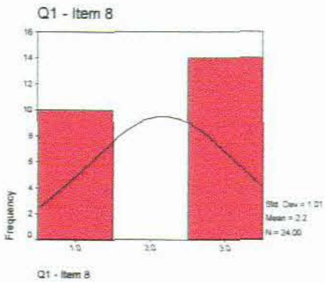


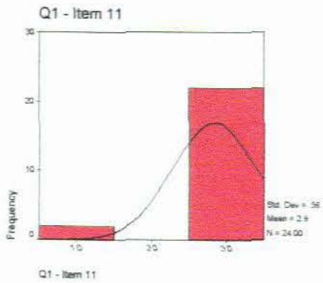


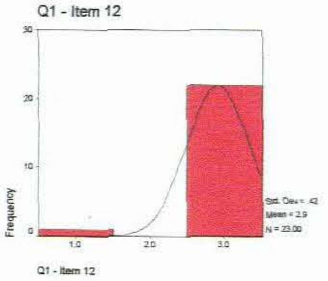


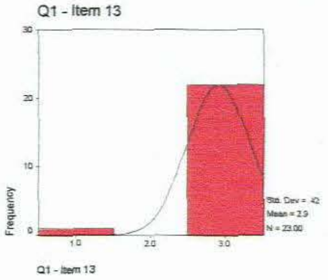


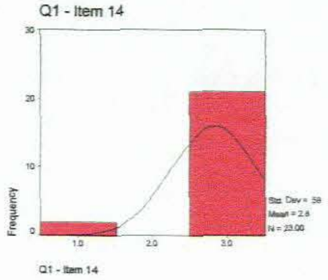


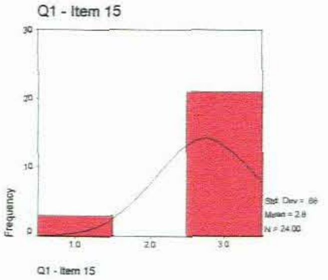


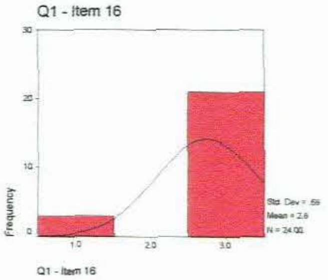


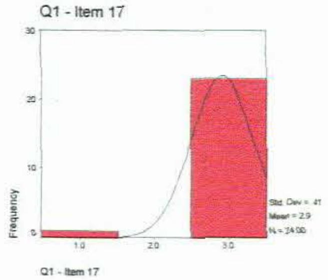


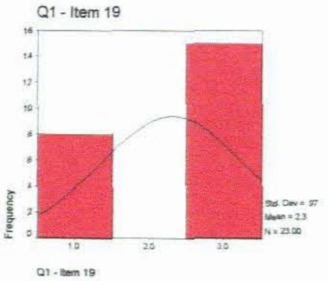


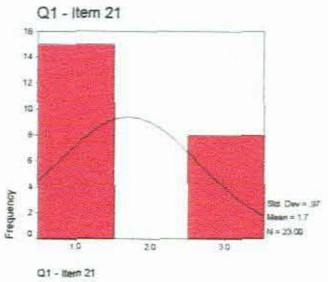


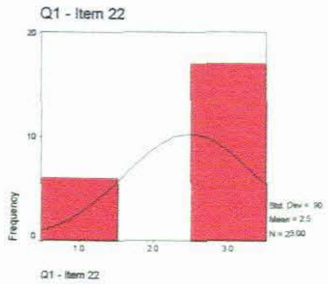


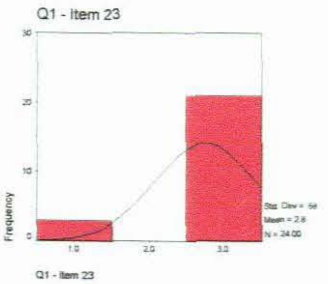


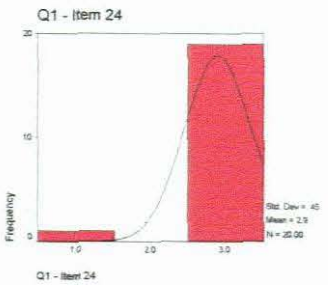




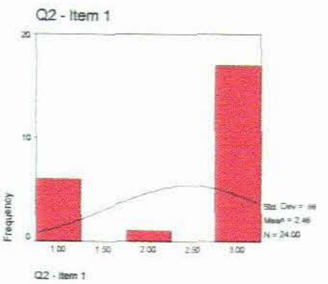


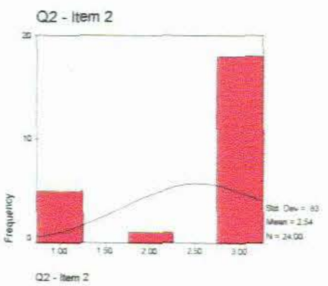


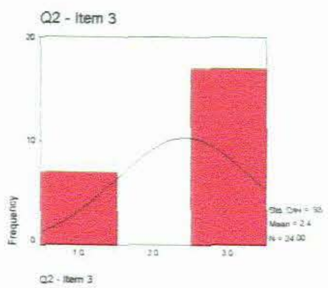




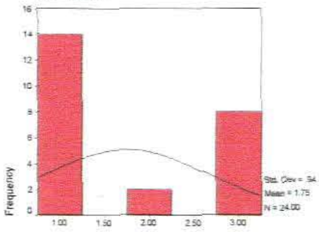
Histograms Questionnaire two





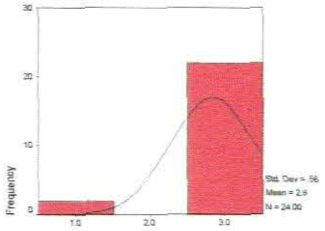


Q2 - Item 4



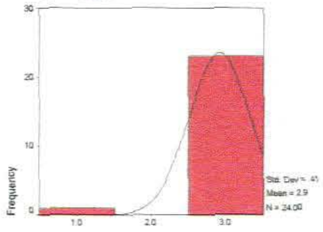
Q2 - Item 4

Q2 - Item 6



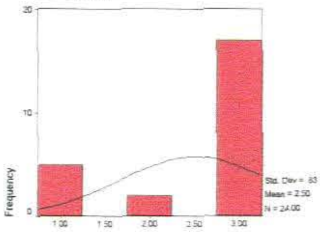
Q2 - Item 6

Q2 - Item 7



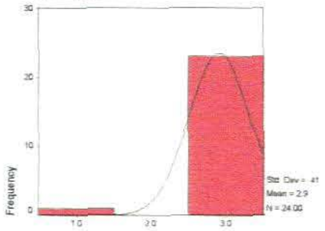
Q2 - Item 7

Q2 - Item 8



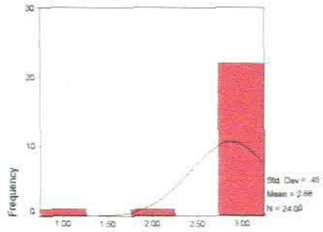
Q2 - Item 8

Q2 - Item 9



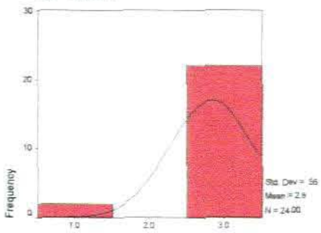
Q2 - Item 9

Q2 - Item 10



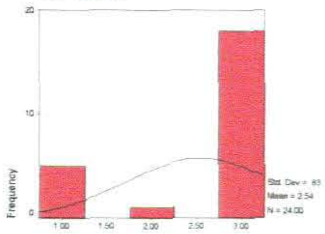
Q2 - Item 10

Q2 - Item 11



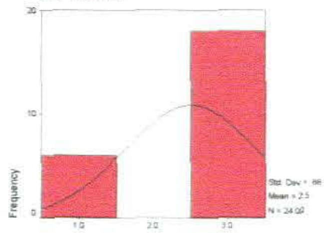
Q2 - Item 11

Q2 - Item 12



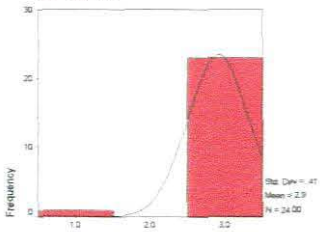
Q2 - Item 12

Q2 - Item 13



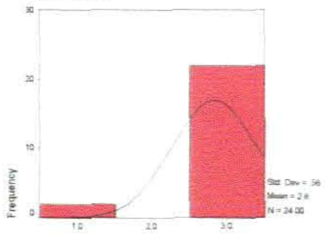
Q2 - Item 13

Q2 - Item 14



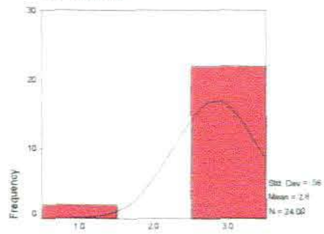
Q2 - Item 14

Q2 - Item 15



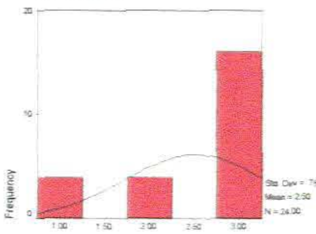
Q2 - Item 15

Q2 - Item 16



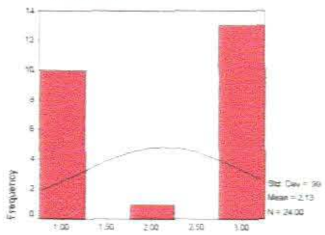
Q2 - Item 16

Q2 - Item 18



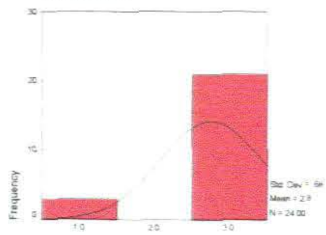
Q2 - Item 18

Q2 - Item 19



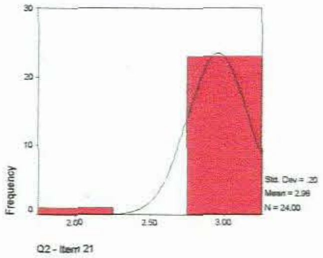
Q2 - Item 19

Q2 - Item 20

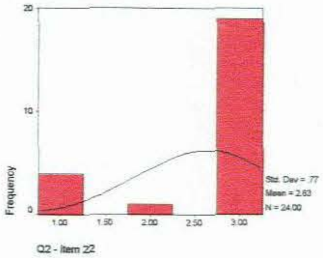


Q2 - Item 20

Q2 - Item 21



Q2 - Item 22



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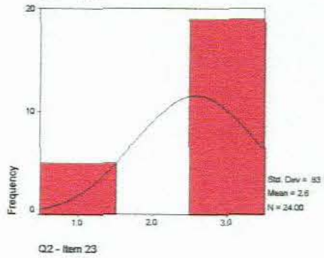

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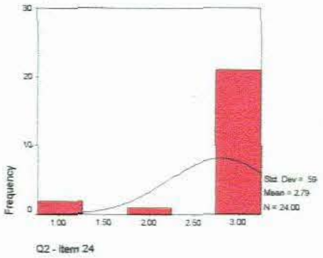

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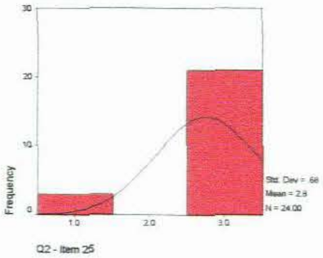

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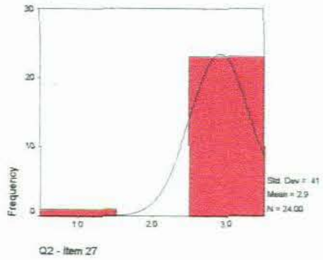
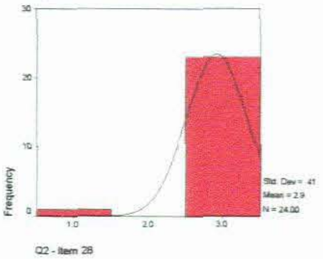


Q2 - Item 28



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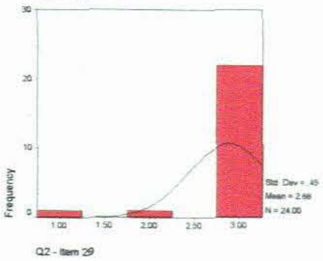

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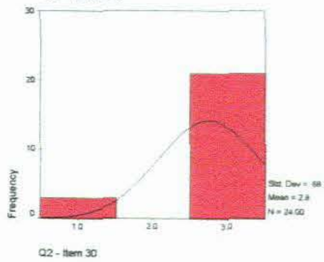

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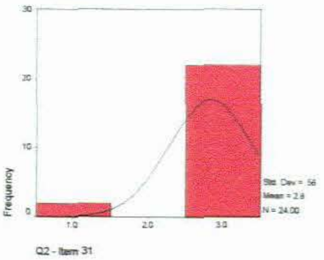

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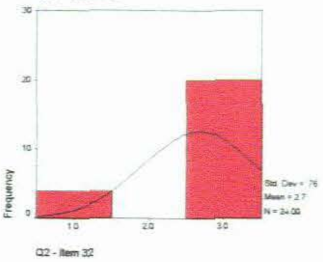

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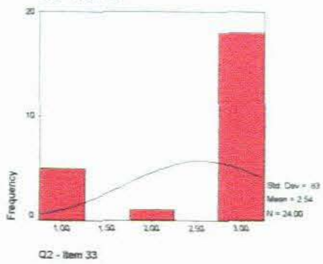
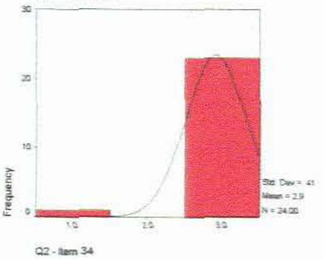
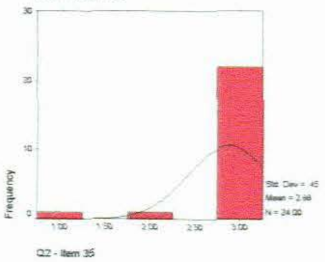


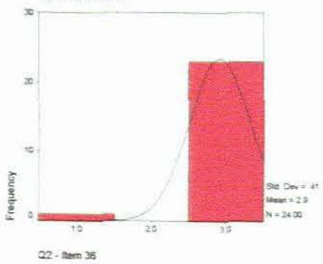
Q2 - Item 34

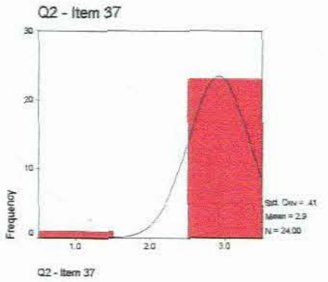


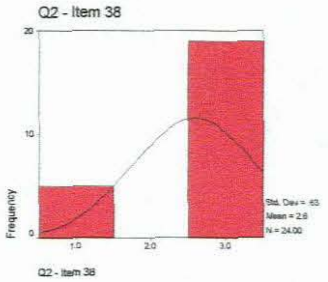
Q2 - Item 35

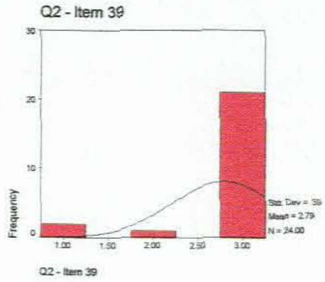


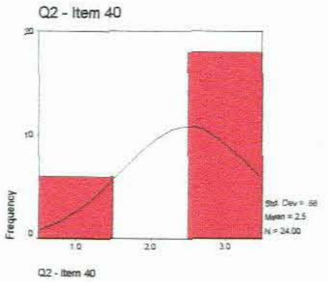
Q2 - Item 36

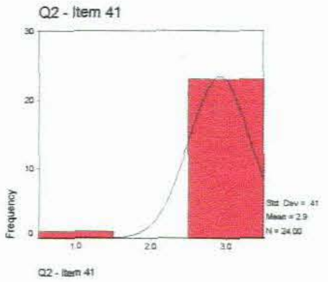


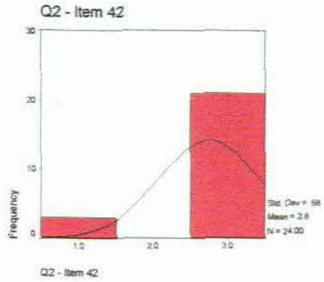


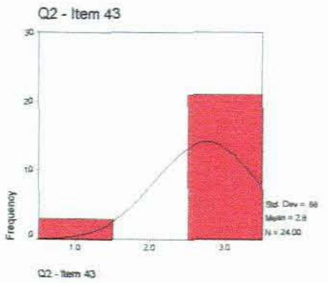


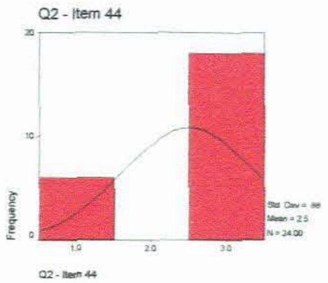


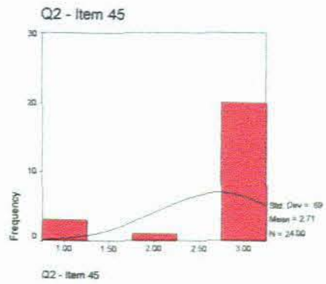


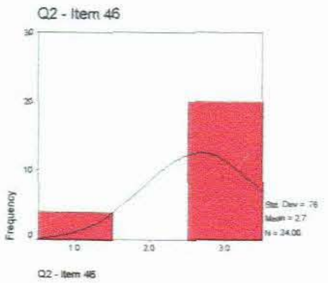


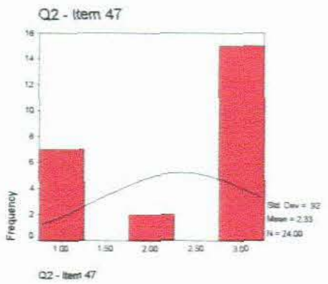


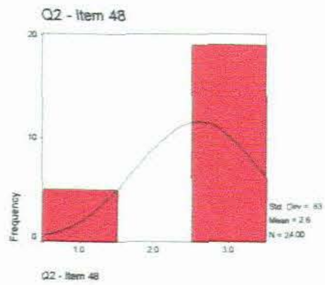




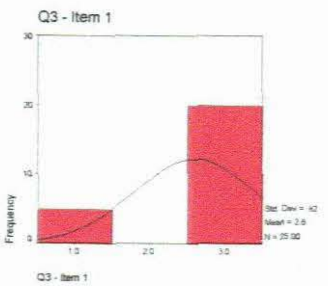


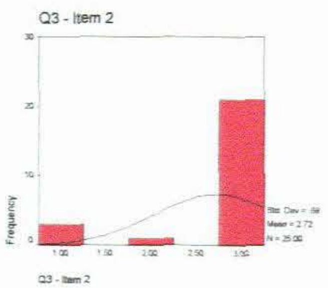


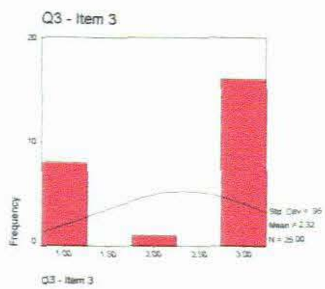




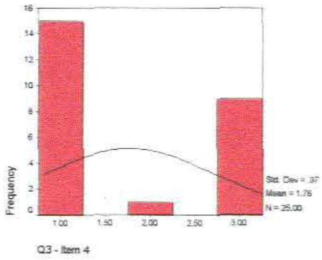
Histograms Questionnaire three



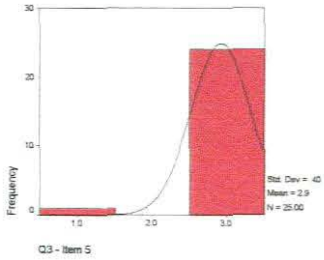




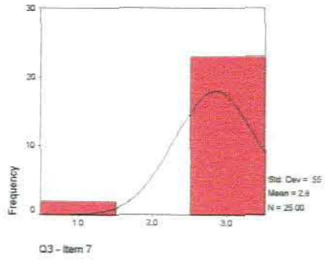
Q3 - Item 4



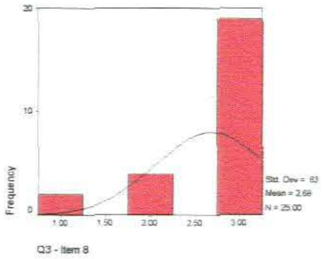
Q3 - Item 5



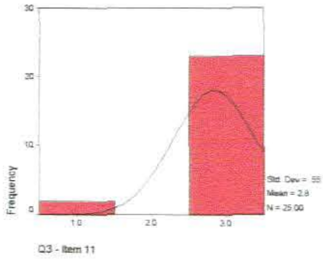
Q3 - Item 7



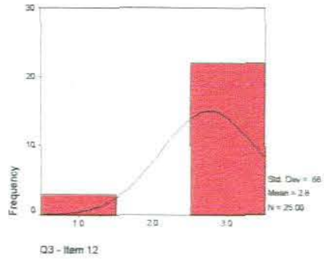
Q3 - Item 8



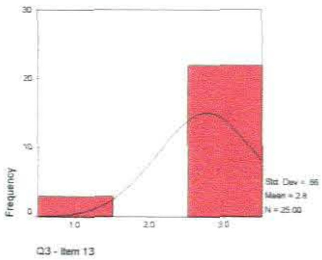
Q3 - Item 11



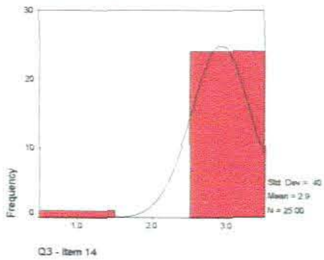
Q3 - Item 12



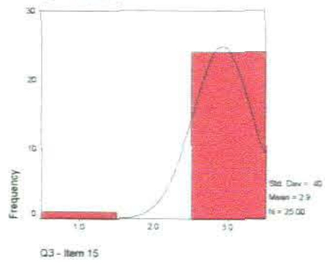
Q3 - Item 13



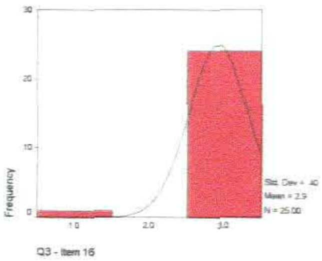
Q3 - Item 14



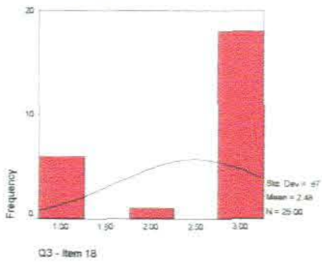
Q3 - Item 15



Q3 - Item 16



Q3 - Item 18



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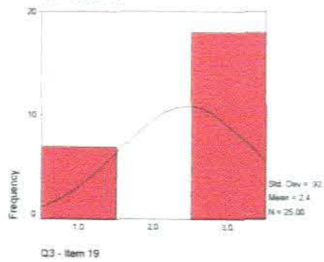

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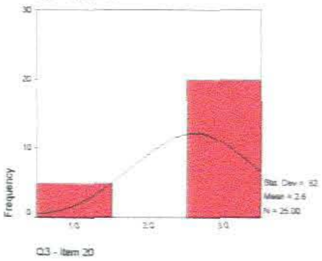
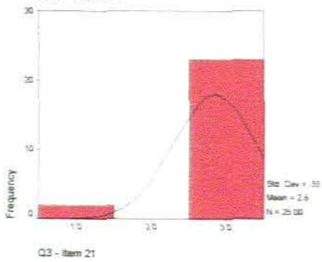


Q3 - Item 21



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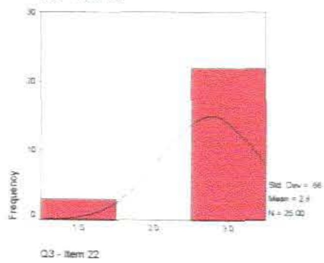

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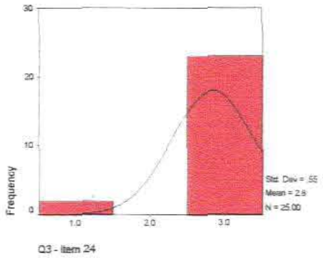

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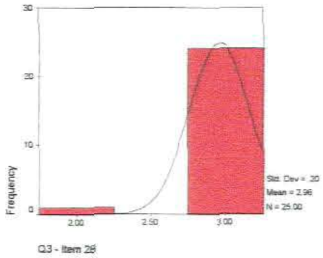

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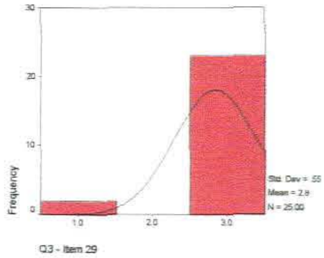

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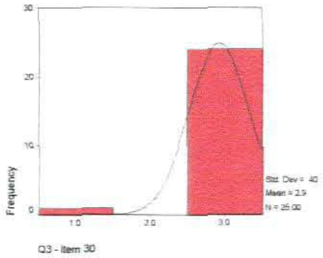

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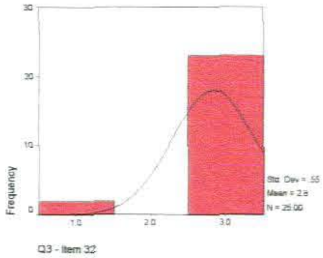

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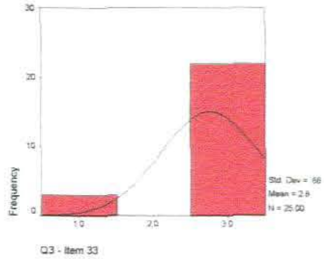
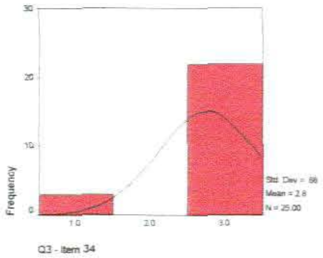


Q3 - Item 34



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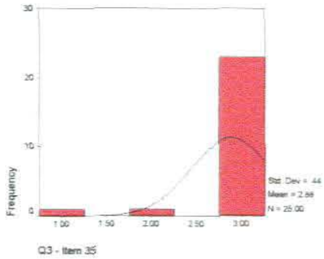

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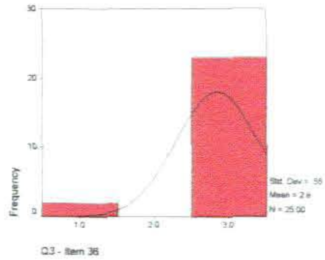

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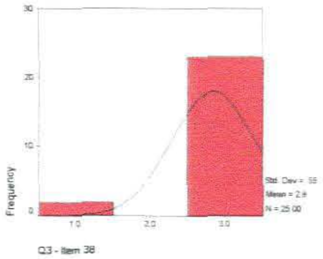

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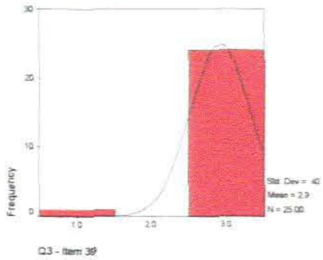

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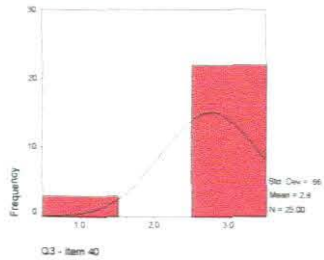

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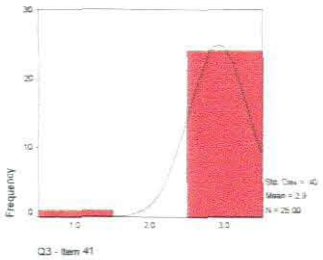

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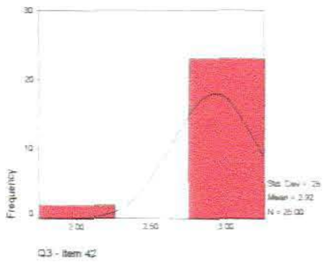

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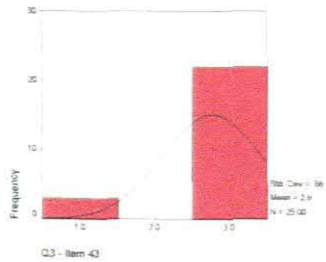
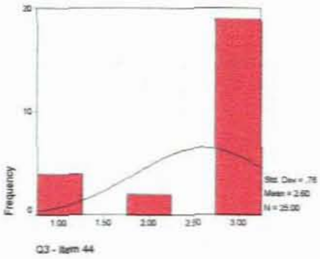


Q3 - Item 44



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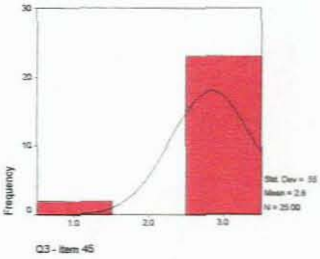

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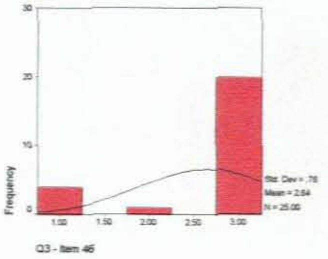

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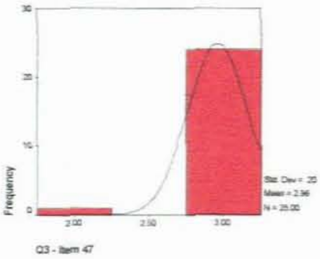
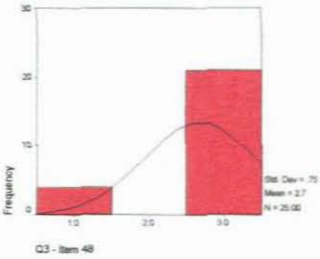


Q3 - Item 48



Histograms Questionnaire four

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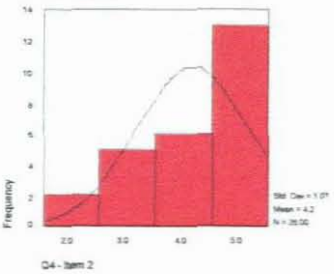

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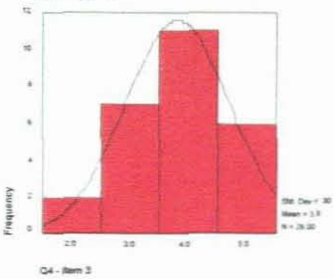

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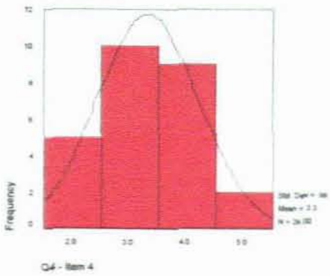

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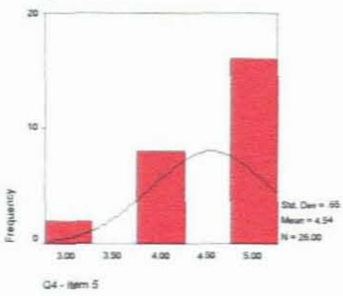

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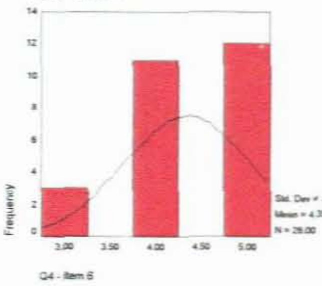

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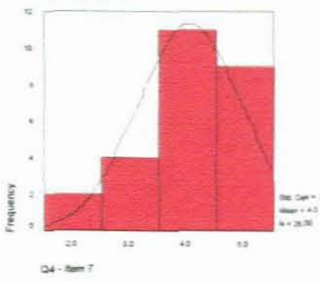

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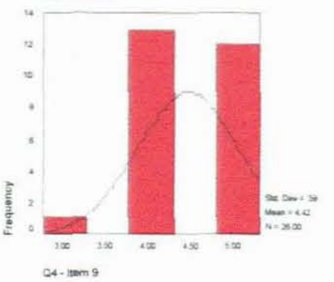
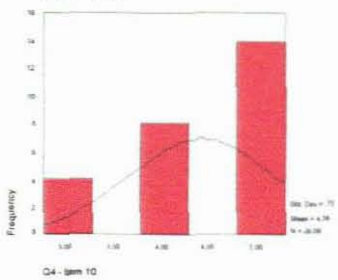
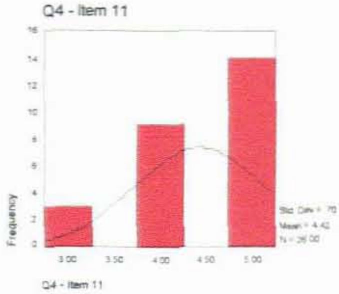


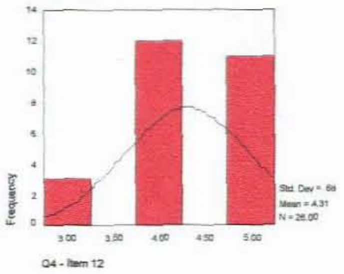
Q4 - Item 10



Q4 - Item 11



Q4 - Item 12



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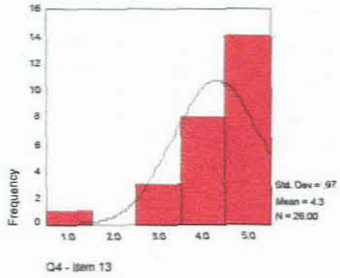

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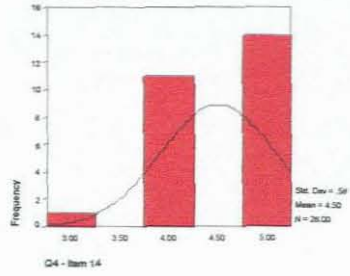

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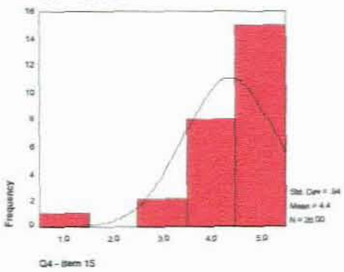

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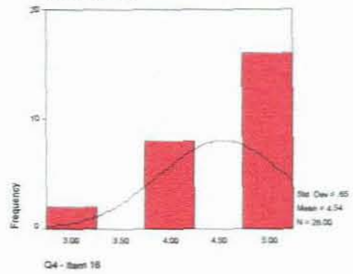

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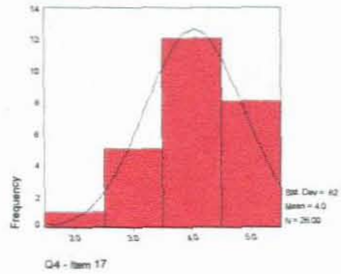

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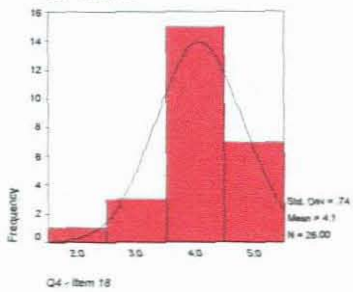

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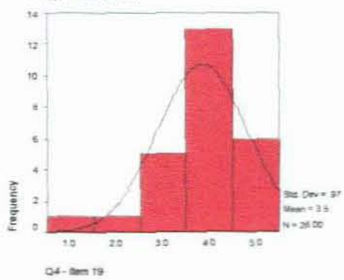
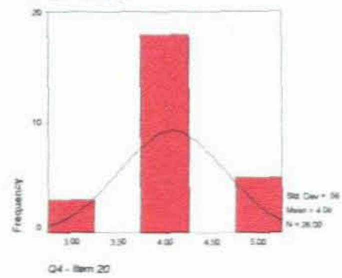
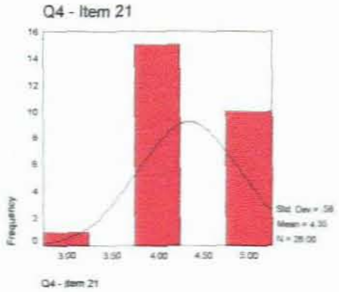


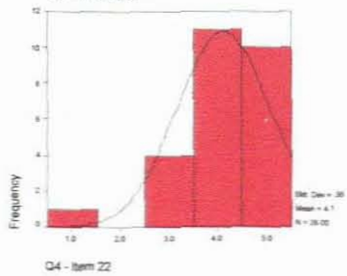
Q4 - Item 20



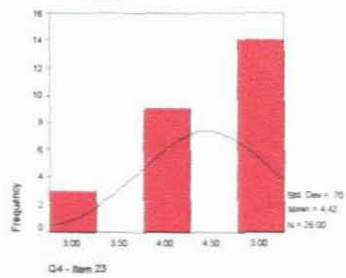
Q4 - Item 21



Q4 - Item 22



Q4 - Item 23



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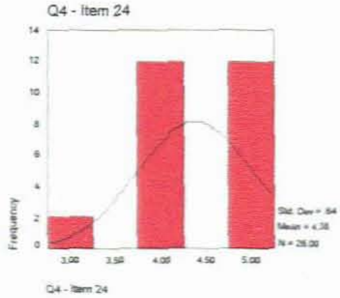
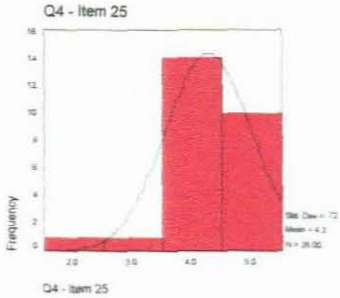


Q4 - Item 25



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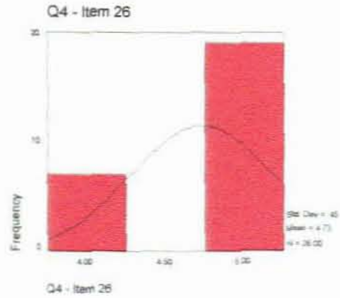
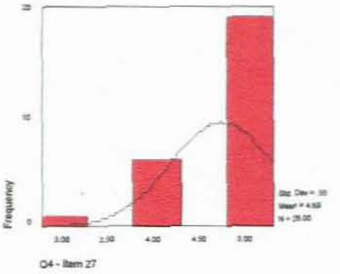


Q4 - Item 27



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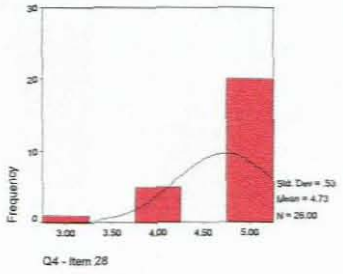

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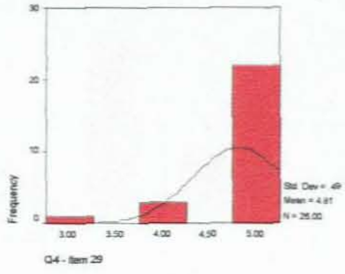

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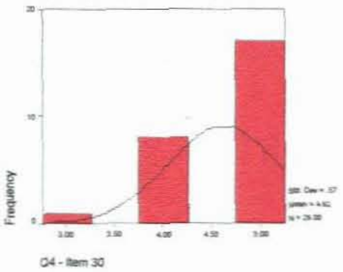

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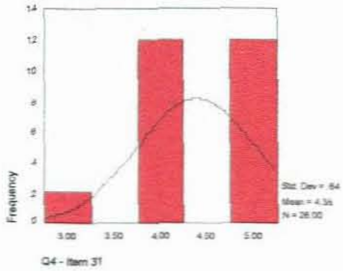

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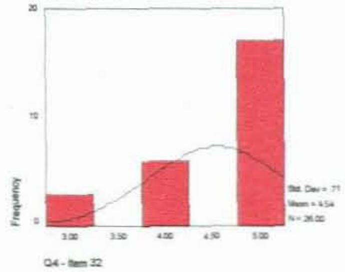

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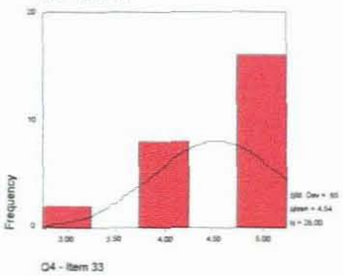

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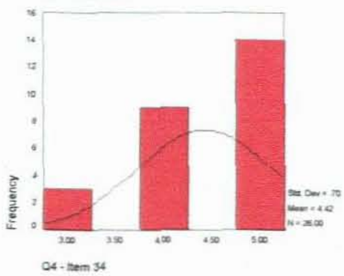

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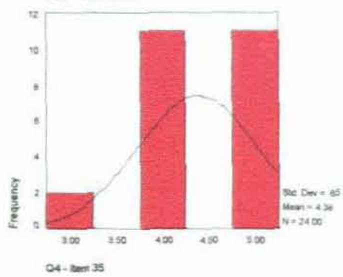

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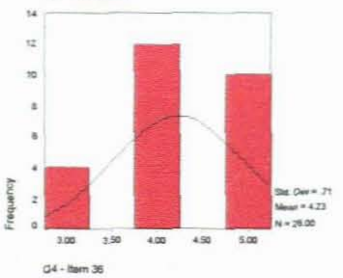

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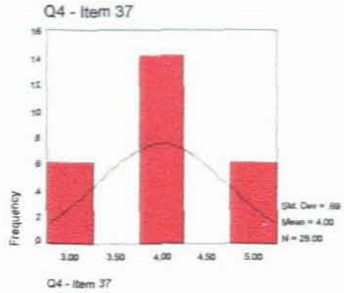

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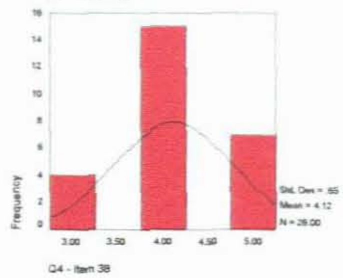

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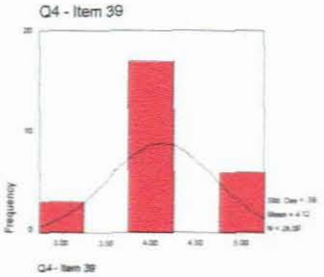

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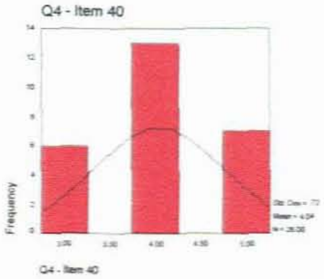
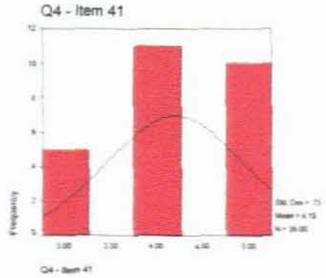
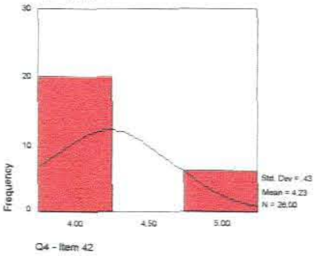


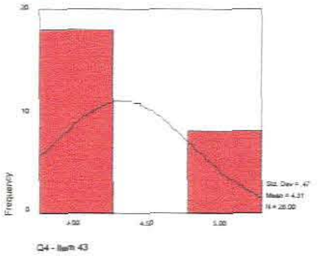
Q4 - Item 41



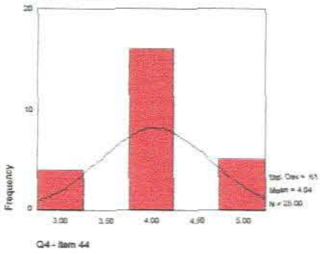
Q4 - Item 42



Q4 - Item 43



Q4 - Item 44



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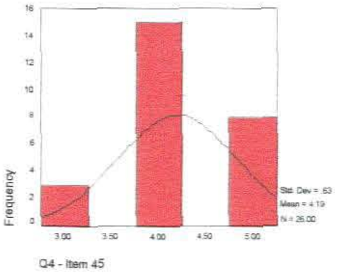

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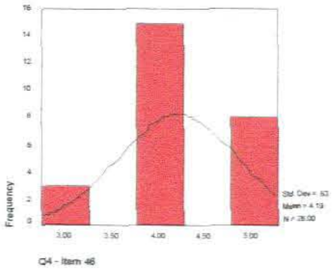

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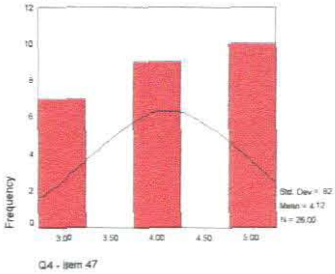

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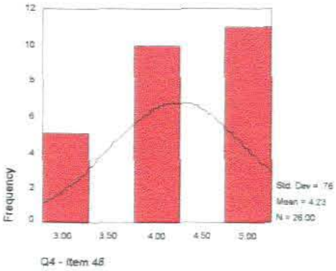
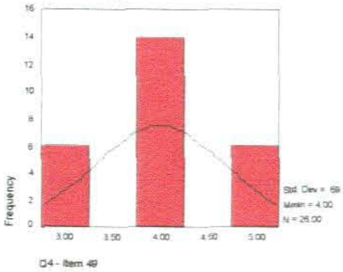
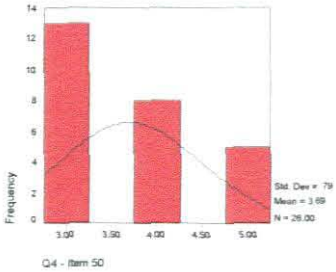


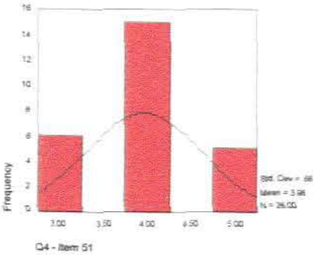
Q4 - Item 49



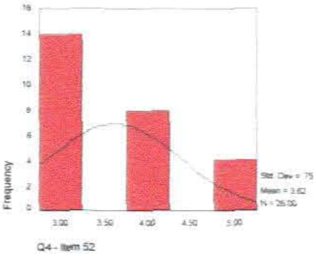
Q4 - Item 50



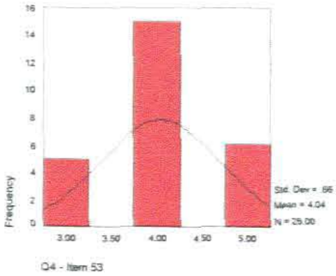
Q4 - Item 51



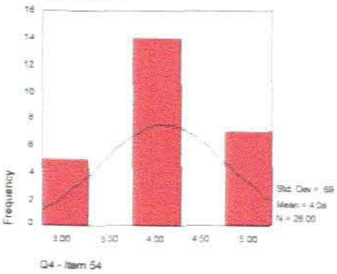
Q4 - Item 52



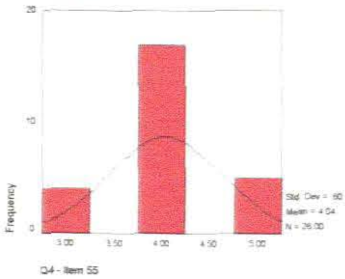
Q4 - Item 53



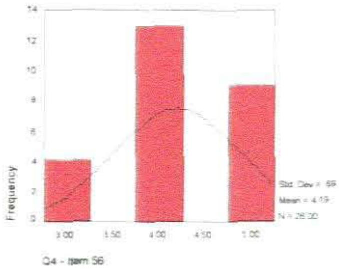
Q4 - Item 54

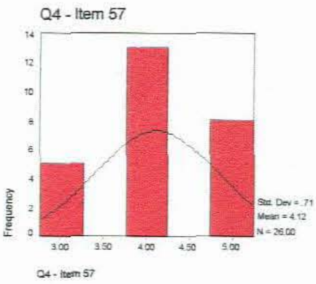


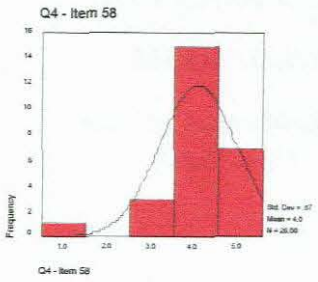
Q4 - Item 55

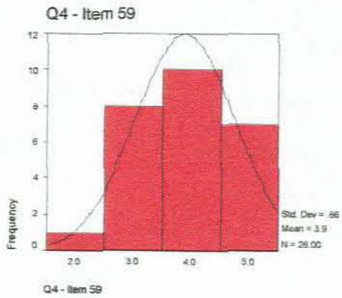


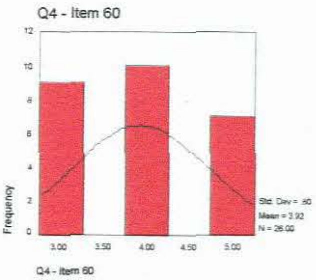
Q4 - Item 56

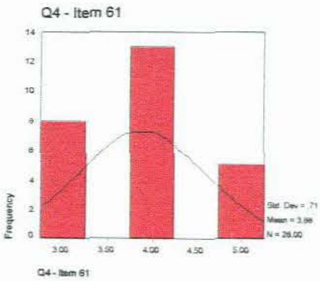


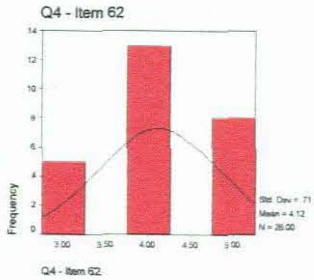

Q4 - Item 57
Frequency
Std. Dev = .71
Mean = 4.12
N = 26.00
3.00 3.50 4.00 4.50 5.00
Q4 - Item 57

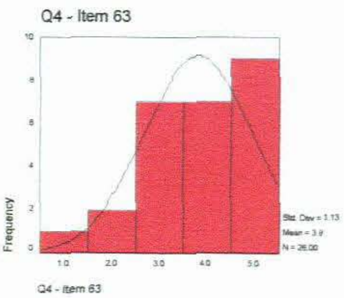

Q4 - Item 58
Frequency
Std. Dev = .87
Mean = 4.0
N = 26.00
1.0 2.0 3.0 4.0 5.0
Q4 - Item 58


Q4 - Item 59
Frequency
Std. Dev = .86
Mean = 3.9
N = 26.00
2.0 3.0 4.0 5.0
Q4 - Item 59


Q4 - Item 60
Frequency
Std. Dev = .80
Mean = 3.92
N = 26.00
3.00 3.50 4.00 4.50 5.00
Q4 - Item 60


Q4 - Item 61
Frequency
Std. Dev = .71
Mean = 3.88
N = 26.00
3.00 3.50 4.00 4.50 5.00
Q4 - Item 61


Q4 - Item 62
Frequency
Std. Dev = .71
Mean = 4.12
N = 26.00
3.00 3.50 4.00 4.50 5.00
Q4 - Item 62

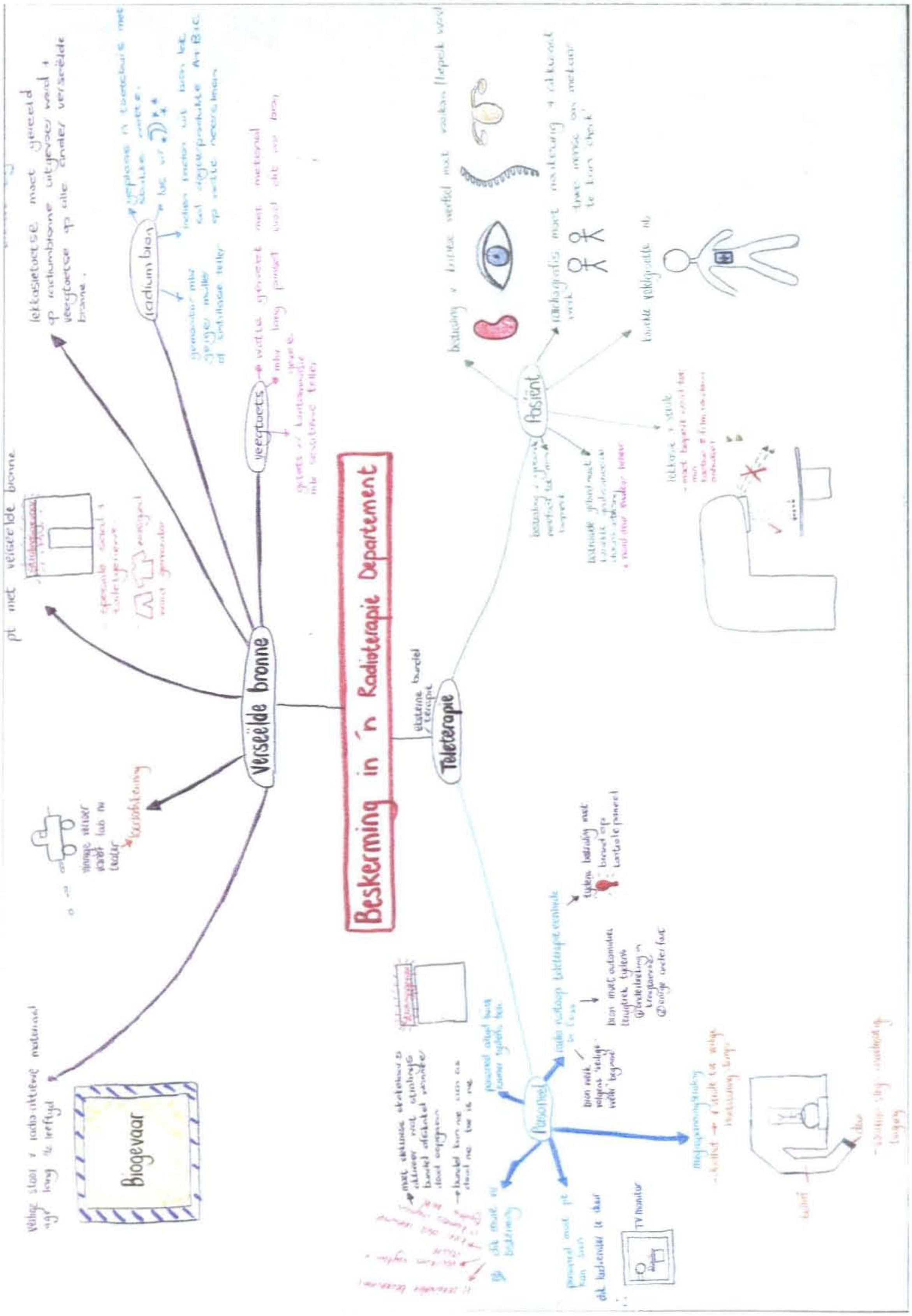

Q4 - Item 63
Frequency
Std. Dev = 1.13
Mean = 3.9
N = 26.00
1.0 2.0 3.0 4.0 5.0
Q4 - Item 63

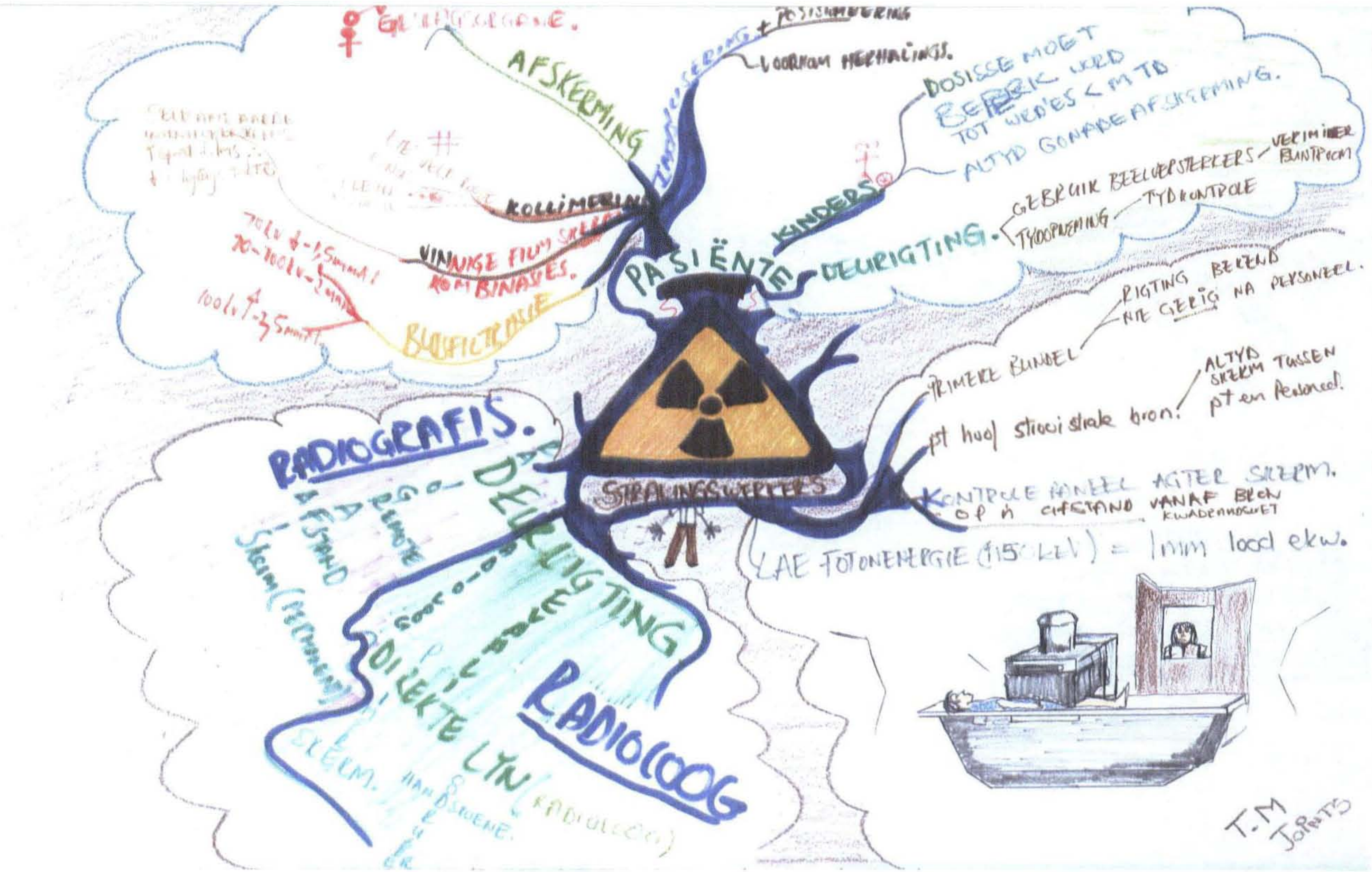
APPENDIX G1

MIND MAPS

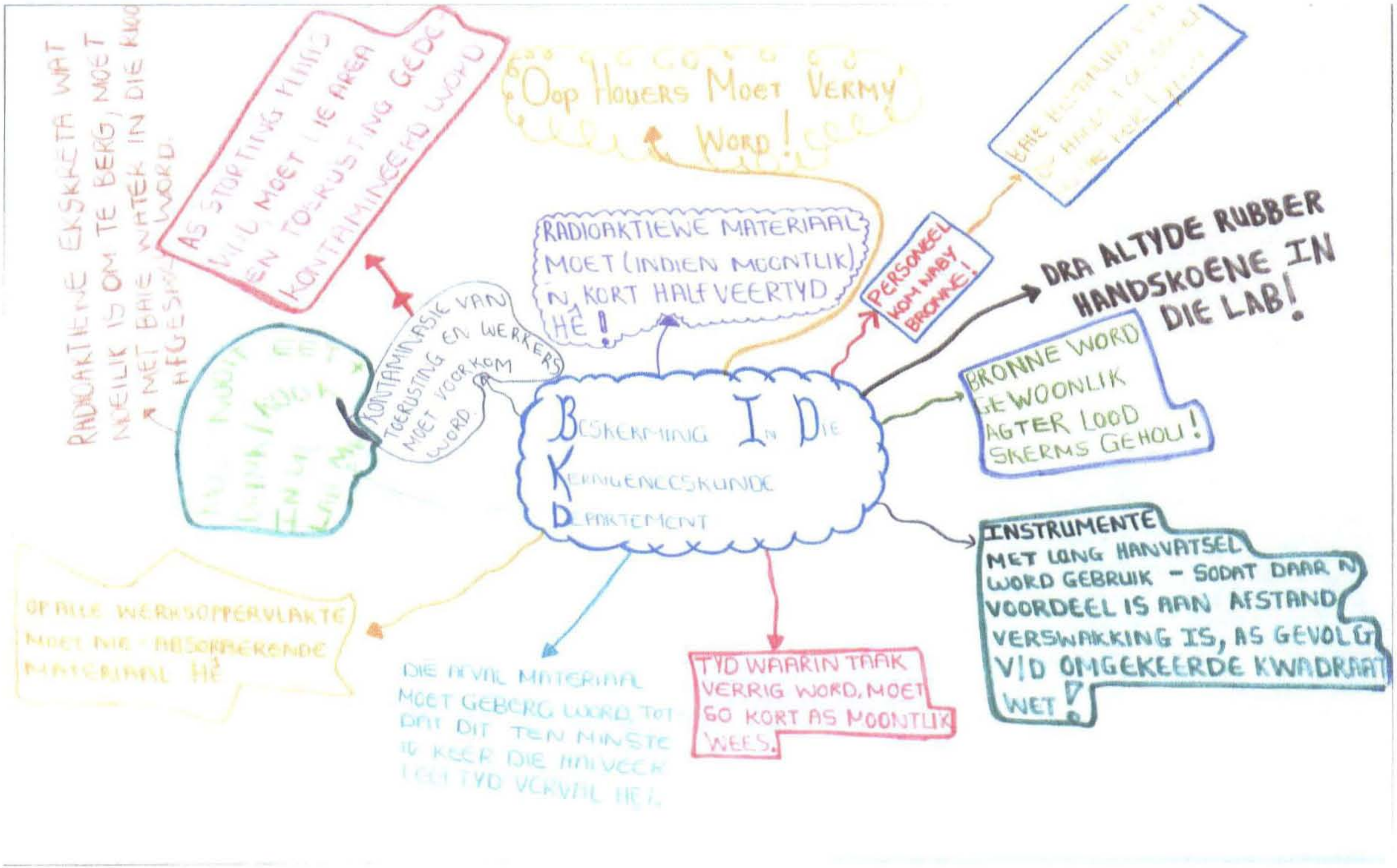
Done by some Students

Student 01



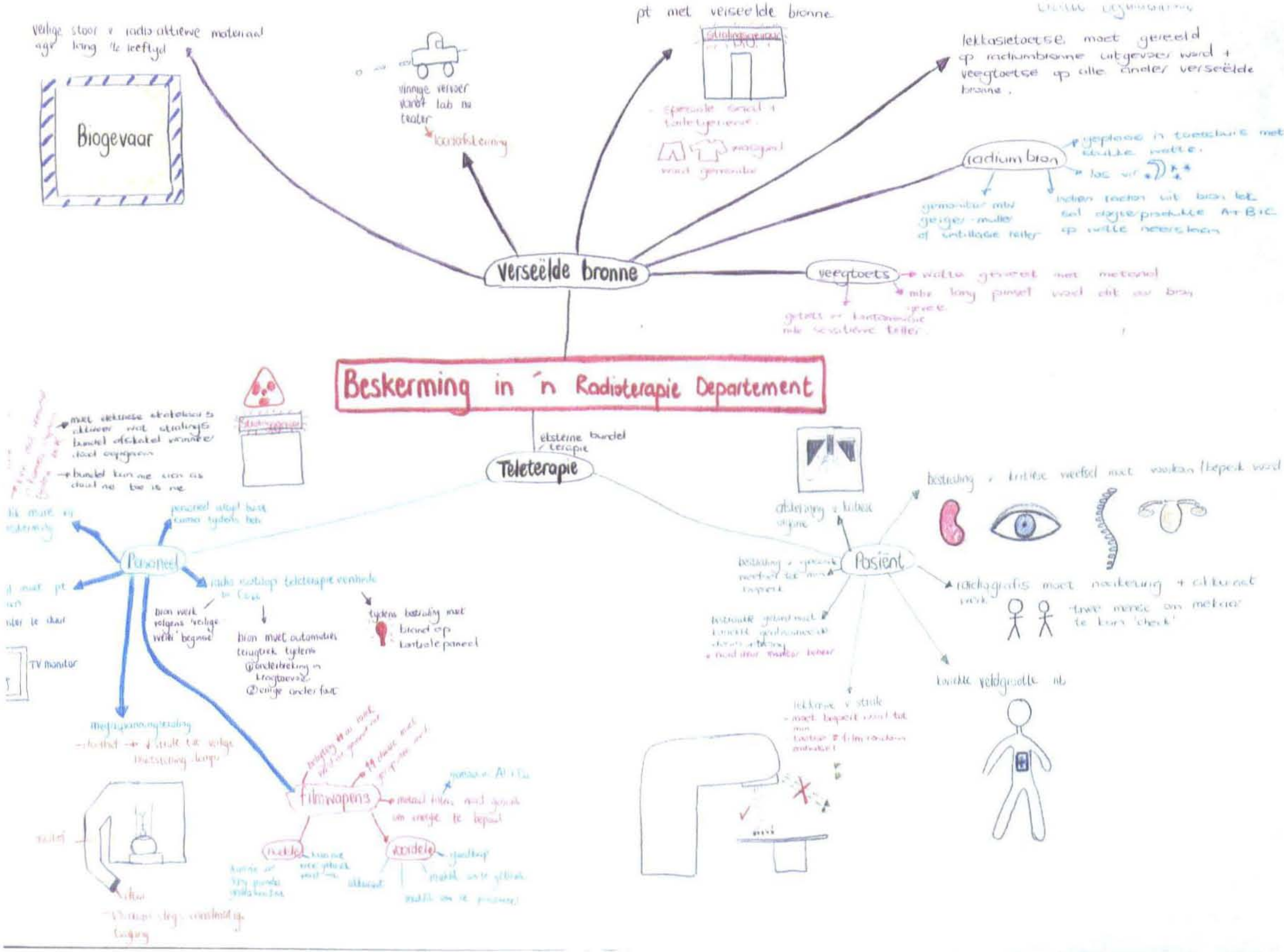

AFSKERMING
VOORKOM HERHALINGS.
DOSISSE MOET BEPERK WORD
ALTYD GONADE AFSKERMING.
KINDERS
GEBRUIK BEELVERSTERKERS
TYDKONTROLE
TYDOPNEMING
DEURIGTING.
PASIËNTE
KOLLIMERING
VINNIGE FILM SKERM KOMBINASIES.
RIGTING BEKEND
NIE GERIG NA PERSONEEL.
PRIMERE BUNDEL
ALTYD SKERM TUSSEN pt en Personeel.
pt hoof strooi strale bron!
KONTROLE PANEEL AGTER SKERM.
OP 'N AFSTAND VANAF BRON
LAE FOTONENERGIE = 1mm lood ekw.
STRALINGSWERKERS
RADIOGRAFIS.
AFSTAND
DEURIGTING
DIREKTE LYN
RADIOLOOG
HANDSKOENE

Student 02

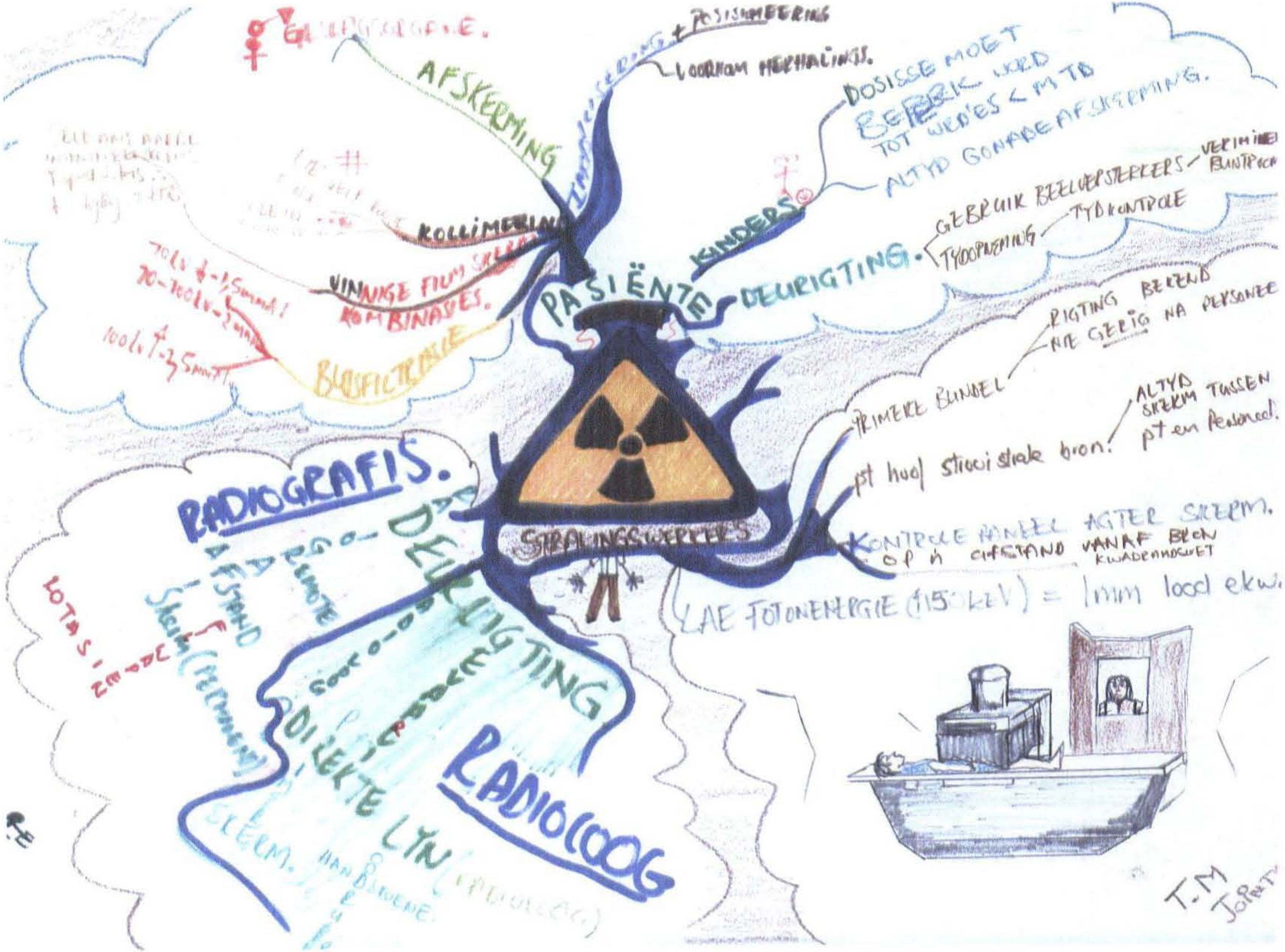


Beskerming In Die Kerngeneeskunde Departement
"Oop Houers Moet Vermy Word!"
RADIOAKTIEWE MATERIAAL MOET (INDIEN MOONTLIK) 'N KORT HALFVEERTYD HÊ!
PERSONEEL KOM NABY BRONNE!
DRA ALTYDE RUBBER HANDSKOENE IN DIE LAB!
BRONNE WORD GEWOONLIK AGTER LOOD SKERMS GEHOU!
INSTRUMENTE MET LONG HANVATSEL WORD GEBRUIK - SODAT DAAR 'N VOORDEEL IS AAN AFSTAND VERSWAKKING IS, AS GEVOLG V/D OMGEKEERDE KWADRAAT WET!
TYD WAARIN TAAK VERRIG WORD, MOET SO KORT AS MOONTLIK WEES.
DIE AFVAL MATERIAAL MOET GEBERG WORD, TOT DAT DIT TEN MINSTE 10 KEER DIE HALVEER TYD VERVAL HÊ.
OP ALLE WERKSOPPERVLAKTE MOET NIE-ABSORBERENDE MATERIAAL HÊ
KONTAMINASIE VAN TOERUSTING EN WERKERS MOET VOORKOM WORD.
AS STORTING PLAAS VIND, MOET DIE AREA EN TOERUSTING GEDEK KONTAMINEERD WORD
RADIOAKTIEWE EKSKRETA WAT MOEILIK IS OM TE BERG, MOET MET BAIE WATER IN DIE KLOSET AFGESPOEL WORD.

Student 03



Corrected Version
Student 01



Corrected Version
Student 02

x-strale ondersoeke word nie geregverdig nie, omdat min informasie oor vorige besërings verkry kan word.

4. Periodieke gesondheidsondersoeke: Baie dokters en gesondheidsorg organisasies doen 'n jaarlikse fisiese ondersoek. As die ondersoek gedoen word, moet x-strale vermy word by asimtomatiese pasiënte.

5. Heelliggaam multisnit Rekenaar Tomografie Beelding: ~~As die~~ Sommige fasiliteite adviseer die prosedure vir self-verwysing. As daar nie 'n bewys is van 'n relevante siekte is nie, moet die ondersoek vermy word. Die stralingsdosis is te hoog.

Herhaling van Ondersoeke

Die frekwensie van herhaling van ondersoeke is so hoog as 10% van alle ondersoeke. In 'n tipiese besige hospitaal is die herhaalde ondersoeke nie meer as 5% nie. Gewoonlik lumbale werwels, torakale werwels en ~~Sommige~~ buik ondersoeke wat die meeste herhaal word. Sommige ondersoeke wat herhaal word is as gevolg van toerusting wat ~~oe~~ foutief is, maar die meeste word veroorsaak deur ~~die~~ 'n fout deur die radiograaf.

Redes vir herhaling is onvoldoende beligting, onvoldoende posisionering, kollimasie, beweging. Ander redes is vuile kassette, onvoldoende gelaaide kassette, lig lekkasies, verkeerde projeksies, verkeerde pasiënt voorbereiding, rooster foute en dubbel beligtings.

Radiografiese Tegniek

Die gebruik van 'n hoë kVp tegniek sal resulteer in 'n verlaging in pasiënt dosis. 'n Verhoging in kVp en 'n verlaging in mAs word ~~gedoen~~ gebruik om 'n aanvaarbare radiografiese beeld te ~~e~~ verkry.

Voldoende kollimasie is essensieel vir 'n goeie ~~radiog-~~ radiografiese tegniek. Wanneer kollimasie gebruik word word pasiënt dosis verlaag en die beeldkwaliteit word verhoog.

Beeld Reseptor.

Die beeld reseptor moet geselekteer word t.o.v die ondersoek wat gedoen gaan word en ook vir die stralingsdosis wat nodig is om 'n kwaliteitbeeld te verkry. Die uiteindelike spoed film skerm kombinasie wat konstant is met die tipe ondersoek wat gedoen gaan word. Dit is die skerm spoed wat die pasiënt dosis bepaal.

Patient Posisionering

Wanneer die boonste ekstremiteite of mammas ondersoek word veral as die pasiënt sittend is moet sorg geneem word dat die bruikbare strale nie die gonades bestraal nie. Die pasiënt moet loodreg aan die gebruikbare straal ~~gepos~~ posisioneer word en 'n loodafskermende voorskoot moet voorsien word.

Spesifieke area Afskerming

Moet gebruik word wanneer sensitiewe weefsel of 'n sensitiewe orgaan in of naby die primêre straal is. Gonade afskerming moet oorweeg word as pasiënt nog in die reproduktiewe ouderdom is, wanneer die gonades naby of in die primêre straal is. Alhoewel afskerming gebruik word, moet voldoende pasiënt posisionering en kollimasie moet gebruik word. Gonade afskerming moet gebruik word as dit nie die aangevraagde diagnostiese informasie belemmer nie.

Corrected Version
Student 03

APPENDIX H

PENINSULA TECHNIKON

STUDENT EVALUATION OF LECTURER

The purpose of this evaluation is for you to assist the lecturer to improve his/her effectiveness as an educator. Your honest responses to the following questions will be most helpful, whether you wish to compliment or criticize the lecturer. Please base your assessments on your own experience of the lecturer. There is no need for you to write your name on this form.

NAME OF LECTURER:	....	**SUBJECT:**	....

COURSE:	....	**DATE:**	....

Please use the following scale to rate the items below:

4 = Very Good; 3 = Above Average; 2 = Below Average; 1 = Very Poor; 0 = Cannot Say

(a)	The lecturer's demonstration of knowledge of the subject	(a)	4	3	2	1	0
(b)	The lecturer's preparation for lectures	(b)	4	3	2	1	0
(c)	The lecturer's stimulation of interest in the subject	(c)	4	3	2	1	0
(d)	The lecturer's encouragement and motivation of students	(d)	4	3	2	1	0
(e)	The lecturer's guidance with the development of skills	(e)	4	3	2	1	0
(f)	The lecturer's availability for consultations	(f)	4	3	2	1	0
(g)	The lecturer's assessment and testing of student's knowledge	(g)	4	3	2	1	0
(h)	The lecturer's punctuality with the starting times of classes	(h)	4	3	2	1	0
(i)	The lecturer's punctuality with returning assignments/tests	(i)	4	3	2	1	0
(j)	The lecturer's fair treatment of all students	(j)	4	3	2	1	0
(k)	The lecturer's setting of learning objectives in class	(k)	4	3	2	1	0
(l)	The lecturer's explanations and examples given in class	(l)	4	3	2	1	0
(m)	The lecturer's assistance with problems experienced by students	(m)	4	3	2	1	0
(n)	The lecturer's facilitation of student participation in the class	(n)	4	3	2	1	0
(o)	The lecturer's interaction with students outside the classroom	(o)	4	3	2	1	0
(p)	The lecturer's demonstration of practical work in the subject	(p)	4	3	2	1	0
(q)	The lecturer's explanation of assignments	(q)	4	3	2	1	0
(r)	The lecturer's guidance in tutorials	(r)	4	3	2	1	0
(s)	The lecturer's encouragement of students to make use of the library	(s)	4	3	2	1	0
(t)	The lecturer's encouragement of students to search for information	(t)	4	3	2	1	0
(u)	The lecturer's encouragement of students to do additional reading	(u)	4	3	2	1	0
(v)	The lecturer's use of audio-visual aids eg. Video, overheads etc.	(v)	4	3	2	1	0
(w)	The lecturer's stimulation of discussions in the class	(w)	4	3	2	1	0

WHAT ABOUT THE LECTURER DID YOU FIND MOST USEFUL?

WHAT ABOUT THE LECTURER DID YOU FIND LESS USEFUL?

WHAT DO YOU SUGGEST CAN BE DONE TO IMPROVE THE QUALITY OF EDUCATION?

ANY OTHER COMMENTS?

Thank you for your participation. Your contribution to the development of our institution is highly appreciated.

APPENDIX I

Program evaluation by students

Radiation Science II B

EVALUATION OF THE 2003 PRESENTATION

Naam: Datum:

1. Ek voel die algemene samestelling en die verloop van die program was:

2. My algemene indrukke van die aanbieder en metode is:

3. Aspekte van die program wat ek die betekenisvolste gevind het was:

4. Hierdie vakaanbieding is soortgelyk aan / verskil van ander vak aanbiedinge aangesien:

5. Ek sou meer by sekere aspekte van die proses kon baat indien:

6. Ek voel starlings wetenskap II B het aan my verwagtinge voldoen / nie voldoen nie aangesien:

7. Ek sou graag die volgende wou voorstel vir toekomstige jare:

8. Enige ander opmerkings

APPENDIX J

INFORMED CONSENT

You are requested to complete the form provided below as proof that you understand that you will contribute to a research project to improve teaching and learning practices in Radiation Science.

I, FULL NAMES, --------------------------, the undersigned, residing at,
ADDRESS: ---Tel: ----------------

Am willing to participate in the research project to improve teaching and learning in Radiation Science.

I understand that everything I that I say or write, or that is observed, will be kept totally confidental, and that my name will not appear on any research document or report.

I also understand that I will be informed of the outcome of the study.

Signed at: ---------------------------on this---------day of--------------

Witnesses: -------------------------------

Your signature

1. ---------------------------

2. ---------------------------