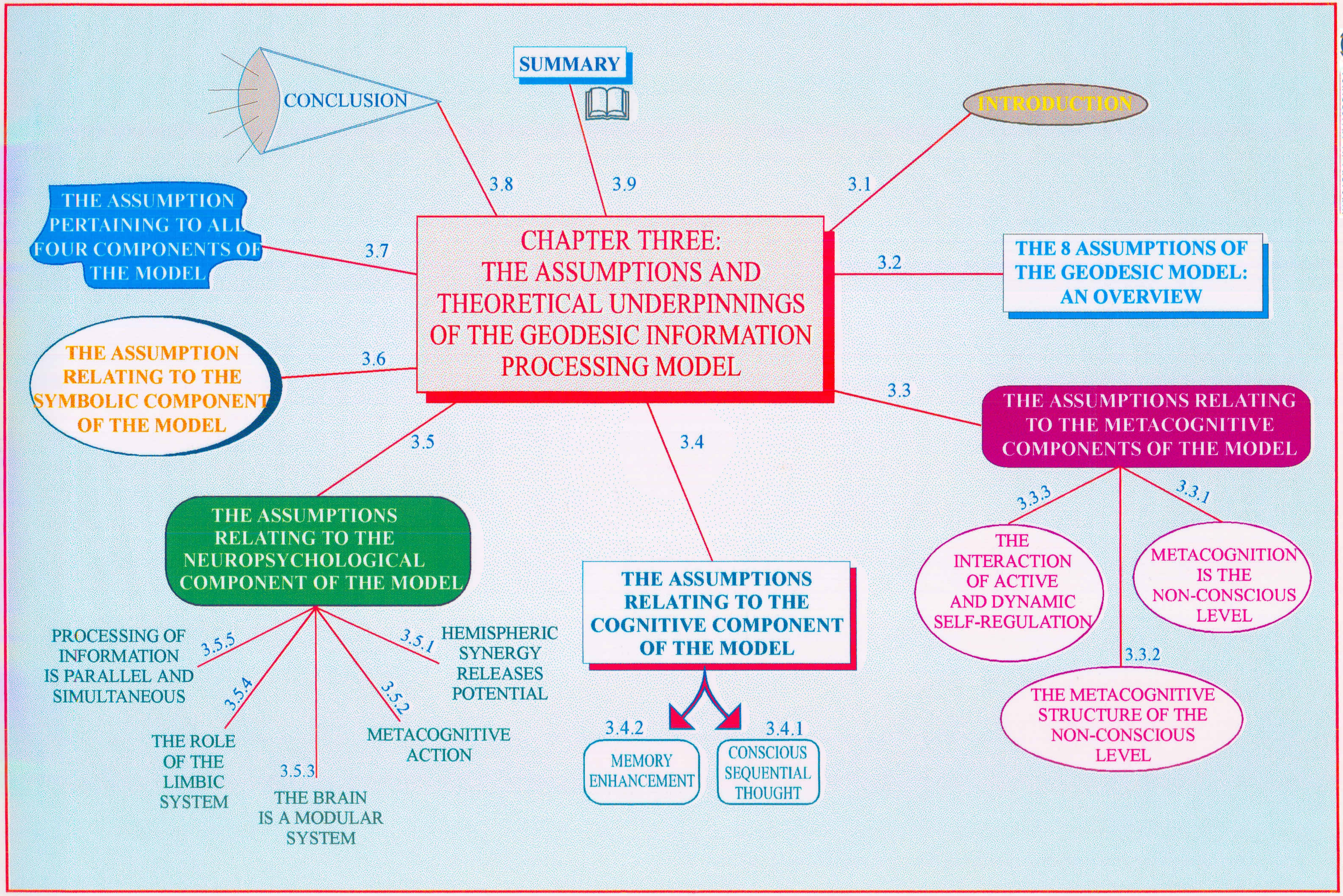

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CHAPTER THREE : THE ASSUMPTIONS AND THEORETICAL UNDERPINNINGS OF THE GEODESIC INFORMATION PROCESSING MODEL

3.1. INTRODUCTION

In order to facilitate the development of innovative life-long learners with effective communication skills, alternative approaches to the perception of learning and the development of human potential are needed. It has been proposed in the foregoing discussions that geodesic frameworks such as the MMA invoke the ability to process information more effectively than traditional behaviouristic and cognitive frameworks and hence the better realisation of potential. This more efficient thought processing is illustrated in the information processing model (see Figure 2.1). There are various assumptions upon which this model is based. It is the objective of this chapter to examine these assumptions and their theoretical underpinnings, as they lead to a redefinition of the non-conscious level, metacognition, cognition and learning. These redefinitions are pivotal in the explanation of the effectiveness of a geodesic approach to intervention and education. In what follows the eight assumptions of the model are briefly outlined and then each is discussed in detail.

3.2 THE EIGHT ASSUMPTIONS OF THE GEODESIC MODEL: AN OVERVIEW

There are eight assumptions underlying the geodesic information processing model (see Figure 2.1 and Table 3.1). The first of these assumptions deals with the metacognitive component of the model. It is assumed that metacognition is the root of the thought process controlling the cognitive process and ultimately the symbolic output. Furthermore, the key to unlocking intellectual potential occurs when the metacognitive level is activated effectively. It is postulated that traditional approaches, which are not geodesic, do not take full advantage of the metacognitive potential of the brain, and that the full spectrum of metacognition is thus overlooked. Within a geodesic approach such as the MMA, it is assumed that the metacognitive level is more adequately activated.

The second assumption postulates that metacognition is the non-conscious level. This implies that the majority of complex higher cortical functioning and learning occurs outside conscious awareness (Reddy, 1979, in Iran-Nejad, 1990; Derry, 1990). The way that metacognition is conceptualised within the geodesic information processing model provides a structure for understanding and analysing the non-conscious level.

The third assumption deals with the concept of self-regulation and relates to the metacognitive and cognitive components of the geodesic information processing model. Traditionally, this is the conscious executive control of thought which forms part of the definition of metacognition (Costa, 1984; Harrison, 1993). According to Slife, Weiss and Bell (1985), self-regulation refers to the planning, monitoring and checking activities necessary to orchestrate cognition. Iran-Nejad (1990) however, argues that this type of self-regulation, termed active self-regulation, is only part of the self-regulation process, accounting for the learning of a functional knowledge base. Over-reliance on this active self-regulation results in rote learners and reduces learning potential (Iran-Nejad, 1990). It is proposed that an additional form of self-regulation, termed dynamic self-regulation, is required to overcome the inherent limitations of active self-regulation (Iran-Nejad & Chissom, 1988). Dynamic self-regulation is rapid, spontaneous, multimodal and co-ordinates the simultaneous as opposed to the sequential aspects of the learning process (Iran-Nejad & Chissom, 1988; Iran-Nejad, 1990). It is the interaction of these two types of self-regulation that will lead to more effective learning (Iran-Nejad, 1990, 1991). Within the geodesic information processing model, the interaction of the two types of self-regulation is viewed as the operating system of effective thought processing. This interaction triggers metacognitive action (see Figure 2.1).

The fourth assumption deals with the cognitive component, which is responsible for the conscious sequential aspect of learning. The activation of the cognitive process is reliant on its interaction with metacognition. This in turn is orchestrated by the interaction of active and dynamic self-regulation. Therefore, according to the geodesic information processing model, the conscious awareness, or the "thinking about thinking" aspect of the thought process is a more advanced level of cognition and not metacognition, as described in traditional definitions.

The fifth assumption, also dealing with the cognitive component, is that memory enhancement is part of the cognitive process. Therefore, although memory is stored on the non-conscious metacognitive level, the actual enhancing of the memory process is facilitated by various techniques that are consciously created on the cognitive level and expressed on the symbolic level.

The sixth assumption of the geodesic information processing model is concerned with the neuropsychological component (see Figure 2.1). Research has indicated that the most effective way of releasing the potential of the brain is through stimulating a synergistic wholistic and complementary pattern of processing between the two hemispheres (Sperry, 1961, in Zaidel, 1981; Ornstein, 1975; Levy, 1985; Springer & Deutsch, 1989). This will allow the natural, wholistic pattern-discrimination ability of the brain to function. Pribram (1971) argues that the brain extracts meaning through wholistic multisource pattern discrimination rather than through single facts or lists. The human brain is not designed for linear unimodal thought, but operates by simultaneously going down many paths (Hart, 1983). Hart (1983) stresses the importance of presenting and assimilating information in larger patterns before the details. Thus, a geodesic framework will need to utilise formats of presenting and assimilating information that allow synergistic multimodal pattern discrimination to occur. The techniques of the MMA, specifically the Mind-Map, are assumed to stimulate multisource pattern discrimination that is brain-compatible (Leaf, 1990; Leaf et al., 1993).

The seventh assumption of the geodesic information processing model deals with the symbolic component (see Figure 2.1). The symbolic component is the expression of the metacognitive action, which is operationalised through the cognitive process. The symbolic component deals with the capacity of human beings to express and communicate meanings through using some symbolic vehicle (Allport, 1980). It is assumed that the symbolic component reflects the thought processing of the person, and is the medium through which the thought process can be manipulated.

The eighth assumption, relating to all four components of the geodesic information processing model, indicates that intelligent learning is the result of the reconceptualisation of knowledge (Iran-Nejad, 1990). The reconceptualisation of knowledge is the end result of the thought process invoked by a geodesic framework such as the MMA. This is in contrast to traditional perceptions of learning which view learning as the incremental internalisation of external knowledge (Reddy, 1979, in Iran-Nejad, 1990; Samples, 1975; Costa, 1984). This latter definition cannot account for the complex creative process involved in intelligent learning and limits learning to the development of a factual knowledge base.

In the ensuing discussion, each of the eight assumptions and their theoretical underpinnings will be explored (see Table 3.1). The assumptions are examined under each of the components of

Table 3.1: The assumptions and theoretical underpinnings of the Geodesic Information Processing Model

LEVEL	ASSUMPTIONS	THEORETICAL UNDERPINNINGS
METACOGNITION	1. Metacognition is the non-conscious level that accounts for the bulk of learning 2. The metacognitive structure of the non-conscious: (1) Metacognitive modules (2) Metacognitive processing systems (3) Metacognitive domains 3. The interaction of active and dynamic self-regulation is the operating system of effective thought processing.	– Automaticity research – Multi-source self-regulation theory – Modular theory – Suggestopeadia – Multiple intelligence theory – Lurian theory – Metacognitive research – Descriptive system theory
COGNITION	4. The cognitive component is the level on which conscious sequential thought occurs. 5. Memory enhancement, as part of the cognitive process, is contextual and content based specific to each module.	– Self-regulation theory – Cognitive research – Taxon and local memory – Memory enhancement research
NEURO-PSYCHOLOGICAL	6.1 Synergy between the hemispheres releases potential. 6.2 Metacognitive results in the activation of descriptive systems through the process of pattern recognition and feedback creating open systems. 6.3 The brain is a modular system of interlinked functional systems. 6.4 The limbic system needs to be activated in order to reconceptualize useful knowledge. 6.5 The processing of information occurs in a parallel simultaneous fashion on a non-conscious level, and in a sequential way on a conscious level.	– Hemisphericity research – Topographic inhibition theory – Descriptive systems – Pattern - recognition – Feedback – Modularity theory – Cognitive-emotive theory – Suggestopeadia – PDP theory – Modular theory
SYMBOLIC	7. The capacity to express and communicate using some symbolic vehicle.	– Symbolic system modular theory
METACOGNITION COGNITION SYMBOLIC NEURO-PSYCHOLOGICAL	8. Intelligent learning is the reconceptualization of descriptive systems leading to new knowledge.	– Self-regulation theory – Suggestopeadia

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* NOTE: SOURCES IN TEXT

the geodesic information processing model, namely, metacognition, cognition, neuropsychology and symbolism. The implications of each of the assumptions for the MMA geodesic framework will also be discussed.

3.3. THE ASSUMPTIONS RELATING TO THE METACOGNITIVE COMPONENT OF THE MODEL

There are three assumptions relating to the metacognitive component of the geodesic information processing model. The first deals with metacognition being the level on which most learning occurs. The second proposes that metacognition provides a structure for the non-conscious level. The third assumption is concerned with the conception of self-regulation and relates to both the metacognitive and cognitive component. A discussion of each assumption follows.

3.3.1. METACOGNITION IS THE NON-CONSCIOUS LEVEL THAT ACCOUNTS FOR THE BULK OF LEARNING

Theoretical underpinnings

The first assumption relating to the metacognitive component, is concerned with the non-conscious level being the root of the thought process where the majority of learning occurs. Various theories have contributed to the assumption that the bulk of learning occurs on the non-conscious as opposed to the conscious level. These theories include: automaticity research (Fodor, 1983; Reddy, 1979, in Iran-Nejad, 1990, in Iran-Nejad, 1990; Allport, 1980; Gazzaniga, 1977; Gardner, 1985; Iran-Nejad, 1990); the two-source theory of self-regulation (Iran-Nejad, 1990; Iran-Nejad & Chissom, 1988); suggestopaedic theory (Lozanov, 1978; Dhority, 1991); and modular theory (Gardner, 1985; Feldman, 1980; Saloman, 1979; Gardner & Wolfe, 1983). These authors indicate that a great deal of complex cognitive activity occurs outside conscious awareness. According to Reddy (1979, in Iran-Nejad, 1990) and Donchin (1991, in Nelson, 1992), approximately 90 per cent of learning takes place on the non-conscious level. This is corroborated by Lozanov (1978), who indicates that potential is released by the activation of the subconscious stores.

This perception of the non-conscious level is in contrast to traditional theories that limit the role of the non-conscious level to dealing with the elementary perceptual analysis of the physical features of environmental stimuli (Nebes, 1974, in Leaf, 1990). Traditional theories indicate that attention and rehearsal are prerequisites for cognitive analysis.

This implies that unattended precepts and unretrieved memories do not make contact with higher mental processing, and therefore do not influence consciousness (Khilstrom, 1992, in Nelson, 1992). Therefore, classical information processing theory cannot account for the process of learning due to the constraints placed on attention, the lack of consideration of the non-conscious level, and the belief that the existence of horizontal processes such as a general problem-solving device, perception, memory, and the like cut across heterogenous content.

In an attempt to explain this expanded role in the perception of the non-conscious level, the theories mentioned above were explored. This literature indicates that cognitive activity can become automatised (Fodor, 1983) and unconscious in the sense that it is unavailable to introspective awareness, yet still influences the cognitive end-product. Hence, metacognition influences cognition. The concept of the non-conscious level is therefore not limited to elementary perceptual analysis of the physical features of environmental stimuli, but can be expanded to include mental processes operating on knowledge structures (Nelson, 1992). This implies that events can affect mental functions even though they cannot be consciously perceived or remembered. This concept is termed attention-delegation (Iran-Nejad, 1990), and indicates that an active allocation of attention is neither sufficient nor always necessary in the learning process. Attention-delegation power is the power to continue an ongoing contribution to the learning process even after the conscious executive has focused attention elsewhere (Iran-Nejad, 1990). Therefore, attention-delegation power remains alert throughout the whole time that internal reconstruction occurs on a task until task completion relieves attention-delegation.

Implications for the MMA

Applying the above research findings to the MMA, it is assumed that the bulk of learning occurs on the non-conscious level, and that this level is the metacognitive level. This is the level on which the metacognitive action of the processing systems, of the metacognitive domain(s) selected, occurs (see Figure 2.1). The metacognitive action results in the activation of existing descriptive systems (Goldberg & Costa, 1981), which are utilised in the reconceptualisation of new descriptive systems. Therefore, by implication, this is the level on which thinking begins, and is the root of the thought process. It is also the level where new descriptive systems are reconceptualised and stored (Pribram, 1971; Goldberg & Costa, 1981). It is proposed that this level is metacognition, which is in contrast to traditional perceptions of learning and thought which view this level as cognition. As discussed previously, conscious sequential processing cannot account for the complex creative learning process, implying that there are limitations inherent in the traditional definitions of cognition and the non-conscious level.

It is postulated that the MMA activates higher mental functions on a non-conscious metacognitive level, and that these higher mental functions are not always initially available to introspection due to the process of attention-delegation. This process is clearly evidenced in the way a person who is not proficient in using the concept of Mind-Mapping creates a Mind-Map. Initially the idea that each concept must go on its own line with an organised pattern of association between the lines, is particularly difficult to integrate. This can be seen in the structure of the Mind-Map (see Chapter Two).

It is assumed that the higher mental function involved is not yet accessible to introspection and still under the control of attention-delegation. As proficiency improves, so the awareness of how to carry out the cognitive strategy - that is, the placement of each concept on a line with appropriate associations between them - improves. When this occurs, the higher mental function(s) orchestrating this particular activity has moved into consciousness (onto the cognitive level) becoming available to introspection. At this stage the higher mental function is refined. That is, an interplay between metacognitive knowledge and experience activates the same or different cognitive strategies to complete the goal of the task as efficiently as possible. These refined strategies are then automatised through experience and are once more rendered to the non-conscious, but will impact positively by being used automatically in the future creation of a Mind-Map. This process is evidenced in that, once the person has integrated the strategy of single concepts per line in an associated way, the error is seldom repeated, implying that the strategy has become automatised (rendered to the non-conscious level) yet will still impact when creating future Mind-Maps. This process is known as attention-delegation (Iran-Nejad, 1990).

The MMA assists in automatising (Fodor, 1983) as well as activating the metacognitive action which will orchestrate the complex cognitive tasks. This automatisation process renders the metacognitive action outside of conscious awareness, yet still available to influence higher mental functions, be they of a communicative or academic nature. Thus, the MMA facilitates the reconceptualisation of descriptive systems (Goldberg & Costa, 1981) and assists in rendering them to the non-conscious level, where they will impact on the reconceptualisation of new useful knowledge (Derry, 1990).

3.3.2. THE METACOGNITIVE STRUCTURE OF THE NON-CONSCIOUS LEVEL

3.3.2.1. Introduction

This assumption implies that, when one refers to metacognition, the non-conscious level is being alluded to. Therefore the MMA model is proposing a structure for the seemingly metaphysical conception of the non-conscious level. This in turn strengthens the contemporary geodesic perception of the expanded role of the non-conscious level because it provides a way of analysing the complex higher cortical functioning that is purported to be occurring on this level.

This assumption is founded on the research on metacognition (Flavell, 1978; Nelson, 1992; Derry, 1991; Paris & Winograd, 1990) and the implied relationship with modular research (Hinton & Anderson, 1981; Feldman, 1980), Lurian theory (Luria, 1980), multiple intelligence theory (Gardner, 1985), self-regulation theory (Iran-Nejad, 1990) and descriptive system theory (Goldberg & Costa, 1981). These theories cut across and link various fields of research. It is the interrelationship of these theories that has led to the uniqueness of this element of the assumption, namely, that metacognition provides a structure for the non-conscious level.

This structure of the metacognitive non-conscious level is visually demonstrated in Figure 3.1, and described in the ensuing discussion. The theoretical underpinnings and implications for the MMA are highlighted for each of the three elements of the structure of the non-conscious level. These elements are the metacognitive modules, the processing systems of the metacognitive modules and the metacognitive domains of the processing systems.

3.3.2.2. The metacognitive modules

Theoretical underpinnings

The first component of the non-conscious level of the geodesic information processing model comprises seven metacognitive modules. A metacognitive module is a cluster of intellectual abilities that form the raw material of thought (Gardner, 1985; Feldman, 1980). These modules influence the thinking process because each produces a specific type of thought based on their

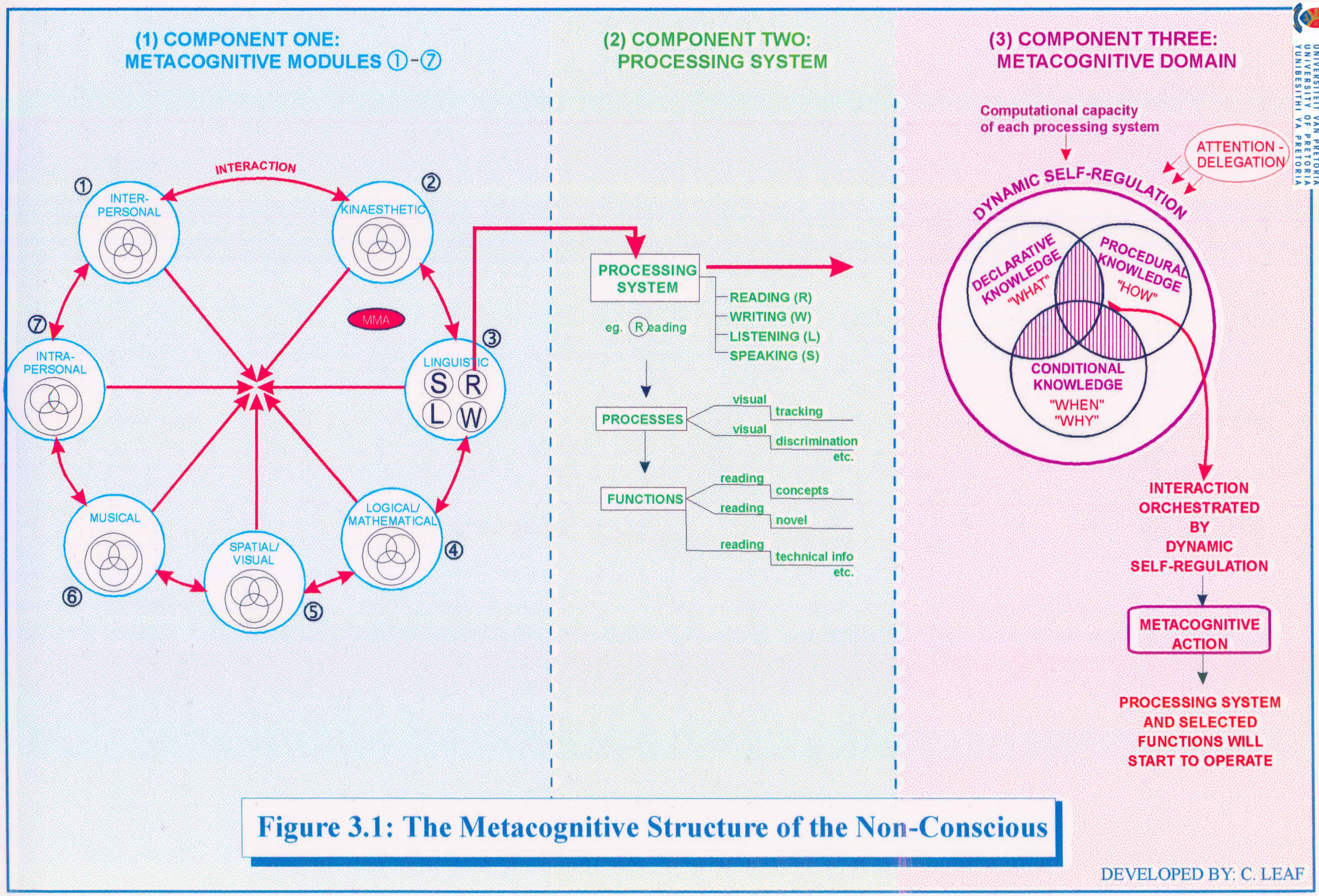


Figure 3.1: The Metacognitive Structure of the Non-Conscious

nature (Feldman, 1980). Higher order thinking such as problem solving, originality, common sense, wisdom, and metaphorical capacity, are the result of the interaction between the modules (Gardner & Wolfe, 1983). Interaction is facilitated by multimodal approaches which tap into the abilities of each module.

The concept of modules is based on the theory of multiple intelligences as developed by Gardner between 1978 and 1985, and Gardner and Wolfe (1983). This theory posits that intelligences are sets of intellectual potentials, or raw computational capacities, of which all individuals are capable by virtue of their membership of the human species (Gardner, 1985). He stresses that human intelligence needs to be genuinely useful: "human intellectual competence must entail a set of skills of problem-solving enabling the individual to resolve genuine problems or difficulties he/she encounters, and, when appropriate, to create an effective product - and must also entail the potential for finding or creating problems - thereby laying the groundwork for the acquisition of new knowledge" (Gardner, 1985: 61). The spectrum of intelligences (Gardner & Wolfe, 1983) includes: linguistic, logical/mathematical, spatial/visual, kinaesthetic, musical, interpersonal and intrapersonal. Gardner (1985) and Gardner and Wolfe (1983) have broken from the common tradition of intelligence theory which stipulates that human cognition is unitary, and that individuals can be described as having a single quantifiable intelligence (Campbell, Campbell, & Dickinson, 1992). Therefore, intellectual behaviour is evidenced in many different ways.

The notion that human cognition consists of a number of special purpose cognitive modules which are dependent on the neural structure of the brain has been endorsed by Fodor (1983), Gazzaniga (1977), Allport (1980), Rozin (1975), and Hinton and Anderson (1981). The operation of these metacognitive modules may be considered autonomous in two senses: each operates according to its own principles, and the operation of each module is not necessarily subject to conscious use (Fodor, 1983; Allport, 1980; Hinton & Anderson, 1981; Gazzaniga, 1977). The modules operation is therefore controlled predominantly through the attention-delegation process. On occasion the contents of the modules will be available to conscious introspection through attention-allocation, but they basically operate in the presence of certain forms of information to be analysed. Thus, metacognition operates at the non-conscious level, as discussed in the previous assumption. In fact, Gardner (1985) argues that the potential to become aware of the operation of the modules may be a special feature of human beings. It is postulated that when this occurs, active and dynamic self-regulation interact.

Implications for the MMA

Although individuals possess the full spectrum of intelligences, some individuals possess varying amounts of each combined in different ways, thus revealing specific cognitive features. According to Campbell et al. (1992), educational and intervention programmes have focused predominantly on linguistic and mathematical intelligence, minimising other forms of knowing. The MMA focuses on the activation and development of all seven intelligences due its multimodal and conceptual nature. It is these seven intelligences which delineate the contents of each metacognitive module on the model.

On the geodesic model, intelligences are renamed metacognitive modules. This is done as each intelligence is made up of sets of "know-how" knowledge, that is, tacit knowledge of how to execute a cognitive act (Gardner, 1985). In the study of skills and abilities, it is customary to make a distinction between "know-how" knowledge, and "know-that" knowledge. The latter is propositional knowledge about the actual set of procedures involved in execution (Campbell et al., 1992; Derry, 1991). Therefore, the intelligences described by Gardner (1985) are limited to one type of metacognitive knowledge, and do not fully explain what occurs when information is processed.

It is proposed that the true release of potential will occur not only when "know-that" and "know-how" knowledge are combined, but also when "know-when" and "know-why" knowledge and self-regulation are added to the formula. Therefore the metacognitive modules of the MMA model expand the notion of intelligences to include not only "what" knowledge, but also "how" and "when/why" knowledge and their self-regulation systems, covering the full spectrum of metacognition. In using the interrelationship between the conception of multiple intelligences and metacognition in the MMA model, a more accurate explanation for the processing of information and development of intellectual potential is provided. This is visually demonstrated and described in Chapter Two.

3.3.2.3. The processing systems of the metacognitive modules

Theoretical underpinnings

The second element of the metacognitive non-conscious is that each metacognitive module consists of processing systems and functions which realise the potential of the metacognitive modules (see Figure 3.1). The conception of processing systems and functions is based on the application of Lurian theory (1963 to 1982), which suggests that the brain does not work in individual bits, nor as a general whole, but as a series of interlaced and interlinked systems. Therefore the brain is not a conglomerate of interconnected working parts, but an infinitely integrated self-regulating system.

A processing system is a result of a whole system of processes. For example, the processing system of reading, which would be part of the linguistic metacognitive module, is made up of various processes such as the visual tracking of letters, the visual discrimination of letters, and the combining of the letters into a unit of meaning. The processing system of reading also has various functions, such as reading for factual knowledge, or reading a novel. A processing system is represented neurologically as a functional system composed of interrelations of different parts of the brain. A function fulfils or realises the processing capacities of functional systems (Luria, 1980). Functions are localised, but functional systems and their processing systems are distributed in the brain because they are made up of the localised functions (Luria, 1980).

According to Luria (1980), if a functional system is damaged, it can be reconstructed by using a different set of functions in different parts of the brain. This hypothesis is corroborated by Leaf (1990), who found that a client suffering a closed head injury significantly improved their cognitive performance after being exposed to Mind-Mapping therapy. It was postulated that the improved performance was the result of the reconstruction of functional systems.

Implications for the MMA

Each metacognitive module on the model comprises various processing systems. Processing systems are divided into functions which will eventually be expressed on the symbolic level by the cognitive action (see Figures 2.1 and 3.1). A processing system is viewed on the MMA model as the channel through which the intellectual abilities specific to a particular domain are expressed. Therefore it is posited that the MMA, due to its brain-compatible nature, will maximise the selection and integration of functions into the most efficient processing systems to operationalise the cognitive acts, resulting in optimal performance.

3.3.2.4. The metacognitive domain

Theoretical underpinnings

The third element of the metacognitive structure of the non-conscious level is the metacognitive domain (see Figure 3.1). This is the computational capacity upon which the complex realisations of the processing systems of the metacognitive modules are based.

This concept of the metacognitive domain reflects the idea that human beings are so constituted as to be sensitive to certain informational content (Gardner & Wolfe, 1983; Feldman, 1980). When a particular form of information is presented, various mechanisms in the nervous system are activated to carry out specific operations on it. From the repeated use of, elaboration of, and interaction among the computational devices, will flow forms of knowledge that can be termed useful and intelligent. Therefore a computational device can be visualised as a set of natural kinds of building blocks out of which productive lines of thought and action are built (Goodman, 1976, in Gardner, 1985).

From the literature on metacognition, it is postulated that a metacognitive domain can be subdivided into declarative, procedural and conditional knowledge (Derry, 1990; Paris & Winograd, 1990). These three types of metacognitive knowledge (declarative, procedural and conditional knowledge) are knowledge about what factors interact in which ways to influence the course and outcome of cognitive enterprises (Flavell, 1978). Derry (1990) defines declarative knowledge as an organised collection of facts and concepts, comprising many disciplines such as History, English and Science. For example, knowing that a noun is a person, place or thing is declarative knowledge. Procedural knowledge is knowledge of "how", performance capabilities or action sequences involving symbol manipulation, such as the ability to read, write or solve algebraic problems (Mastropieri & Bakker, 1990). Being able to identify the method required to solve a quadratic equation represents procedural knowledge. Finally, conditional knowledge is the "when" and "why" of applied knowledge and strategies, and is therefore a combination of declarative and procedural knowledge.

According to Flavell (1978), metacognitive experiences are any affective experiences that accompany or pertain to any intellectual enterprise. He also indicates that metacognitive experiences are especially likely to occur in situations that stimulate a lot of careful, highly complex thinking (Flavell, 1978). Borkowski, Schneider and Pressley's (1989) model of efficient information processing confirms this viewpoint. In their model these authors demonstrate how metacognitive components of declarative, procedural and conditional knowledge influence cognitive strategy selection and use in order to achieve the end result, which is efficient cognition.

Implications for the MMA

Each processing system within each metacognitive module on the MMA model has a computational capacity known as the metacognitive domain. This metacognitive domain operates the processing systems of the metacognitive modules. When the three elements of the metacognitive domain (declarative, procedural and conditional knowledge) interact, the result will be metacognitive action (see Figure 3.1). Metacognitive action directly influences the cognitive level. The quality of the interaction determines the quality of the cognitive action, and ultimately, the symbolic output.

The interaction of the three types of metacognitive knowledge is influenced and orchestrated by dynamic self-regulation. Dynamic self-regulation refers to metacognition in action, or how metacognition orchestrates cognitive aspects (Paris & Winograd, 1990). It is proposed that the MMA influences dynamic self-regulation, thus facilitating elaborate interaction amongst these computational devices, the metacognitive domains, to produce intelligent forms of knowledge. A chemical analogy can be used to explain the interaction of the metacognitive domains as facilitated by the MMA. The metacognitive domains are elements in a chemical system, the basic constituents of which can combine to form compounds of various sorts and into equations that result in various processes and products. The metacognitive domains of the metacognitive modules, while initially raw and unmediated, have the potential to be involved in symbolic systems through mediation (Gardner, 1985). It is postulated that the MMA provides this mediational system, facilitating the combination of raw elements into productive intelligences and performance.

Therefore, the monitoring of cognitive enterprises proceeds through dynamic self-regulations controlling the actions of and interactions among the three types of knowledge of the metacognitive domain. It is postulated that the MMA stimulates this dynamic interplay, which will affect the cognitive function, and ultimately, the symbolic output. Thus, cognitive strategies achieve cognitive progress, and a knowledge of what and how to use these cognitive strategies is the result of the metacognitive action of the metacognitive domains. The latter is invoked by the MMA which by implication invokes highly active and complex thinking.

3.3.3. THE INTERACTION OF ACTIVE AND DYNAMIC SELF-REGULATION IS THE OPERATING SYSTEM OF EFFECTIVE THOUGHT PROCESSING

The third assumption deals with the concept of self-regulation and relates to the metacognitive and cognitive components of the geodesic information processing model.

Theoretical underpinnings

The assumption stated above is based on Iran-Nejad's (1990) two-source theory of self-regulation. Iran-Nejad (1990) proposes two different sources of internal self-regulation in contrast to the traditional idea of one, as discussed in Chapter Two.

In adopting a two-source perspective on internal self-regulation, the conception of interaction becomes significant. This interaction is important because of its potential implications for academic learning and education in general. The ensuing discussion evaluates the advantages of the interaction between active and dynamic self-regulation.

A single source theory (conduit or traditional) of internal self-regulation implies that change only occurs when the internal executive directly allocates attention to the source of change (Anderson, 1985; Schneider & Shiffrin, 1977), resulting in incremental internalisation. Thus it is a sequential one-thing-at-a-time process, which is limiting. The two-source theory, by contrast, implies that constructional change is governed by attention-delegation and allocation, and not by attention-delegation alone. Attention-delegation is the ability of the dynamic self-regulatory process to continue its ongoing contribution to internal reconstruction even after the executive moves immediate attention to another site (Iran-Nejad, 1990). This occurs when the central executive controlling active self-regulation interacts with the local component which is dynamic self-regulation.

Dynamic self-regulation involves the actions of evaluating, planning and self-regulating (Iran-Nejad, 1990). Furthermore, dynamic self-regulation is seen as being the route to the so-called "vastly untapped subconscious stores" that Lozanov (1978) refers to in the science of suggestopaedia. Iran-Nejad and Chissom (1988) propose that dynamic internal self-regulation is a possible solution to how the internal construction system manages to overcome the inherent limitations of the executive control. The dynamic control concept suggests that brain microsystems and subsystems can use local resources in as many independent sites as necessary to regulate their own activity.

Furthermore, it is proposed that it is dynamic self-regulation that maintains alertness in the components throughout the whole time that internal reconstruction on the particular task is in process (Iran-Nejad, 1989, 1990). This is in accordance with the implication from the literature that cognitive activity can become automatised (Fodor, 1983), and therefore unconscious in the sense that it is not available to conscious introspection, yet still influences the cognitive end-product.

Implications for the MMA

The primary objective of the MMA is to create autonomous independent learners (Slabbert, 1989), and it is believed that this objective will only be achieved when interaction between dynamic and active self-regulation are activated. Once this interaction occurs, the cognitive process is activated. Cognition is regulated by metacognition, and carries the metacognitive action of the processing system through to the symbolic expressive level. It is hypothesised that the MMA plays a role in activating and enhancing this interaction.

Thus the implication of the two-source theory for the MMA model is that the metacognitive experiential component can be likened to dynamic self-regulation controlling the metacognitive non-conscious process. Active self-regulation can be viewed as the executive of the conscious cognitive process carrying out the metacognitive function.

On the cognitive level, dynamic and active self-regulation will interact to produce the output, thus the conscious level and non-conscious level will influence output. There will however, be times when only active self-regulation operates alone, for example, when a new production is being learnt for the first time. Once this production starts to become internalized, active and dynamic self-regulation will interact, resulting in improved depth of processing. It is further proposed that the quality of the interaction will determine the effectiveness of learning and, ultimately, the development of intelligence. It is at this level that the MMA is believed to make its greatest contribution that is, the enhancement of the interaction process.

Iran-Nejad (1989, 1990) argues that young children are much more effective learners than older children because of the authenticity of the environment in which they learn and its inherent relationship with the multisource nature of learning. An authentic environment will facilitate the interaction between active and dynamic self-regulation. Older children, by contrast, become increasingly more proficient in their use of active self-regulation, which in itself is not negative. However, it becomes a problem when over-reliance on the untrained or even ill-trained active executive occurs, resulting in over-reliance on learning strategies at the expense of dynamic self-regulation (Iran-Nejad, 1989, 1990). This results in sequential rote learners reducing potentials. The objective, by implication, would be to have interaction between active and dynamic self-regulation. This can be facilitated by geodesic approaches such as the MMA.

Therefore, it is postulated that the MMA allows the interaction to occur, enabling the learner to engage in multimodal encoding unencumbered by potential interference from sequential one modality at a time executive encoding. The MMA process also allows the active executive, which develops with maturity and which is increasingly intentional (Iran-Nejad, 1990), analytic and sequential, to interact positively with dynamic self-regulation. Thus metacognition and its executor, dynamic self-regulation, can be trained to optimise the cognitive process by developing active self-regulation using geodesic approaches such as the MMA.

Chi (1985) argues that the more expert or experienced one becomes within a field, the more dynamic self-regulation controls the situation. Evidence of the latter would be the use of more effective problem-solving strategies by an expert as opposed to a novice (Chi, 1985). Chi (1985) found that novices attacked a problem by trying various paths until the correct solution was arrived at. In contrast, experts reflected on a problem in order to conceptualise it, and used underlying principles to form hypotheses to be tested towards the solution (Chi, 1985). It is felt that the process of becoming an expert is dependent on the quality of the interaction of dynamic and active self-regulation, which can be facilitated by the MMA. This is important because considerable evidence has accumulated that suggests that an emphasis on metacognition during training can result in significant long-term improvements in cognitive tasks (Bereiter, 1985; Bransford, 1979).

The geodesic framework of the MMA uses a cognitive task analysis (Redding, 1990) where the metacognitive skills of the expert are analysed, and the discrepancy between the expert and the novice performance is fed back to the novice. This is in contrast to traditional behavioural approaches which specify training objectives, materials and behavioural criteria needed to meet performance objectives. It is posited that cognitive task analysis facilitates the interaction between active and dynamic self-regulation because it has a process orientation as opposed to the product orientation of behaviourism.

3.4. THE ASSUMPTIONS RELATING TO THE COGNITIVE COMPONENT OF THE MODEL

In this section two assumptions relating to the cognitive component of the geodesic information processing model are presented: that cognition is the level on which conscious sequential thought occurs and that it is also the level on which memory enhancement occurs.

3.4.1. THE COGNITIVE COMPONENT IS THE LEVEL ON WHICH CONSCIOUS SEQUENTIAL THOUGHT OCCURS

Theoretical underpinnings

The fourth assumption of the geodesic information processing model is that the cognitive component accounts for the conscious sequential allocation of immediate attention to a task. The cognitive component is viewed as a construct of the mind apart from the metacognitive component, and not as another level of the same process as in traditional perceptions of cognition. This is in accordance with much of the recent, more geodesic views on cognition and metacognition (Brown, 1990; Flavell, 1978; Khilstrom, 1992, in Nelson, 1992; Iran-Nejad, 1990; Gardner, 1985; Gardner & Wolfe, 1983). The difference between traditional behaviouristic approaches and geodesic approaches to cognition lies in the perception of the role that cognition plays in the learning process. Cognition is traditionally viewed as the level where intentional, voluntary or executive self-regulation occurs (Bereiter, 1985; Brown, 1978; Costa, 1984).

However, as already discussed under the self-regulation assumption, learning on this level occurs slowly and hierarchically, with knowledge of simpler facts being mastered before more complex structures (Iran-Nejad & Chissom, 1988). According to traditional cognitive behaviouristic approaches, this is the level on which complex learning occurs, and metacognition is the level where conscious analysis of the cognitive process occurs. This would imply that metacognition is the consciously analytical part of the cognitive process, a separate higher level of cognition and a very conscious process (Reddy, 1979, in Iran-Nejad, 1990; Slife et al., 1985; Brown, 1978). However, this traditional assumption of the distinction between cognition and metacognition cannot account for the creative and multisource nature of learning, as conscious sequential and effortful attention-paying results in committing facts and definitions to memory and not creative problem-solving. There must be another level involved in order to account for both fact learning and the creative problem-solving learning of complex schemata. Geodesic approaches to learning and intellect (Lozanov, 1978; Dhority, 1991; Gardner, 1985; Iran-Nejad, 1990) recognise the limitations of trying to learn complex schemata in a conscious sequential manner only, and indicate that this conscious cognitive component can therefore only account for about 10 per cent of learning. In accordance with the literature on the expanded role of the non-conscious level and self-regulation, cognition and metacognition are redefined in order to account more accurately for the creativity and multisource nature of thought and learning. These definitions are discussed in the next section.

Implications for the MMA

Metacognition and the role of self-regulation have already been discussed under the first three assumptions. In this section the difference between cognition and metacognition is highlighted. This difference is visually demonstrated in Figures 2.1 and 2.3. Within the geodesic framework of the MMA, the cognitive level accounts for the conscious thinking that occurs directly before the symbolic act which is the output. This conscious thinking is slow and sequential and operates under the control of active and dynamic self-regulation thus requiring effortful attention-paying. The conscious cognitive process can range from basic thinking skills to higher levels of abstract thought depending on the quality of the metacognitive interaction, as well as the interaction of active and dynamic self-regulation. Cognition within the MMA geodesic approach is also viewed as the process that operationalises the metacognitive action, and is thus the result of the interaction of active and dynamic self-regulation.

The effectiveness of cognition is therefore dependent on the interaction with metacognition, as well as the efficiency of metacognition. Metacognition, on the other hand, is viewed as the non-conscious level where the bulk of learning occurs. By implication, if something is conscious, it has been moved onto the conscious cognitive level by the interaction of dynamic and active self-regulation. In contrast to cognition, the non-conscious metacognitive level is viewed as being fast, simultaneous and active in the creative assimilation, reconceptualisation and processing of the information that will be utilised on the cognitive level.

3.4.2. MEMORY ENHANCEMENT IS PART OF THE COGNITIVE PROCESS AND DEPENDS ON CONTEXT AND CONTENT

Theoretical underpinnings

The fifth assumption posits that the enhancement of memory, which will eventually be stored on the metacognitive modular level, occurs on the cognitive level. This assumption is based on the literature reviewing how memory can be improved (Buzan, 1991; O'Keefe & Nadel, 1978; Russell, 1986; Dhority, 1991; Lozanov, 1978; Jensen, 1995; Feldman, 1980; Boller & Rovee-Collier, 1992).

The framework adopted in the MMA for reviewing long-term memory systems is that proposed by O'Keefe and Nadel (1978) because it adopts a modularity perspective which is geodesic. O'Keefe and Nadel's theory (1978) indicates that each module of knowledge has its own memory system specific to that module, for example linguistic or spatial mathematical. Each module would thus possess adapted formats of memory, which allow their specific characteristics to be realised (Gardner, 1985; Feldman, 1980).

O'Keefe and Nadel (1978) discovered a critical biologically-based difference between the two ways new information is dealt with: the brain sorts and stores information according to whether it is embedded in context or content (Jensen, 1995). The difference between the two is that information embedded in context (episodic/locale memory) is stored in relationship to a particular location or circumstance with which it is associated and categorised. In contrast, information embedded in content (semantic/taxon memory) is unrelated factual information contributing to the knowledge base of memory (Jensen, 1995).

Referring back to the structure of the non-conscious level (see assumption two and Figure 3.1) and the metacognitive domain specifically, context and content memory can be compared to declarative, procedural and conditional knowledge. Declarative and procedural knowledge, unless associated with each other and with conditional knowledge, will simply become content memory. Content memory does little to contribute to creative problem-solving learning and the development of potential as knowledge of unrelated facts is not deep processing. This type of learning is often the result of conscious cognitive rote-learning under the control of active self-regulation alone. In order to create context memory, the declarative, procedural and conditional knowledge need to be associated meaningfully.

Research has indicated that context memory has unlimited capacity, forms quickly, is easily updated, requires no practice, and is used effortlessly by everyone (Jensen 1995; Hand, 1986; O'Keefe & Nadel, 1978). This would indicate that context memory is under the control of dynamic self-regulation on the metacognitive level. According to Boller and Rovee-Collier (1992), this natural context memory is based on movement, music, activation of all sensory modalities, sounds, puns, relationships, associations and position in space and time. In addition the formation of natural memory is motivated by curiosity, novelty and expectations. Information embedded in content (semantic) is, by contrast, usually learned through rote and by following lists. The learning of content without a context is difficult for the brain (Hart, 1983). Unfortunately this type of learning is typified by traditional academic approaches (Hart, 1983; Dhority, 1991; O'Keefe & Nadel, 1978; Jensen, 1995). It tends to lead to rote learning without thinking. According to O'Keefe & Nadel (1978), this taxon (content) system is categorical and will disintegrate if the information goes unrehearsed. Therefore, by adding pictures, sounds, colour, dimension, and passionate involvement to the learning process, a context is built up around the conceptual information, causing the memory to be placed within the context (locale) system (Hand, 1986). Furthermore, according to Calvin and Ojemann (1994), active memory is an organised pattern of synaptic strengths, but it needs an overall pattern of associations to give it meaning. Thus memory improves when context has been established through associated and categorised patterns.

On a biological level, when something learned is rehearsed, the axonal and dendritic connections enlarge allowing for more chemical transmission to be emitted into the synapse, which in turn makes it easier for the message to be passed on (Hand, 1986). When a learned item is practised in many ways, the neurons make new connections with different cells, networking the information by branching the message to different sites in the brain (Hand, 1986; O'Keefe & Nadel, 1978).

Implications for the MMA

In the geodesic information processing model, memory is seen as part of the cognitive process, where the new descriptive systems are reconceptualised. Once a new descriptive system is reconceptualised, it is stored in the appropriate metacognitive domains of the specified metacognitive modules in the form of declarative, procedural, and conditional knowledge. Therefore, reconceptualisation of new knowledge is actualised and enhanced on the cognitive level, then stored on the metacognitive level, where it will be used in the future reconceptualisation of new knowledge.

The process of storing is enhanced by organisation, association and categorisation in the selected information, which are facilitated by the spatial pattern structure of the Mind-Map. The actual structure of the Mind-Map contributes to the enhancement of natural memory because "the information can also be stored in a fabric or weave of 'mental space' which is a thematic map of the intellectual landscape, where learning occurs as a result of changes in location or circumstance, or the use of thematic teaching, storytelling, visualisation and metaphors" (Jensen, 1995: 205). The Mind-Map's structural nature builds meaning networks which enhance an organised useful development of knowledge. The Mind-Map thus facilitates the networking of information across the brain-building patterns of meaning.

Organisation is enhanced when the context is provided, such as when concepts as opposed to key words are used in the creation of the Mind-Map, as concepts are contextually based and key words are content-based. The MMA is context building, which facilitates the placement of information in the context (locale) system. During the creation of the Mind-Map using the MMA, colour, patterns, images and dimension, movement and sound are all used to provide a context for the information. In this way declarative, procedural and conditional knowledge are interrelated, which improves memory. Additionally, in the MMA, specifically in the output stage, the learner is encouraged to make the work "come alive" through the use of intensified sensory input.

3.5. THE ASSUMPTION RELATING TO THE NEUROPSYCHOLOGICAL COMPONENT OF THE MODEL

The sixth assumption of the MMA model is concerned with the neuropsychological aspects of: synergy between the hemispheres, pattern recognition, modularity, the limbic system and parallel and sequential processing. Each of these aspects of the neuropsychological component is examined separately in order to establish the theoretical underpinnings and implications for the MMA.

3.5.1. ASPECT ONE: *Synergy between the hemispheres releases potential*

Theoretical underpinnings

In order to release potential, the left and the right cerebral hemispheres need to function synergistically, which is the natural performance capability of the brain (Jensen, 1995). Therefore, in order to perform on a higher level cortically, the two hemispheres need to process information in a complementary fashion. In order to establish the theoretical underpinnings of the harmonious functioning of the brain, the research on hemisphericity needs to be examined.

Speculation concerning the nature of hemispheric asymmetry has followed research with split-brain patients and other investigations into the functioning halves of the brain (Sperry, 1961, in Zaidel, 1981; Ornstein, 1975; Diamond, 1972, in Leaf, 1990; Zangwill, 1975; Levy, 1985). The issues surrounding hemispheric specialisation are diverse, complex and sometimes controversial. An exploration of hemisphericity reveals that the true development of potential lies in the collaborative effort of both hemispheres.

Since the split brain research (Sperry, 1961, in Zaidel, 1981; Ornstein, 1975; Levy, 1985), the idea that the two hemispheres are specialised for different modes of thought has led to the concept of hemisphericity, which refers to the idea that an individual relies more on one hemisphere than on the other. This different utilisation of the hemispheres is presumed to be reflected in the individual's cognitive style (Jensen, 1995; Springer & Deutsch, 1989; Kline, 1990).

This research has also led to a progression of labels describing the processes of the left and right hemispheres (Dhority, 1991). According to Springer & Deutsch (1989) the most widely cited characteristics of left and right hemisphere processing may be divided into five main groups which form a kind of hierarchy, namely:

- ❑ Left hemisphere: verbal, sequential, logical / analytical, rational, western thought
- ❑ Right hemisphere: non-verbal / visuo-spatial, simultaneous, gestalt, intuitive, eastern thought.

However it would appear that the difference between the hemispheres is in the way they process information, as opposed to their having different abilities (Springer & Deutsch, 1989; Levy, 1985; Jensen, 1995).

The left hemisphere has a more sensory and motor-specific processing function, the right hemisphere a more associative processing function, and these functions are complementary. This indicates that what are major capabilities of one hemisphere, are minor capabilities of the other hemisphere (Levy, 1985). The hemispheres are in fact, able to perform each other's functions in different complementary ways (Goldberg & Costa, 1981; Levy, 1985). Sagan (1977) indicates that left and right hemisphere processing has to interact in a complementary way to produce higher cortical functioning. He argues that in order to solve complex problems in changing circumstances, both cerebral hemispheres are required and the corpus callosum plays an important role in the integrating process. In the normal functioning brain, both hemispheres share in mental activities (Kimura, 1973). According to Hand (1986) scientists have yet to discover one higher intellectual function controlled entirely by one hemisphere. Levy (1985) has confirmed that both sides of the brain are involved in nearly every human activity - it is all a matter of timing and degree of involvement. Gazzaniga (1985, in Jensen, 1995: 14) argues that "events occurring in one hemisphere can influence developmental events occurring at the same time at very remote parts of the other hemisphere". The right cerebral hemisphere processes wholistically in a random fashion, and the left processes parts in a sequential fashion (Jensen, 1995). Thus, the right hemisphere has a greater capacity for dealing with informational complexity and for processing many modes of representation of a task. The left hemisphere is better at tasks requiring fixation on a single often repetitive mode of representation. Most cognitive and metacognitive tasks require a combination of both types of processing (Jensen, 1995; Levy, 1985).

The relaying of information between the hemispheres occurs via the corpus callosum. The corpus callosum, the largest of the hemisphere's interconnecting nerve fibres, plays an important role in the synergistic processing of information and the development of patterns of meaning. The corpus callosum has been seen as an interhemispheric integrator, a means of updating each hemisphere regarding information received by the other, and even suppressing one hemisphere while the other takes over some activity (Myers, 1956; Ferguson, 1985, in Larsson & Starrin, 1988; Sidtis & Gazzaniga, 1983, in Gardner, 1985). However, according to Springer & Deutsch (1989) and Cook (1984) this viewpoint does not account for the corpus callosum's complex interconnections to so many regions of the brain. Cook (1984) alternatively describes the role of the corpus callosum as a topographical inhibitor which shows how activation of complementary aspects of almost any function in the two hemispheres can occur. That is, an excited neuron on one side sends a generalised message to the other. This message would call on related programmes in order to prompt further understanding. One of the assumptions underlying Cook's (1984) model is that related aspects of some item in memory are represented in the brain anatomically near each other, or at least access to these related aspects is provided by neighbouring neurons.

Implications for the MMA

The MMA uses techniques that stimulate a synergistic processing between the hemispheres. These techniques include colour, images, patterns, dimension, movement and concepts arranged in a logical, analytical and associative way using spatial and pattern principles. In the Mind-Map one shifts from the parts to the whole constantly in a simultaneous fashion, and this alternating between the gestalt picture and the sequential details facilitates complementary interaction between the hemispheres (Jensen, 1995). Linear monochromatic note-taking, by contrast, only allows sequential "one-thing-at-a-time" analysis of information which obscures a gestalt impression and thus limits the potential flexibility of thought. Due to the nature of the MMA, the right hemisphere's ability to deal with informational complexity is facilitated at the same time as the left hemisphere's ability to focus on repetitive modes of representation and single fixations. Therefore sequential single items of knowledge, as well as the simultaneous patterns of meaning arising out of categories of associated information, are both dealt with on the Mind-Map. This is in contrast to linear representations which only deal with sequential single items of knowledge.

Cook's (1984) topographic inhibitory model explains why the Mind-Map structure is so effective as an associative tool for the creative expansion of ideas. According to Cook (1984), the two hemispheres are designed to collaborate with each other during the thinking and learning process. Using the left hemisphere alone for higher cortical functions will limit the quality of the information processing, leading to rote type learning. The MMA, which takes advantage of the processing capabilities of both hemispheres, will facilitate the collaborative effort between the hemispheres. Cook's (1984) model accounts for why the Mind-Map stimulates ideas. The spatial arrangement of the networks of thought that are developed on the Mind-Map are literally the visual representation of the synaptic connections between the neurons. Synaptic connections that are anatomically linked by the axons and dendrites across both hemispheres will, when activated, release a flow of electrical activity across these associated connections. These connections represent the cognitive associations made between the information in the problem-solving stage of the learning process. These cognitive associations are represented visually on the Mind-Map. This is the reason for the rule of one word per line, with each progressive line growing out of the previous one, that has to be applied when Mind-Mapping. Each concept on the Mind-Map has to be represented as closely as possible to the concept it is associated with, in a logical rational fashion. This arrangement of inter-relationships grows deductively from the central global theme outwards and inductively inwards in an associative way. Linking lines are used to show the associations between nodes; by implication, the closer the nodes are together, the more closely associated are the concepts. Thus, the interlinking lines represent the route of access between complementary associated ideas, allowing for more flexibility in thought.

Therefore the Mind-Map becomes the visual or overt representation of the raw material of the non-conscious, which are the linked synaptic connections. Looking at the pattern of the Mind-Map will serve to activate the associations made on the anatomical level. This is the stimulation of ideas referred to earlier. Furthermore, because Mind-Maps are overt, they are open to manipulation. Useful knowledge out of which meaning can be extracted will not arise out of a selection of random associations between the right and left hemispheres. Rather, this arrangement will be organised with recognisable patterns of associations. Thus, two distinctly different patterns of neuronal excitation are produced within bilaterally identical regions, allowing the two brains momentarily to hold different perspectives on the same information (Cook, 1984).

The more organised the bilateral representation, the more efficient the metacognitive action, leading to more effective cognitive action, and, ultimately, more effective symbolic output. It is proposed that the MMA enhances this process because organisation of concepts is fundamental to the Mind-Map. By implication, therefore, a disorganised Mind-Map would indicate that the different perspectives being held in the two hemispheres at the same time are random and have literally not made connection and are therefore not reconceptualising useful knowledge. The Mind-Map would allow the identification of how the new patterns are incorrect.

3.5.2. ASPECT TWO: *The metacognitive action results in the activation of descriptive systems through the process of pattern recognition and feedback, creating open systems*

Theoretical underpinnings

It is assumed that the MMA invokes the interaction of declarative, procedural and conditional knowledge regulated by dynamic self-regulation, which results in metacognitive action. This metacognitive action in turn activates existing descriptive systems through a process of pattern-recognition and feedback. These descriptive systems are used to reconceptualise new knowledge. The result is that open systems of processing are created.

Research into the pattern recognition nature of the brain and the way in which the brain deals with incoming information has led to the above assumption of the geodesic model (Hyden, 1977; Hart, 1983; Pribram, 1971; Jensen, 1995; Nummela & Rosengren, 1985; Anokhin, 1976, in Buzan & Dixon, 1976; Goldberg & Costa, 1981). The concept of descriptive systems and the pattern-recognition nature of the brain are central issues in the motivation for the multi-dimensional as opposed to linear structure of the Mind-Map.

A descriptive system is a built-in organisational scheme that the brain has for dealing with incoming information (Goldberg & Costa, 1981). Depending on the type of new information to be learned, certain descriptive systems will be activated and processing will occur. The level of complexity of the cognitive act will determine how efficiently and how many descriptive systems are activated (Goldberg & Costa, 1981). The activation of descriptive systems is done through the process of pattern recognition (Pribram, 1971; Hart, 1983; Hyden, 1977). Pattern-recognition occurs when patterns in the environment are recognised, and our nerve cells either block or pass on that message according to a recognition factor which is similar to Anokhin's expectation and experience concept (Anohkin, 1976, in Buzan & Dixon, 1976). This will lead to the secretion of excitatory or inhibitory chemicals and this in turn is the process through which we learn and remember (Hand, 1986: Hand & Stein, 1986: Hart, 1983). Therefore, the brain constructs maps of external and internal stimuli.

The areas in the brain responsible for pattern-detection and concept creation contain structures that categorise, discriminate and recombine the various brain activities occurring in different kinds of global mappings (Hart, 1983). Pribram (1979) indicates that the brain extracts meaning through wholistic pattern discrimination rather than singular facts or lists, and that the initial stages of processing are parallel rather than serial. Pribram (1979) argues that feature analysis and meaning extraction are the result of pattern matching as opposed to feature discrimination and detection.

Consequently, the human brain is not designed for linear thought, but operates by simultaneously going down many paths (Hart, 1983). Hart (1983) emphasises the importance of presenting information in larger patterns before the details - in other words deductively. Hence, the traditional notion of presenting information sequentially building up to the whole is incorrect. Rather one needs to develop analogical patterns where the gestalt is presented first, and then the details.

Nummela and Rosengren (1985) emphasise the importance of patterns in learning and state that the neocortex is both a pattern maker and pattern detector in the creation of meaning and reconceptualisation of knowledge. Therefore, the structures in the brain, instead of categorising outside inputs from sensory modalities, categorise parts of past global mappings according to modality, the presence or absence of movement, and the presence or absence of relationships between perceptual categorisations (Jensen, 1995). The pattern detection structures in the brain must be able to activate or reconstruct portions of past activities of different types of global mappings, for example, those involving different sensory modalities. In addition, these pattern detection structures need to be able to recombine, repattern, reformulate, or compare the patterns (Jensen, 1995). Every new pattern (newly reconceptualised knowledge structure) is relegated to the non-conscious (Hart, 1983; Jensen, 1995; Lozanov, 1978). The process of reconceptualising new patterns of knowledge utilises both the conscious and non-conscious levels (Jensen, 1995).

The process of acquiring descriptive systems is enhanced by feedback. Feedback is necessary to generate information about the effectiveness of the brain's programmes, and is essential for optimal brain functioning (Hart, 1983; Dhority, 1991). This concept of feedback relates to the research done by Anokhin (1976, in Buzan & Dixon, 1976), which indicates that the choice neurons have is based on feeding back to the neuron the results of the action selected. He also found that the more that was expected from the neuron, the more the neuron responded by growing additional dendritic connections. This research has been corroborated by Rosenzweig (1976, in Buzan & Dixon, 1976), who has shown that an increase in connections between neurons results in improved cognitive functioning. Thus "high quality, high volume input is the raw material on which the brain thrives " (Dhority, 1991: 22).

As the learner interacts with the environment, proteins present in nerve cell membranes apparently enable the activation of large numbers of neurons simultaneously (Springer & Deutsch, 1989). The more sensory channels used to input information, the greater the number of storage sites activated (Hyden, 1977). According to Hyden (1977), the working hypothesis is that protein differentiation caused by experience and learning will secure the concomitant activation of all the neurons which have undergone a similar differentiation from the same stimulus. It does not matter in what part of the brain the neurons are located, at learning neurons become highly active in a collaborative way across both hemispheres. The learning mechanism of the brain is active and not reactive as in a conditional behaviouristic system (Hyden, 1977; Hand, 1986).

Implications for the MMA

The emphasis of the MMA is on the meaningful acquisition of useful knowledge through the utilisation of a non-linear multidimensional diversified patterned format. The MMA considers the role of the non-conscious level and acknowledges the role of implicit intuitive knowledge. The emphasis is on meaning and intrinsic motivation.

The Mind-Maps are the patterned "tools" of the MMA. Mind-Maps help the patterns in the environment to be recognised. It is postulated that during the process of Mind-Mapping, the activation of descriptive systems across both hemispheres is enhanced and improved because the Mind-Map is a pattern that stimulates the collaboration of electrical activity across the hemispheres which activate the pattern recognition process in the brain. More specifically, the patterns arising out of the MMA activate the knowledge arranged in global mapping formats within each metacognitive module (linguistic, spatial, mathematical, etc). The logical associated arrangements between the perceptual categorisations on the Mind-Map result in efficient activation of the descriptive systems of the modules. This assists in the recognition of the inter-relationships between the information, which results in creative integrated learning. The pattern-making nature of the brain is of paramount importance in the creation of brain-compatible environments. This serves as further motivation for proposing the MMA as a framework within which to develop meaningful learning.

The actual structure of the Mind-Map invokes pattern recognition because of its deductive/ inductive nature. That is, concepts are stored and presented on the Mind-Map radiating deductively outwards from a central point, and inductively inwards towards a central point. This leads to analogical reasoning being applied in the creation and interpretation of the Mind-Map, making the MMA an active process approach. Programmes are created by having a correct general idea (activation of background knowledge), and then by gradually reducing error through the feedback process (Hart, 1983). According to Dhority (1991), what a learner needs is to be guided and encouraged as he acquires descriptive systems which requires much trial and error. The Mind-Map provides a way of observing programme selection, the acquisition of descriptive systems and the reconceptualisation of knowledge, as the Mind-Map visually represents the thought process.

Furthermore, through feedback, the MMA creates an open system of learning which allows a larger number of processing units to be activated in order to create the most efficient state of activation across the whole system. This could be equated on a psychological level with the highly efficient performance of a cognitive task such as problem-solving. Hence the "open system" that is created within the MMA framework is not a randomised flow of information, but a highly organised creative structured process. In other words, freedom within structure is created.

An environment is created that conforms to the natural neuropsychological functioning of the brain, allowing increased expectation and thus increased interconnections between neurons, leading to enhanced metacognitive and cognitive functioning. Rosenzweig and Bennet (1976), in their attempt to ascertain the biological processes involved in learning and memory, have confirmed the susceptibility of the brain to actual physical and clinical changes from different types of exposure. Their research indicates that what is needed is to find better means of "packaging" information to aid learning and retrieval. Thus, the MMA is an attempt to provide a framework within which to package information in order to create open systems. The MMA provides learners with a way to conceptualise ideas, shape thinking, understand better what they know, and finally, to create meaning from within, using the process of feedback.

A Mind-Map can be viewed as a way of observing mental processes in action because as one creates, these tracings by the hand are actually sensory representation of the electrochemical signals being passed from one neuron to another. The Mind-Map format ensures that storage and retrieval will be more efficient than if a linear format is used. The latter forces thinking into a linear sequence when the mind is processing different levels of information rapidly in a parallel way, and thus obscures the thought process. Linear thinking is not compatible with the way the brain functions, and for this reason, problems in organising, sequencing, logic, and categorisation will be experienced.

Cultural and individual differences may influence the repertoire of pre-existing codes or descriptive systems. The MMA will allow the individual to express this individuality of thought patterns (Leaf, Uys & Louw, 1993). By manipulating the thought patterns an individual can develop into an independent autonomous learner and advantage can be taken of the open system of the mind.

All the sensory channels are induced by the geodesic methodology of the MMA,. It could thus be hypothesised that the MMA increases the number of proteins present in the nerve cell membranes, which increases the efficiency and rate of firing, and hence more activation and better cognitive functioning.

3.5.3. ASPECT THREE: *The brain is a modular system of interlinked functional systems*

Theoretical underpinnings

The mental processes of the brain can be conceived of as having independent or encapsulated modules each operating according to its own rules and showing its own processes (Feldman, 1980; Gardner, 1985). These modules, although independent, all interact to produce metacognitive and cognitive activity. A modular system's perspective favours vertical models like language, musical processing, and visual analysis, each with its own characteristic mode of processing, as opposed to horizontal processes like general perception and memory (Gardner & Wolfe, 1983).

The conception of modularity and functional systems in the brain was initially devised by Anokhin (1976, in Buzan & Dixon, 1976), and later developed in the functional system theory by Luria (1963 to 1982), and has been supported by Fodor (1983), Gazzaniga (1977), Allport (1980), Rozin (1980), and Hinton and Anderson (1981). Luria's theory is different from the research that attempts to ascribe certain whole functions to the left hemisphere and others to the right. The modularity perspective (Luria, 1982; Gardner, 1985; Gazzaniga, 1977; Rozin, 1980; Allport, 1980; Hinton & Anderson, 1981) views the brain as being organised into independently functioning modules that have representation across both hemispheres. Neurologically, the modules are represented as modular columns of neuronal cells ascending from the cortex to the subcortex to the limbic system across the left and right hemispheres (Luria, 1978; Gardner, 1985). Each module is viewed as having its own processor and memory. That the modules work together in the execution of complex tasks is accepted, but as Gardner (1985) says, at any one historical moment, one can specify the modules as independent units.

Research in neurology has shown that there are units of subserving microscopic abilities in the individual columns of the sensory or frontal area (Rosenzweig & Bennet, 1976; Diamond, 1988; Mountcastle, 1978; Zaidel, 1985). It has also been shown that there are much larger units visible to inspection which serve more complex and molar functions such as linguistic abilities - much like Luria's functional systems (Mountcastle, 1978; Crick, 1981; Hubel, 1980, in Gardner, 1985). These studies suggest a biological base for modularity.

Gardner's extrapolation of modularity is developed in his theory of the "multiple intelligences", where an intelligence is viewed as a vertical module of knowledge such as linguistic, spatial, or musical, as already discussed. Furthermore these studies have suggested the presence of areas in the brain that correspond at least roughly to certain forms of cognition, as well as implying a neural organisation for different modes of information processing (Gardner & Wolfe, 1983; Springer & Deutsch, 1989).

Implications for the MMA

The modularity perspective provides a more geodesic way of analysing the knowledge base of long term memory as well as providing a more accurate explanation for the synergistic functioning of the brain. In a modularity perspective, knowledge is grouped into vertical as opposed to horizontal categories. For example linguistic knowledge has representation across both hemispheres within a modular column of neuronal cells. If linguistic knowledge is the stimulus, and a geodesic framework such as the MMA is used, then the resultant electrical activity will be activated within the linguistic module across the left and right hemispheres in a complementary fashion allowing two perspectives of the same information to be held at the same time. This will allow associations to be made that would not occur if the left hemisphere was stimulated alone as in traditional approaches.

Based on Gardner's (1985) theory, the MMA identifies seven such groupings (see Figure 2.4) of knowledge. These seven groupings of knowledge, or metacognitive modules in the MMA model, represent the basic knowledge base that is used to reconceptualise new knowledge which occurs constantly from infancy to death. The way in which newly reconceptualised knowledge is stored in relation to the existing knowledge base determines whether the knowledge will be useful in that it will be able to be used creatively in a problem-solving context. Using a geodesic approach such as the MMA, knowledge will be stored associatively in an organised categorised way across both hemispheres, allowing the information to be recalled and therefore used more easily. If the interaction of declarative, procedural and conditional knowledge is facilitated, as in the MMA, the result will be effective multimodal memory storage because the contextual as opposed to content memory will be used. Traditional rote learning approaches, by contrast, will only store unrelated factual information resulting in content memory.

Therefore, the implication of a modularity perspective for the MMA is that it provides a biological base for the conception of processing systems and metacognitive modules and domains. Furthermore it subserves the conception that both hemispheres need to work together to realise potential, that the functional unity of the brain cannot be broken, and that if the two sides of the brain work together in a complementary fashion, both sides will produce more than if only one side is used.

3.5.4. ASPECT FOUR: *The limbic system needs to be activated in order for useful knowledge to be reconceptualised*

Theoretical underpinnings

The limbic system plays a critical role in the development of potential as it mobilises the cerebral resources and this triggers the utilisation of the non-conscious stores. In this way, the depth of processing is increased.

Research into the association between emotion and the metacognitive patterning needed for learning has established the ways in which the limbic system influences learning. Ornstein (1987), Sobel (1990, in Jensen, 1995), and Rosenfield (1988) argue that emotions influence learning in two ways: positive emotions influence the depth of processing, and allow the brain to make better perceptual maps. Maclean (1978) indicates that emotions, hormones, and feelings all affect learning. Research into the memory of animals indicates that the midbrain plays a role in learning (Jensen, 1995). Studies by McGaugh and Intrioni-Collision (1990) have verified the role of limbic area, hormones and the amygadala in long-term memory. The work of O'Keefe and Nadel (1978) has established the role of the hippocampus in learning and indexing.

The literature pertaining to the cognitive-emotive link suggests that once the limbic system is involved, the activation levels in the neural circuitry are stronger and more reinforcing, resulting in better memory storage and intellectual function (Hand, 1986). De Andrade (1986: 111) indicates that "not all pieces of information matter from the viewpoint of the mobilisation of the cerebral resources: only those that penetrate the limbic system serve as a trigger for the utilisation of reserves not used". He argues that in order for information to penetrate the limbic system, it needs to be emotised, that is, rationally defined objectives need to be clearly translated into mental representations through the use of emotions, using the auditory, visual and kinaesthetic channels. Maclean (1978) has shown that the limbic system receives information from all intero- and exteroreceptive systems and elaborates it into emotional sensations. It appears that the mental non-conscious is the link with the limbic system, and that suggestive phenomena tap the non-conscious. Thus, the limbic system is the link to the development of usefully reconceptualised knowledge.

Suggestopaedia (Lozanov, 1978) recognises the potential of non-conscious mental activity in increased recall of existing descriptive systems, and in the reconceptualisation of new knowledge. Utilising and refining the methods of relaxation, music and yoga breathing, he produced a method that has been found to be greatly effective in learning. The three psychophysiological laws upon which his work are based reveal his integrated view of the brain. These are: the global participation of the brain, the simultaneous process of analysis and synthesis, and the indivisible participation of the conscious and non-conscious (Dhority, 1991). Furthermore, Lozanov's (1978) three inseparable fundamental principles correspond with Hart's (1983) concept of pattern detection, which he argues are activated more efficiently through the accessing of the non-conscious. Thus Lozanov's (1978) approach is also neuropsychological, and complementary to the MMA, and for this reason elements of this approach are incorporated into the MMA. Nelson (1988) proposes a process model which demonstrates the interconnectedness between imagery and the limbic system and in which the cognitive process of imagery activates the limbic system. In other words, thinking in images may increase neurotransmitter activity in the limbic area. Nelson (1988: 368) states that "since imagery affects the limbic system and hypothalamus, it can assist in bringing emotional memories to conscious view, modulate emotional reactions and enhance motivation".

Implications for the MMA

The emotive-cognitive link has important implications for the MMA in that the approach aims to create a positive attitude in the learner towards the learning task so that the learner will become autonomous and self motivated. The MMA incorporates strategies from suggestopaedia, as initially proposed by Badouin and developed into an applied educational science by Lozanov (1978). These strategies are used in combination with the Mind-Map in order to facilitate the cognitive-emotive link.

The MMA assists in the process of attaching emotions to each event and thought, forming patterns of meaning to construct the larger picture. The Mind-Map itself is an enjoyable activity as it allows learners to bring their own talents, cultural perspectives and individual perceptions to the task (Leaf, Uys & Louw, 1993). It allows learners to gain control over the learning situation as they are able to observe their cognitions due to the overt nature of the Mind-Map and thus gain immediate feedback. Furthermore, clinical application has proved that if a positive active emotional involvement is not invoked, the individual battles to create Mind-Maps successfully on an independent level (Leaf, 1990).

Nelson (1988) indicates that there are three keys in making imagery most responsive to the limbic system: rhythm, movement and emotions. In translating these keys into practical techniques in the MMA, elements of the science of suggestopaedia, as developed by Lozanov (1978), have been utilised in adapted formats. All three of these keys, namely, rhythm, movement and emotions, are therefore utilised in the techniques of the MMA. This relaxes the limbic system's negative potential, allowing intellectual pursuit to progress more readily. The teacher and/or therapist, using a geodesic approach such as the MMA, will facilitate the activation of the limbic level of the individual through the use of music, imagery, relaxation, and laughter, which appeal to all the modalities.

It has been clinically observed that when initially learning to create Mind-Maps, clients are dependent and concrete in their thought processes, and sometimes negative towards the activity due to the active involvement required in the thinking process (Leaf, 1990). This attitude could be a result of the traditional environment that tends to invoke rote learning and hence a lack of active thinking. At a point in mediation, however, a change is evidenced in the independent utilisation of the Mind-Map as a study and organisational strategy. Until this stage is reached, the Mind-Map process will have limited success. Therefore until the learning situation is experienced on an emotional level, it is not processed deeply enough to be stored on the metacognitive level and stimulate effective metacognitive action. Once the cognitive-emotive link is experienced, however, the task becomes automatised into the metacognitive level. It is postulated that the active processing invoked by the geodesic nature of the MMA is more likely to induce the cognitive-emotive link than traditional approaches, resulting in the deeper processing that is required for creative intelligent learning.

Motivation is tied to emotional response and therefore fear or anxiety will inhibit motivation (Hart, 1983). Hart terms this downshifting, where cognitive activity is stopped because the emotion overrides the reasoning ability. Positive emotional responses evoked through imagery can maximise motivation by overriding negative emotional responses from the limbic system (Nelson, 1988). One of the rules of the Mind-Map is the use of imagery in the creation, as well as in the output (the memorising of the Mind-Map). The learner is told to visualise, to make the Mind-Map "come alive".

This stage of the Mind-Mapping process is known as the creative visualisation stage as opposed to "learning", with its negative connotations. The creative visualisation process appeals to the function of the amygadala, which is involved in imagination and retrieving or storing memories (Restak, 1979). Certain steps of the creative visualisation process are repetitive and require the involvement of the visual, auditory, and kineasthetic modalities. This appeals to the function of the hippocampus, which is involved with storage and retrieval of memories (Restak, 1979). As a structure, the hippocampus is responsive to repetitive stimulation (rhythm), and spatial-motor sensations (Restak, 1979; Springer & Deutsch, 1989). Thus the use of music throughout the MMA will appeal to the hippocampus because of its rhythmic nature, which matches the heart rate and breathing which are controlled by the limbic system. The Mind-Map, as the "tool" of the MMA, is structurally full of visual imagery in its multidimensional shape, and in the use of pictures, symbols and colour. Thus, the MMA and the Mind-Map, due to their nature, activate the limbic system, which results in improved cognitive functioning.

3.5.5. ASPECT FIVE: *Processing of information occurs in a parallel simultaneous fashion on the non-conscious level, and sequentially on the conscious level*

Theoretical underpinnings

On the non-conscious level the processing of information is fast and parallel, and on the conscious level, processing is sequential and slow (Reddy, 1979, in Iran-Nejad, 1990; Iran-Nejad, 1990). Therefore, the nervous system is seen to process information in a predominantly simultaneous parallel fashion. Learning situations need to reflect this in order to be successful. Hinton and Anderson (1981) developed a model called parallel distributed processing (PDP) also known as connectionism, in order to explain the parallel processing of information on the non-conscious level.

The PDP model (Hinton & Anderson, 1981) has the brain as its conceptual analogy for the human information processing system - especially the synaptic connections among neurons. This is in contrast to classical information processing theory, the analogy of which is the microchip of the high speed computer. In addition, the PDP model considers that almost all information processing, including the higher mental functions involved in language, memory and thought, occurs on the non-conscious level. This is in accordance with the assumptions of the metacognitive component.

The PDP model postulates the existence of a large number of processing units or modules each doing a specific task in both hemispheres. The systems mutually influence each other once activated, until the whole system is in a state of activation, which represents the information being processed (Hinton and Anderson, 1981). Allport (1980) and Hinton and Anderson (1981) propose that the modules interact simultaneously in parallel to produce intelligent knowledge rather than sequentially in series, which limits the process of thought. Furthermore, Hinton and Anderson (1981) indicate that each module is specifically keyed to and activated by a certain kind of information making them content dependent. Therefore in the PDP model it is assumed that information about an object is distributed widely across the system rather than being localised in any particular unit (Khilstrom, 1992, in Nelson, 1992). The PDP model abandons the traditional assumption that information is processed in a sequence of stages (Hinton & Anderson, 1981). Parallel processing allows information to be analysed rapidly as large numbers of activated units can influence each other at any particular moment in time, which results in information being analysed very rapidly. Both the number of simultaneously active processing units, and the speed at which they pass information among themselves may exceed the span of conscious awareness (Khilstrom, 1992, in Nelson, 1992). It can be postulated that consciousness is a matter of time rather than activation. Therefore the implication is that unconscious processing is fast and parallel, while conscious processing is slow and sequential (Khilstrom, 1992, in Nelson, 1992; Iran-Nejad, 1990).

More specifically, cognitive activities are related, not to the quantity of information to be processed, but to the presence of particular patterns to which specific neural structures must resonate, known as pattern-detection (see assumption five, section 3.4.2.). Hinton and Anderson (1981) and Allport (1980) indicate that the modules operate in parallel with the module that fires the most, dominating the cognitive activity.

Allport (1980) claims that every production system, or module of knowledge, is content dependent, thus cognitive activities are related to the presence of particular patterns to which particular neural structures resonate (1980). The research of Eriksen and Botella (1990) and Crick (1981, in Jensen, 1995) also verifies the parallel processing nature of the brain which is multi-path and multimodal, with very little learning occurring in an orderly sequential fashion. According to Ornstein (1975), many things are done at once on a biological, physical and intellectual level. Hart (1983) argues that the brain operates simultaneously on many different levels of processing in a world of colour, imagery, emotion, shape, intensity, sound, taste, and more. The brain assembles patterns, composes meaning, and sorts life experience. Therefore, it appears that parallel as opposed to serial processing is natural to the functioning of the brain.

Implications for the MMA

The geodesic nature of the MMA allows rather than restricts the natural parallel processing nature of the brain. When the neural structures of the brain are allowed to process in a predominantly parallel way, learning becomes more creative and therefore more effective. More specifically, the MMA facilitates parallel firing in the metacognitive module that is predominantly being stimulated, as well as interaction between the modules. This is because of the patterned nature of the Mind-Map, which activates the multimodal and multi-path nature of parallel firing within and between the metacognitive modules. Conscious serial processing of information, the result of linear traditional stimulation, cannot produce the same effect because linear presentation is not a meaningful pattern. Neural structures respond to context dependent patterns that are meaningful. If there is no associated patterning forming in the knowledge, then the neural response is limited to creating content as opposed to context memories. The MMA therefore provides a learning situation which reflects the natural parallel processing ability of the brain.

3.6. THE ASSUMPTION RELATING TO THE SYMBOLIC COMPONENT OF THE MODEL

The seventh assumption is concerned with the symbolic expression of thought, which is the final stage of the geodesic model.

3.6.1. THE MIND-MAP IS THE SYMBOLIC EXPRESSION OF THE THOUGHT PROCESS

Theoretical underpinnings

The symbolic component deals with the capacity of humans to express and communicate meaning using some symbolic vehicle. Symbol use has been the key in the evolution of human nature, giving rise to myth, language, art science (Gardner, 1985). Thus the focus of the symbolic level is on the symbolic vehicles of thought. It involves the understanding of language, mathematics, visual arts, gestures and other human symbols. According to Gardner (1985), Allport (1990), Fodor (1983), much of what is distinctive about human cognition and information processing involves the deployment of these various symbol systems. A major issue of this approach is whether the operation of one symbol system, such as language, involves the same abilities and processes as music, gesture and Maths. The symbolic perspective seeks to compose a developmental portrait not only of linguistic, logical and mathematical symbols of classic Piagetian theory, but on the full range of symbol systems encompassing musical, bodily, spatial, and personal symbol systems (Gardner, 1985).

Implications for the MMA

In the MMA model, the symbolic level is the expression of the cognitive act which has operationalised the metacognitive action. Therefore, the quality of the symbolic output is dependent on cognition, which, in turn, is dependent on metacognition. In the MMA, the Mind-Map, as the overt "tool", becomes the symbolic vehicle of the processing of information, a way of observing the product of the human mind. The Mind-Map shows the thought process that is behind the symbolic output. On the MMA model (Figure 2.1), only the linguistic module is developed due to the orientation of the current research.

Each of the other six modules can also be expanded through the metacognitive and cognitive levels to their specific symbolic expression. However, the Mind-Map requires input from all the different modules to produce intelligent knowledge, and thus serves as a tool for encouraging their interaction. The Mind-Map can therefore be used to monitor, develop and improve the symbolic level, which is seen as the capacity to communicate meaning.

The symbolic system approach becomes the link between the nervous system with its structures and functions, and the culture with its roles and activities. According to Gardner (1985: 300), "in dealing with symbols like words or pictures, with symbolic systems like maths or language, with symbolic products like scientific theories or literary narratives, we have commerce with entities and levels of analysis, that can address both biology and anthropology". In other words the symbolic systems approach advocates the use of systems that follow the natural neuropsychological functioning of the brain. The MMA may provide a brain-compatible route from raw intelligences to effective symbolic expression.

3.7. THE ASSUMPTION PERTAINING TO ALL FOUR COMPONENTS OF THE MODEL

The eighth assumption relates to the metacognitive, cognitive, symbolic and neuropsycholgical components of the model.

3.7.1. INTELLIGENT LEARNING IS THE RECONCEPTUALISATION OF DESCRIPTIVE SYSTEMS LEADING TO NEW KNOWLEDGE

The final assumption of the MMA model deals with the conception of intelligent learning. This assumption is the result of the integration of all the components of the MMA model and therefore refers to the metacognitive, cognitive, symbolic and neuropsychological levels.

Theoretical underpinnings

Two assumptions govern traditional approaches to learning, namely, that learning is the internalisation of external knowledge, and that it occurs under conscious executive control

(Iran-Nejad, 1989, 1990; Reddy, 1979, in Iran-Nejad, 1990). As the result effortful attention-paying is seen as the single most important regulator of learning. According to Iran-Nejad (1990) this limits the domain of learning to committing facts and definitions to memory.

In adopting a geodesic approach, learning is alternatively viewed as the creative reconceptualisation of internal knowledge involving a "discontinuous change from a structure with one wholistic character (or quality) to another structure with a different wholistic character" (Iran-Nejad 1990: 577). Thus, learning a complex schema is not simply an incremental enlargement of a simpler one through internalisation or assimilation of more external facts, or making internal modifications to the simpler schema (Iran-Nejad & Chissom, 1988). It is literally the creation of new parallel descriptive systems to accommodate the new knowledge. As in the formation of crystals, each new piece that is added is a complete new complex unit lying alongside the piece that it is associated with. Reconceptualisation involves the spontaneous reinterpretation of previously encoded facts but with the benefit of hindsight (Kintsch, 1980). Learning new information leads to recomprehension and reinterpretation of previously encoded information. Gestalt psychologists indicate that mental constructions are not simple constructions with something added, but are more analogous to chemical combinations where something new is formed that is qualitatively different (Bereiter, 1985). Therefore as something new is being learned, the previously encoded facts and other internal knowledge spontaneously reorganise into new combinations.

There is evidence that students who regard learning as internalising external knowledge suffer from fear of failure, negative attitudes and a disorganised approach to learning (Derry, 1990; Paris & Winograd, 1990). Iran-Nejad (1990) argues that the incremental internalisation hypothesis may actually impair learning strategies because there will be an over-reliance on active self-regulation as opposed to the use of both active and dynamic self-regulation. This counterproductive conception of learning sends learners along the ineffective path of effort, resulting in learning seldom going beyond committing facts and definitions to memory (Bloom, 1984).

Implications for the MMA

A fundamental principle of the reconceptualisation of knowledge as opposed to incremental internalisation is that a qualitative shift occurs from one organic whole to another (Iran-Nejad, 1990). In other words, existing schemata are used to reorganise and create new parallel schemata. Therefore it is not an incremental enlargement of a simpler schema through the assimilation of more external facts; rather is it a recreation of a new schema.

The reconceptualisation as opposed to incremental internalisation approach implies that simultaneous functioning is a prerequisite for sequential fact learning and not the other way around (Iran-Nejad, 1990). Reddy (1979, in Iran-Nejad, 1990) observes that the conduit framework (the conception of learning as being the internalisation of external knowledge, ready-made in books, lessons, notes) is responsible for the cautious attitude displayed by students in academic settings. For example, when asked to summarise, students "play safe" and cannot break away from the original phrasing. Clinical experience has shown that this conduit framework inhibits creative thinking.

Furthermore, the traditional approach to learning has stressed its active nature where one thing is learned at a time because the central executive level can only process one thing at a time (Bransford, 1979). Even in Vygotsky's sociocultural theory the contribution of the individual learner is left out because other-regulation governs the inter and intra psychological functioning (Wertsch, 1985). Iran-Nejad (1990) and Harrison (1993) argue that motivational problems may be symptoms of maladapted internal self-regulation processes because of the focus on external at the expense of internal self-regulation.

In order to create Mind-Maps, knowledge has to be reconceptualised, as incremental internalisation cannot explain the results obtained when Mind-Mapping. This is because structurally the arrangement of the Mind-Map is deductive outwards and inductive inwards. This implies that analogical thinking is required to process the concepts. In the deductive arrangement, the concepts are associated and categorised from the general to the specific, and the converse applies for the inductive arrangement. A simple listing of facts will therefore have no place on a Mind-Map. In order to fit into the schema, the information has to be creatively reconceptualised implying that the meaning has to be sought via the active redesigning of existing descriptive systems.

The organisation of the information will not necessarily follow the outline of the information in the external source (teacher, text, audio-visual). It has to be reconstructed by the learner in order to create meaning and depth of processing. The traditional culture in schools that fosters rote memorisation of facts arranged in linear monochromatic lists does not require creative thinking

(Sizer, 1984). He argues that "students are all too often docile, compliant and without initiative" (Sizer, 1984: 84).

The Mind-Mapping process, by contrast, requires the active extraction, expansion and representation of meaning constructs, and is therefore a process of schema-building. In order to build schemata, concept meanings embedded in a framework of propositions are needed (Novak & Gowin, 1984). According to Novak and Gowin (1984: 15), a proposition is "two or more concepts labelled and linked by words in a semantic unit". In order to recognise and build these concept-propositional schemata, the metacognitive interaction of declarative, procedural, and conditional knowledge required is facilitated by active and dynamic self-regulation. Meaningful learning proceeds most easily when new concepts are subsumed under more inclusive or general concepts (Novak & Gowin, 1984). This is allowed for in the deductive/inductive arrangement of the Mind-Map discussed earlier. Novak and Gowin (1984) indicate that the representation of general to specific concepts should be hierarchical in arrangement. However, it is felt that this process too closely represents the monochromatic listing which obscures thinking (Kline, 1990), and encourages conduit-type thinking. The representation of concepts needs to be more multidimensional, which is more brain-compatible, as in the Mind-Map structure. Adopting Iran-Nejad's (1990) definition of learning as a multisource internal reconstruction process, both fact learning and the learning of complex schemata can be explained. The MMA refines this process due to its organisational associative conceptual nature.

Intelligent learning and the resultant realisation of potential will result when knowledge is reconceptualised into meaningful descriptive systems. This can only occur when a brain-compatible environment is created which in turn facilitates the full spectrum of metacognition to be activated. A fully activated metacognitive system will result in more effective cognitive processing and, consequently, superior symbolic output.

3.8 CONCLUSION

It has been proposed that a geodesic approach, such as the MMA, invokes more effective thought processing and learning than traditional behaviouristic approaches. At the core of a geodesic approach are the features of brain-compatibility and simultaneous learning which account for its effectiveness. These brain-compatible features were explored under the eight assumptions of the MMA model which led to a redefinition of the roles allocated to the non-conscious level, the conscious level, metacognition, cognition, and learning.

Within the geodesic approach of the MMA, metacognition is viewed as the root of the thought process and the level on which the bulk of learning occurs. Furthermore, metacognition is viewed as being synonymous with the non-conscious level and as providing a structure for analysis of the non-conscious. The non-conscious level processes information rapidly, simultaneously and in parallel, and is orchestrated by dynamic self-regulation. The non-conscious level is also viewed as influencing the conscious level and, because the non-conscious level is metacognition, this is the level where the thinking process starts. This is in contrast to traditional approaches which perceive metacognition as the "thinking about thinking" level. These views regard metacognition as a higher or more abstract form of cognition, sometimes even as a separate process, but nevertheless as a very conscious sequential thinking activity implying that the bulk of learning occurs on the conscious level. Traditional approaches view the conscious level as the level on which cognition and metacognition occur, accounting for most learning, and relegate the non-conscious level to a very basic perceptual role.

Cognition, within the geodesic approach of the MMA, is perceived as occurring on a separate level, where conscious sequential thinking occurs under the control of active and dynamic self-regulation. This conscious thinking can range from basic thinking skills to higher level abstract thought and "thinking about thinking" skills (the traditional role of metacognition). The effectiveness of cognition is dependent on the effectiveness of metacognition and the interaction between the two, which in turn is dependent on the interaction between active and dynamic self-regulation.

Learning, within the bounds of the MMA geodesic approach, is viewed as the reconceptualisation of knowledge as opposed to incremental internalisation. Therefore simple schemata are not simply added to, but are recreated as new schemata are associated with the existing schemata. In this way factual as well as complex creative problem-solving learning can be accounted for.

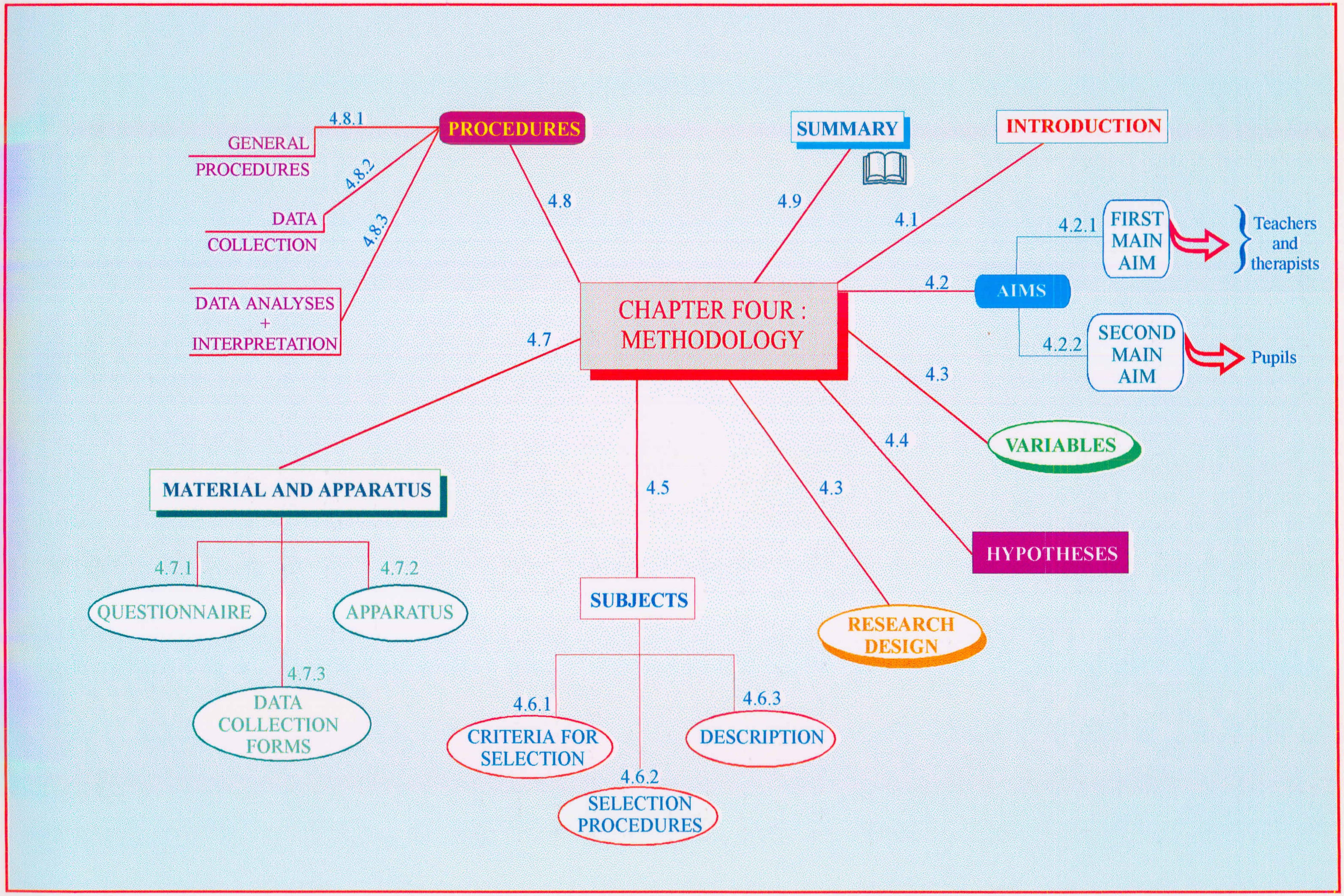
Finally, the MMA is brain-compatible due to the neuropsychological emphasis, in that the techniques used stimulate a synergistic processing between the cerebral hemispheres, activate the limbic system and facilitate the natural pattern-recognition nature of the brain, allowing parallel processing within the modules to occur. Therefore, the MMA provides an alternative approach to the perception of learning. It is a comprehensive model and framework that falls within the realms of a humanistic geodesic approach, which is believed to be more appropriate in the facilitation of learning than traditional approaches. The present research set out to test this assumption experimentally.

3.9. SUMMARY

In this chapter, the four components of the geodesic information processing model, and the eight assumptions arising out of them, are explored in order to identify their theoretical underpinnings and implications for the MMA. These four components are the metacognitive, cognitive, symbolic and neuropsychological. These assumptions led to a redefinition of metacognition, cognition, the conscious level of thinking, the non-conscious level of thinking, and intelligent learning. The geodesic model, therefore, is seen to provide an alternative approach as well as a theoretical base to the perception of learning. The objective of the chapter was to develop a theory explaining why the geodesic framework of the MMA invokes more effective thought processing than traditional behaviouristic approaches to education and therapy.

ALL WE ARE DOING IN LIFE
IS CATCHING UP WITH WHAT
OUR BRAIN ALREADY KNOWS

Gazzaniga (1977: 76)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CHAPTER FOUR: METHODOLOGY

4.1. INTRODUCTION

Current learning theory and education is based on a cognitive behaviouristic approach (Novak & Gowin, 1984; Paul-Brown, 1992) and hence, consideration of the metacognitive and neuropsychological aspects of the learning process are neglected (Gardner, 1985; Derry, 1990). Efforts to understand the learning process must build upon a knowledge of the interaction of the biological and psychological processes (Luria, 1980; Gardner, 1985).

Furthermore, a global model of learning needs to integrate the individual within an authentic learning environment allowing personal growth under self-regulation (Iran-Nejad, 1990). According to Paul-Brown (1992), focusing on the purpose and nature of learning responds to the need to integrate communication skills with academic content.

Education requires competent communication skills - both oral and written - as prerequisites for school success (Bunker, McBurnett & Fennimore, 1987). Therefore, the speech-language therapist, with a background in language, communication, developmental psychology, speech and hearing sciences, linguistics and learning theory, is eminently qualified to become involved in the integration of communication, learning and education (Damico, 1987; Bunker et al., 1987; Paul-Brown, 1992; Tattershall, 1987). This expanded role of the speech-language therapist to promote overall school success requires flexibility and can best be achieved in a consultative and collaborative manner (Paul-Brown, 1992; Simon, 1987).

In view of the complex nature of learning, as well as the limitations of current approaches to learning in education, a more geodesic approach to learning is needed. It is proposed that the MMA is such an approach, that can be used to facilitate a wholistic approach to learning and, hence education. Furthermore, the emphasis of the MMA is on the facilitation of improved information processing and communication through a strategic versus skill-based approach, and as such, employs the concepts of consultation and collaboration in its implementation.

The underlying philosophy of the MMA is that traditional frameworks inhibit rather than enhance effective thinking as they are not neuropsychologically and metacognitively oriented, and thus not geodesic. In order to investigate the assumptions and effectiveness of the MMA model, and in doing so to underscore the need to change to geodesic methodologies if innovative lifelong learners are to be developed, a language learning disabled population was selected for the current study.

The language learning disabled population has various constraints limiting their ability to become good information processors and innovative learners (Borkowski, Schneider & Pressley, 1989). The literature indicates that in general, language learning disabled pupils are more passive, lower in self-efficacy, and are less strategic in terms of learning skills with weaker problem-solving abilities than their average achieving counterparts (Borkowski et al., 1989; Derry, 1990; Paris & Winograd, 1990; Erskine, 1986; Palmer et al., 1989; Zakaluk & Klassen, 1992). Some of these problems are due to environmental factors, such as parents being inconsistent in teaching their children to be strategic and organised during early critical stages of development; teachers focusing on product and content versus processes; society rewarding success rather than effort, and goal achievement rather than progress (Derry, 1990; Zakaluk & Klassen, 1992; Iran-Nejad, 1990).

It is thus not surprising that many students, both those in the mainstream and those with language and learning impairments, experience problems with innovative learning, thinking and achieving to the best of their potential. Simply stated, students often spend the majority of their learning years in environments that inhibit instead of promoting the development of their potential. If pupils already have an identified language and learning disability, they will be even more constrained by systems and environments that "de-educate" (Johnson, 1987).

If a geodesic approach could be shown to have a positive effect on the performance of language-learning disabled students, this would be a strong motivation to change all learning philosophies to a geodesic philosophy. It is therefore the purpose of the current study to determine the effectiveness of a geodesic approach to learning, the MMA, as a collaborative and consultative model which provides a different system and environment in education and therapy.

4.2. AIMS

The overall objective of the current study is to determine the effectiveness of the MMA training programme in enabling teachers and therapists working with language-learning disabled pupils to create geodesic learning environments and consequently improve the thinking, learning and potential of their students.

4.2.1. FIRST MAIN AIM

The first main aim was to determine the effectiveness of the MMA programme in increasing, changing and improving the knowledge, attitudes and skills of a group of teachers and therapists with regard to geodesic principles to a level of expertise which would enable them to incorporate these principles into their therapy and teaching. In order to achieve this the following sub-aims were arrived at:

- To establish the **knowledge**, **attitude** and **skills** of the teachers and therapists regarding geodesic learning principles in terms of the categories of neuropsychology and metacognition **before** and **after** attending the MMA programme;
- To determine the **change** in the teachers' and therapists' knowledge, attitude and skills regarding these principles; and
- To determine the influence of age, language and qualifications on the teachers' and therapists' knowledge, attitude and skills in these areas.

4.2.2. SECOND MAIN AIM

The second main aim was to determine the effectiveness of the application of the MMA principles by the teachers and therapists on the academic and learning performance of pupils in three remedial schools as ascertained by changes in percentages for English, Afrikaans, Maths and cultural subjects (History, Geography, Science, Biology, Health, Environmental Studies). The sub-aims were formulated as follows:

- To establish the longitudinal trend of academic results in the selected schools over 1991 and 1992: in general, per phase, per standard and per subject, to act as a baseline and control, and to correlate this with the 1993 results, to determine the change that occurred;
- To establish the longitudinal trend of each subject per phase and per standard, in order to determine in which subject the MMA methods had the most influence..

4.3. VARIABLES

In the current study there are two types of variables - the independent variable and dependent variable. The independent variable is an extraneous dynamic that attempts to alter the situations of the experiment, and is therefore controlled by the investigator (Leedy, 1989). The independent variable of the current research is the Mind-Mapping Approach (MMA) training programme.

The dependent variables are not controllable and will influence the outcome of the experiment in certain ways and therefore require consideration (Leedy, 1989). The dependent variables of the current research include:

- The knowledge, attitude and skills of the teachers and therapists regarding geodesic learning principles;
- The biographical variables of age, language and qualifications of the teachers and therapists;
- The academic results of the pupils.

Age, language and qualifications are considered to be dependent variables as they may have a significant effect on the receptiveness of the teachers to the MMA training, as well as to their application thereof. Knowledge, attitude and skills regarding geodesic learning principles are important in that they have a correlational relationship in terms of change (Byron, 1986). Thus all three must change significantly to effect a paradigm shift to a new concept. Finally, the changes that occur in the academic results of the pupils will indicate the influence of the independent variable, the MMA programme, on pupils in remedial academic settings.

4.4. HYPOTHESES

The following hypotheses were formulated, namely:

H1 There would be a positive change in the teachers' and therapists' knowledge, attitude and skills after the MMA programme.

H2 There would be a positive change in the pupils' academic results after the introduction of the MMA programme.

H3 There would be a positive change in knowledge regarding the geodesic learning principles of the MMA in terms of the categories of neuropsychology and metacognition.

H4 There would be a positive change in attitude regarding the geodesic learning principles of the MMA in terms of the categories of neuropsychology and metacognition.

H5 There would be a positive change in skills regarding the geodesic learning principles of the MMA in terms of the categories of neuropsychology and metacognition.

H6 : The biographical variables of age, language and qualifications would have an influence on the change in knowledge, attitude and skills of the teachers and therapists.

H7 The natural trend of academic results for the language-learning disabled would be a negative downward trend, that is, results would worsen as pupils progressed through to higher standards.

H8 The introduction of the MMA geodesic principles by the teachers in 1993 would alter the natural trend positively.

H9 Phase 2 (standards 2, 3 and 4) would demonstrate the most benefit from exposure to the MMA learning principles, followed by phase 3 (standard 5), and then phase 1 (grades 1, 2, standard 1).

H10 Academic performance in cultural subjects would demonstrate the greatest improvement after the pupils' exposure to the MMA, followed by English, then Afrikaans, then Maths.

4.5. RESEARCH DESIGN

The adapted ABA design (Table 4.1) of the current research is essentially a pre test post test control group design which examines the cause and effect of an extraneous variable (the MMA training programme), and therefore falls within the realms of experimental methodology (Leedy, 1989). The design was adapted as follows: firstly, the nature of the data under examination required the establishment of longitudinal trends to serve as baseline measures as well as controls; secondly, the effectiveness of the dependent variable (the MMA programme) is evaluated on two levels - change in the teachers and therapists, as well as change in the pupils; thirdly, a descriptive survey technique, the questionnaire, was incorporated into the study in order to extrapolate the common pattern or the norm that the phenomena under investigation (the teachers and therapists' knowledge, attitude and skills regarding learning and thinking - the dependent variables) follow and how these change. Figure 4.1 illustrates the tectonic structure of the research design.

According to the basic structure of this methodology, the research comprised two experiments: one, the training of ***teachers and therapists*** in the MMA programme; and two, the application of the MMA programme in education and therapy with the ***pupils*** by the teachers and therapists.

Table 4.1 : The Tectonic Structure of the Research Design

EXPERIMENT ONE		EXPERIMENT TWO	
	TEACHERS AND THERAPISTS		**PUPILS**
A¹	Baseline and control (Pre-questionnaire)	**A¹**	Baseline and control (1991 + 1992 Academic results)
B	Direct training	**B**	Exposure - Indirect training
A²	Post-evaluations (= Post-questionnaire)	**A²**	1993 Academic results

In the first experiment the three stages of the ABA design were as follows. The first or pre test stage (A1) involved the questionnaire given to the teachers and therapists to provide a baseline measure. This baseline measure is assumed to reflect the pattern or the norm of the phenomena under investigation (Leedy, 1989). In this instance, the data obtained from the pre questionnaire was the knowledge, attitude and skills of the teachers and therapists regarding geodesic learning principles before exposure to the MMA programme. The second stage (B) involved the training of the teachers and therapists in the MMA programme. This served as the experimental stage. Finally, the third or post test stage (A2) involved the teachers filling in the same questionnaire four months after training with an additional section.

In the second experiment there were also three stages. Stage one (A1) involved the establishment of the longitudinal trends of academic results for English, Afrikaans, Maths and cultural subjects prior to the intervention, to act as a baseline. As these trends were established over time (1991-1992), they also served as the controls for the experiments with the pupils. The second stage (B) of the experiment with the pupils involved the introduction and exposure to the pupils of the MMA programme in education and therapy by the teachers and therapists. This served as the experimental phase. Stage three (A2) was the post test phase, where the pupils' academic results for 1993 were compared to the trends established for 1991-1992.

The attempt to alter the patterns of the questionnaire reponses and the academic results was made by the introduction of an independant variable (B) - the MMA training programme. This independent variable was introduced in two ways, directly to the teachers and therapists, and indirectly to the pupils. Therefore two levels of influence were being explored: the changes in the teachers and therapists, as well as the effect of these changes on the pupils' academic results and general performance in the classroom, through the introduction of the MMA principles to the pupils by the teachers and therapists.

It should be noted that the reason the baseline measure and the control are the same is that during the time frame that the experiment was carried out, all the teachers, therapists and their pupils in the schools selected were exposed to the MMA principles. Control for the teachers and therapists was established on the basis of paired testing (A1 to A2), as they completed the same questionnaire pre and post training with a four month time delay in between. Comparison of their knowledge, attitude and skills regarding geodesic principles was carried out through direct comparing of their responses to the questions pre- and post-training. The teachers and therapists thus served as their own controls. As regards the pupils, the control group could not be a simultaneously selected group unexposed to the experimental variable. Instead, an historical trend of academic performance over a two-year period was established, against which the performance of the experimental group was measured. Further details of the exact design appear under pupil selection procedures below.

The design of the current study also emphasises factors of external validity in that establishing a trend over time as a basis of comparison enables one to generalise the effect of the experimental variable to other similar academic groups (Leedy, 1989; Borg & Gall, 1971, in Gardner, 1985).

The use of a random sampling as well as longitudinal trends increases the control and therefore the accuracy of making generalisations (Leedy, 1989). In addition, the descriptive survey method of the questionnaire enables generalisations to be made about the knowledge and attitude of a specific group of teachers and therapists with regard to traditional perceptions of learning, and how these might change as a result of exposure to alternatives, as long as bias is acknowledged.

4.6 SUBJECTS

Two groups of subjects were utilised in the current study: the teachers and therapists, and the pupils.

4.6.1. CRITERIA FOR SELECTION

Certain criteria were determined for the selection of the two groups of subjects in this study. These were as follows.

Teachers and therapists

There were three criteria for the selection of the teachers and therapists:

1. The subjects had to have either a teaching or therapy qualification (speech-language, remedial teaching, psychology, occupational therapy) in order to ensure that they had the necessary backgrounds to enable them to work with pupils with language-learning disabilities.
2. The subjects had to be working in special education settings specifically with pupils with language-learning disabilities in order to ensure that they had experience with pupils with language and learning disabilities.
3. The subjects had to understand English as the MMA course was conducted in English.

Pupils

There were three criteria for the selection of the pupil group:

1. Pupils had to have identified language and learning disabilities in order to qualify as subjects for the study.
2. Pupils had to be in traditional special education environments for language-learning disabled pupils in order to qualify as subjects for the study.

3. Pupils had to be in a primary school setting as the current study was conducted on pupils from grade one to standard five in order to qualify as subjects for the study.

4.6.2. SELECTION PROCEDURES FOR THE SUBJECTS

Three remedial schools were selected which were dual medium, GED schools from grade one to matric. The curriculum and organisation within the schools were therefore the same. The following selection procedures were then carried out for the two groups of subjects of the current study.

Teachers and therapists

The course was offered to all teachers and therapists in the primary sections of each of the three remedial schools. A talk was given which provided an overview of the present research and the benefits of the programme. Forty-five teachers and therapists, approximately 75% of the total possible number, opted to take part. Of these, 36 were teachers and 19 were therapists.

Pupils

Pupils were selected from grade one to standard five across the three selected remedial primary schools. A computerised formula was used to randomly select a group of pupils for each of the years 1991, 1992 and 1993. The 1991 and 1992 pupils were to act as a control and baseline, whilst the 1993 pupils were to form the experimental group. The random sampling procedure resulted in a total of 461 pupils - or more accurately, sets of academic results - out of approximately 3000 for 1991 and 1992, and 329 sets of results for 1993 out of approximately 1000. This gave a total of 790 sets of academic results, referred to as dataset one.

It was then realised that the random selection resulted in some pupils appearing two or three times, and thus the results of these pupils were used in two or three years. This dependency factor affected the purity of the data. For this reason, those pupils who appeared more than once were traced backwards from 1993 to 1991, and a second pupil group was created by identifying from the raw data pupils that had complete records over three consecutive years. The academic results of this group of 75 pupils is referred to as dataset two.

The data from this group were purer, but the group was still not large enough to deduce statistical implications, and was actually only a subset of the total pupil group. Furthermore, on sorting the data of this pupil group, it was found that the weighting was uneven. That is, of the

75 pupils, 57% were in phase three, 16% were in phase two and 26% were in phase one. As this uneven weighting would influence the accuracy of the final results, it was decided that the academic results of the second pupil group would only accurately reflect what was happening if analysed within the entire pupil group. For this reason a third dataset was created from the first two datasets. In order to account for the dependency, the data were grouped into various combinations by statistical procedures. The total sample size of the third data set was 639 sets of results.

4.6.3. DESCRIPTION OF THE SUBJECTS

4.6.3.1. Teachers and therapists

Table 4.2 provides a summary of the description of the teachers and therapists who acted as subjects. Across the three schools selected, there were 26 teachers (grade 1 to standard 5), three speech-language therapists, 12 remedial teachers, three occupational therapists and one psychologist. Of the 26 teachers, 13 worked in phase one, nine in phase two and four in phase three. Details of the ages, language and qualifications of these subjects appear in the Results chapter.

Table 4.2 : Teacher / Therapist Description

STATUS	PHASE 1	PHASE 2	PHASE 3	TOTALS
	Gr I / ii / Std I	2 / 3 / 4	Std 5	
TEACHERS	n = 13	n = 9	n = 4	26
SPEECH THERAPISTS	n = 3	------- → -------- →	-------- →	3
OCCUPATIONAL THERAPISTS	n = 3	------- → -------- →	-------- →	3
PSYCOLOGIST	n = 1	------- → -------- →	-------- →	1
REMEDIAL	n = 12	------- → -------- →	-------- →	12
				45

* Therapists were not restricted to a phase - worked across all phases

4.6.3.2. Pupils

All pupils selected had identified language and learning disabilities and were either English or Afrikaans speaking.

The pupils were grouped into phases 1, 2 and 3 (see Table 4.3). This was the equivalent of the categorisation in the schools into junior primary, senior primary and junior high school. The categorisation reflects the curricula and teaching methodology, which are adapted to each age group.

Table 4.3 : The Phase / Standard Grouping

PHASE	GRADE / STANDARD PER PHASE
ONE	Grade One Grade Two Standard One
TWO	Standard Two Standard Three Standard Four
THREE	Standard Five

4.7. MATERIAL AND APPARATUS

The material and apparatus used in the study are described forthwith.

4.7.1. THE QUESTIONNAIRE

A questionnaire was complied for use in the study.

4.7.1.1. The aim of the questionnaire

A questionnaire compiled with the aim of tapping the teachers' and therapists' qualitative knowledge, attitude and skills about geodesic learning principles was administered prior to and shortly after the experiment, that is, the MMA training programme.

The objective of the questionnaire was to identify whether there was a predominantly traditional behaviouristic attitude to the learning and intellectual process pre-training, and if this changed post-training and, if so, how.

4.7.1.2. The design of the questionnaire

The questionnaire (see Appendix I) developed for this study was modelled on metacognitive and neuropsychological concepts related to learning and the development of potential and therefore applies to the decision-making domain (Jensen, 1995; Gardner, 1985; Campbell et al., 1991; Derry, 1991). It contained both closed (multiple choice) and open-ended items. The same questionnaire was used pre- and post-training, except that post-training questionnaire had an extra four open-ended questions which allowed the teachers and therapists to comment on how they had implemented the MMA programme, as well as the difficulties and/or positive effects of the programme.

The 51 questions were organised into different sections according to the area of knowledge being investigated. Section A dealt with biographical and identification data. Section B probed the academic learning process in school and therapy situations and comprised 18 closed questions. These questions included knowledge about the function of the brain and the importance of this knowledge in the learning situation, specifically in relation to memory and thinking. An example is "Is it necessary for students/clients to know how their brains function, in order to improve their learning skills?" Respondents were required to repond on a three-point scale, "yes", "no" or "unsure".

Section C also probed the academic learning process in schools, but dealt more specifically with how the teachers and therapists rated their knowledge of these concepts. There were nine closed questions in this section, an example being "How much do you know about creativity?" Respondents were required to rate their knowledge as "expert", "some" or "little".

Section D identified characteristics of the learning and thinking process, and was aimed at evaluating the teachers' and therapists' attitude to this process. There were 15 statements to be rated in this section, an example of the latter being: "The learning environment must be quiet and serious". Respondents were required to rate the importance of each characterisitc on a four-point scale from "of no importance" to "of very great importance".

Section E (Appendix II) required the respondents to define certain terminology related to the learning, thinking and intellectual process and therefore comprised open-ended questions. The five items requiring definition were learning, memory, visualisation, accelerated learning and super teaching.

Section F (Appendix III) was only included in the post-training questionnaire. Four open-ended questions probed the way in which the teachers and therapists had applied the MMA training principles in their teaching and therapy. It also allowed for comment on any difficulty they had experienced, and whether they felt their pupils had benefited or not. Various categories of answers were identified by the examiner (see Appendix III). Question F1 deals with how the concepts of the MMA were applied in therapy or the classroom and had 16 categories. The respondents could have mentioned all 16 categories or just one and were marked accordingly. Question F2 tapped difficulties experienced with applying the concepts and had five categories. Question F3 required the respondents to indicate whether they felt their pupils had benefited from the application of the concepts and also had five categories. Question F4 allowed for any additional comments, and also had five categories.

The 51 items of sections B to F were categorised for analysis according to whether they dealt with metacognitive or neuropsychological aspects of geodesic learning principles. The division between the metacognitive and neuropsychological questions was not indicated on the questionnaire as it was used for analysis purposes only. The questions in the neuropsychology category concerned brain-behaviour relationships; and the metacognitive questions dealt with the roles of the conscious and non-conscious, comprehension, thinking skills, problem-solving and the concept of learning. Some questions had both neuropsychological and metacognitive elements in them and were analysed accordingly. These items were then further categorised into knowledge, attitude and skill components. This categorisation resulted in six categories for analysis namely (see table 4.2.): metacognitive knowledge (KM), metacognitive attitude (AM) and metacognitive skills (SM); neuropsychological knowledge (KN), neuropsychological attitude (AN) and neuropsychological skills (SN). Table 4.4 summarises which questions in each section of the questionnaire tapped which of the six categories.

Table 4.4 : Questionnaire Category Description

	KNOWLEDGE	ATTITUDE	SKILLS
NEUROPSYCHOLOGY	QUESTIONS: B : 1, 2, 3, 4, 7, 9, 11, 13, 18 C : 1, 3, 8, 9 E : 2, 3	B : 2, 3, 10 11, 12, 13 16, 18 D : 7, 9 E : 2, 3	B : 13, 14, 15, 16, 17 C : 4, 5, 6 E : 1, 4, 5
METACOGNITION	B : 13, 14, 15, 16, 17 C : 2, 4, 5, 6, 7 E : 1, 4, 5	B : 5, 8, 6 D : 1, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 15 E : 1, 4, 5	B : 13, 14, 15, 16, 17 C : 4, 5, 6 E : 1, 4, 5

4.7.2. THE APPARATUS USED FOR THE MMA TRAINING PROGRAMME

The apparatus used for the MMA training programme included a training manual, transparencies, videos, taped music and reference material.

4.7.2.1. The MMA training manual

The aim of the manual was to provide the content of the MMA training in a comprehensive manageable format making the training easier to follow. It was also intended a reference source for the teachers and therapists to use in the application of the MMA programme in their education and therapy.

The manual consists of 13 Mind-Maps created by the researcher for purposes of demonstration and explanation. The Mind-Maps contain the geodesic learning principles and how to apply these principles. The manual can be found in Appendix IVA and is not commercially available.

4.7.2.2. The MMA training transparencies

All the items in the training manual were put onto transparencies for projection. Additional transparencies were prepared for explanation purposes. These included examples of various levels of Mind-Maps and time-management Mind-Maps and can be found in Appendix IVB.

4.7.2.3. Videos

Two videos were also used in the MMA training programme in order to provide extra information on the brain and paradigm shifts. These were "The Enchanted Loom" (BBC production, 1986) of the brain's potential, and "Discovering the Future: A Question of Paradigms", (Charterhouse production, 1989). Appendix IVC contains a brief summary of each video as well as their references.

4.7.2.4. Music

A selection of baroque, classical and adapted baroque and classical music from the Learning Institute in America was used throughout training. The purpose of including the music was to demonstrate the beneficial effects of the music on concentration and attention. The list of the tapes and their sources can be found in Appendix IVD.

4.7.2.5. Reference material

Reference material pertaining to the concepts being trained in the MMA programme was made available for the participants to read if they wished to find out additional information about geodesic learning. A list of these books with full references is provided in Appendix IVE.

4.7.3. THE DATA COLLECTION FORMS

The data collection forms which were created and used for the recording of the pupils' academic results can be seen in Appendix V.

4.8. PROCEDURES

4.8.1 THE GENERAL PROCEDURE

The general procedure comprised eight phases and is presented in Figure 4.1. The components of the research design involved in each phase are also shown. It can be seen, for example, that phase two (A1 of experiment 1) was carried out in March, April and May 1993 of the experimental year. In the ensuing sections, the general procedure is discussed according to phase.

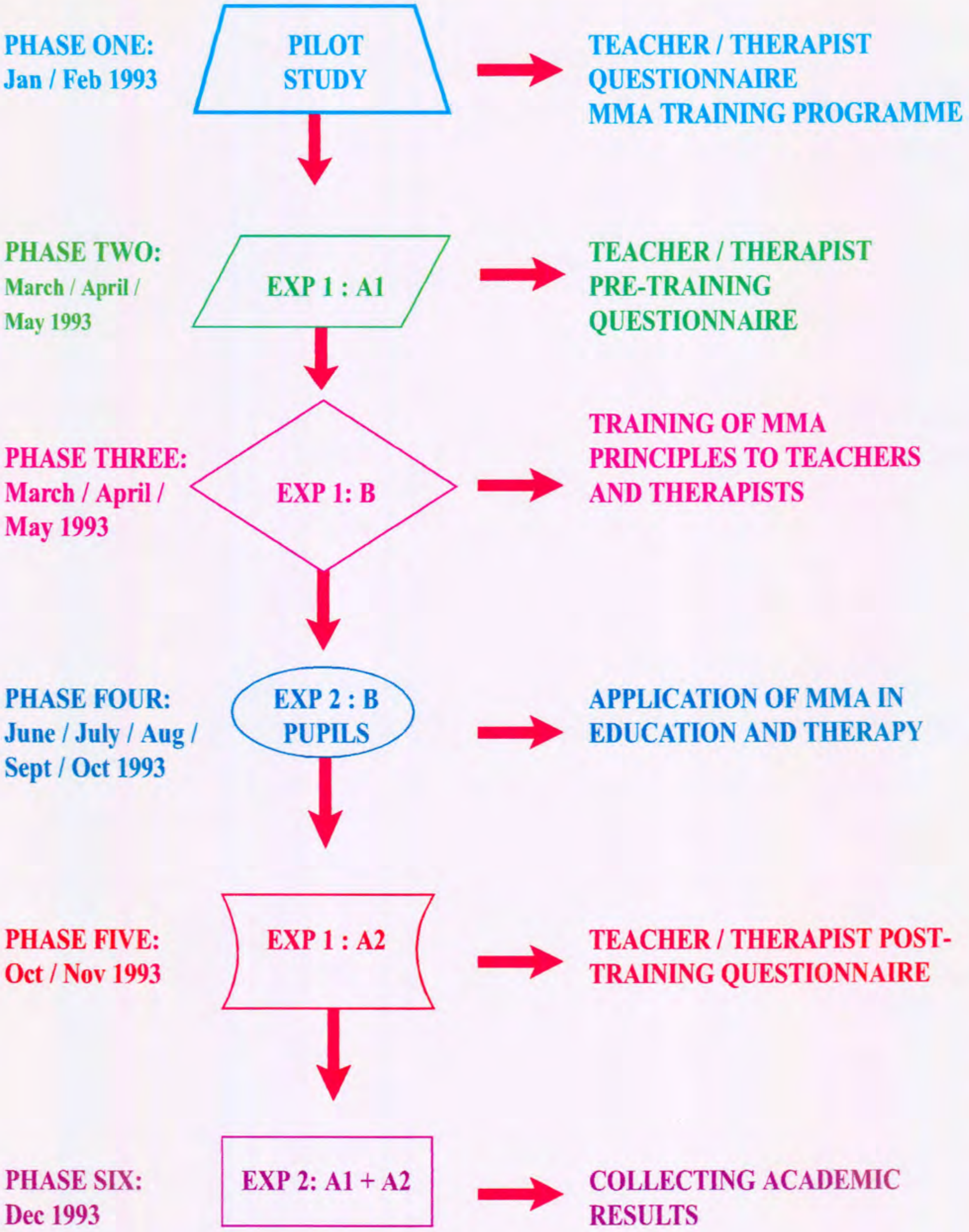

Figure 4.1 : Schematic layout of the order of the general procedure of the experiment

4.8.1.1. Phase one: The pilot study

The pilot study was conducted in two parts. The first part involved the application of the MMA programme in the training of 150 teachers and therapists cross-culturally. A survey was carried out by the researcher one month after completion of the training course using the interview method. The results indicated a positive response in that 70% of the teachers and therapists were using the method. However, one methodological problem became clear, in that the teachers and therapists requested hands-on training in the application of the principles. The MMA training course was consequently extended to include practical examples, as well as a three-hour practical session in the application of the MMA techniques in therapy and teaching situations.

The second part of the pilot study tested the questionnaire and involved a sample of fifteen teachers and ten therapists. The aim was to determine the effectiveness of the questionnaire in evaluating teachers' and therapists' knowledge, attitude and skills regarding the concepts of learning and the development of potential. The teachers and therapists were requested to read through the questionnaire and indicate, through the group interview technique, whether the language of the questions was clear, or whether any of the items was ambiguous, and whether the questions were phrased precisely enough to elicit the answers that the researcher was seeking. The results indicated that the questionnaire was able to fulfil its objectives and thus no changes were made.

4.8.1.2. Phase two (A1 of experiment 1): Pre-training questionnaire

The pre-training questionnaire was given to the teachers and therapists collectively just before the first session of training on day one of the MMA course. They were given 30-45 minutes to complete the questionnaire, which was then collected before training began.

4.8.1.3. Phase three (B of experiment 1): MMA training course

Phase three comprised a three-day (12 hour) MMA programme for the teachers and therapists. The details of the course are provided in Table 4.5. The table shows the time frame of the training, session breakdown, and the exact content covered trained in each session. Practical demonstrations were done using examples from the curricula of the schools involved as well as exercises in the training manual (Appendix IV).

Table 4.5 : The Procedure of the MMA Training Programme
Total Duration : 12 Hours

	Session	Time	CONTENTS	OBJECTIVE
DAY ONE	1	30 min	**INTRODUCTION :** * Function of the brain * Synergy and geodesic principles * Human potential * Introduction to principles of MMA * Layout of course	* To increase the awareness of the geodesic and synergistic principles of the brain * To link above awareness to performance potentials
	2	30 min	**VIDEO :** "The Enchanted Loom" A BBC Production on the latest research on the brain	* Reinforce principles discussed in introduction * Increase awareness of the potential of the brain * Stimulate thinking about brain and education
	3	15 min	**UPSIDE-DOWN DRAWING :** Participants have to copy an upside-down drawing	* The exercise provides practise of the synergy principles * To demonstrate how a difficult task becomes easy when synergy and geodesic principles are applied
	4	45 min	**PREPARATION :** * Brain-synergy exercises * Nutrition and the effect on the brain * Music and the brain * Relaxation * Visualisation	* Learning as an electrical-chemical process is explained and the effect of nutrition, music, relaxation and visualisation on the electrical-chemical process is discussed stressing the importance in relation to learning
	5	60 min	**EFFECTIVE READING SKILLS :** * Saccadic eye-movement theory * The pacer and hand movements * Mechanical eye movement exercises	* The important link between eye movements and comprehension is discussed and demonstrated. * Practice no how to achieve effective eye movements and hence improved comprehension is provided * Home programme given
	6	90 min	**LAWS OF MIND-MAPS :** * Discussion of laws of how to make mind maps * Demonstration of how to make mind-maps in all subjects	* A practical session by trainer demonstrating principles and the 'how' of mind-mapping * Course participants are required to copy the demonstrated mind-maps * Discussion of mind-maps and possible applications

	Session	Time	CONTENTS	OBJECTIVE
DAY TWO	7	60 min	**JIG-SAW PUZZLE :** * The Overview * The Preview * The In-view * The Golden Rule for concept selection	* The metacognitive approach to identifying concepts is demonstrated and practised * The steps involved in making lesson summaries and mind-maps from books is explained and demonstrated
	8	60 min	**REVIEW AND MEMORY :** * Memory rhythms * Creative visualisation * Mnemonics * Study periods	* The concept of taxon and locale memory and memory rhythms is explained. How mind-mapping facilitates more effective storage and recall is explained and demonstrated * The difference between rote-learning and thinking learning is demonstrated and explained
	9	30 min	**SUMMARY OF THE MMA :** Summary of all the geodesic principles of the MMA	* Consolidation of the principles of the MMA
	10	60 min	**PROGRAMME 1 :** * Story analysis and metacognition * Steps involved in applying the MMA Principles in therapy and teaching * The importance of geodesic principles in activating the metacognitive and cognitive level	* To understand the concepts involved in story analysis and the importance of training the metacognitive level * How to apply mind-mapping principles as a framework for teaching and therapy * To understand the importance of using geodesic frameworks in order to release potential.
DAY THREE	11	120 min	**TEACHING MIND-MAPPING :** * How to teach mind-mapping to pupils of different ages * Demonstration of mind-mapping in all subjects as a teaching tool and study method	* To understand the different types of mind-maps * How to select and teach mind-maps according to age * Understanding the use of mind-maps as a study tool
	12	120 min	**PRACTICAL SESSION :** * Practical session where course participants create own mind-maps on work related to their teaching subjects and type of therapy * Discussion of how to implement MMA geodesic principles in their school	* Course participants practice mind-mapping their own work individually and in groups under supervision. * Discussion encouraging participants to actively plan how they are going to implement the MMA geodesic principles

4.8.1.4. Phase four (B of experiment 2): Application of the MMA principles in education and therapy

From July to November, the teachers and therapists were expected to apply the concepts learned in the training programme in their education and therapy. They were encouraged to apply the principles in the presentation of lessons and therapy activities, as well as to teach the pupils how to use the methods as a study aid and research tool.

4.8.1.5. Phase five (A2 of experiment 1): Post-training questionnaire

Five months after the MMA training programme, the teachers were given the questionnaire again plus an additional four questions (section F). This was done by going to each of the three schools where the purpose of the post questionnaire was explained to the teachers and therapists collectively. They were given two days to complete the questionnaires, after which the researcher collected them from the school secretaries.

4.8.1.6. Phase six (A1 and A2 of experiment 2): The pupils' academic results

The researcher obtained the pupils' 1991, 1992 and 1993 academic results from the promotion schedules in the record files of the schools. This was done over the last two days of the 1993 school year.

4.8.2. DATA COLLECTION

The data for the teachers and therapists were collected from the pre and post questionnaires. The data for the pupils were collected from the promotion schedules for 1991, 1992 and 1993 in the record files in the office of each of the schools involved in the study.

4.8.3. DATA ANALYSIS AND INTERPRETATION

4.8.3.1. Recording procedures

The responses of the teachers and therapists to the questionnaire were coded according to which element of which question was selected. For example, if there were three options and a respondent chose the second, a 2 was recorded in the adjacent column on the questionnaire (see Appendix I). These codes were then recorded on the punch card processing sheets and fed into the computer as the raw data.

The data for the pupils were recorded by accurately tabulating the academic results for 1991, 1992 and 1993 onto the data collection forms (see Appendix V). These results were then recorded onto punch card processing sheets and fed into the computer as raw data.

4.8.3.2. Analysis Procedures

Statistical analysis provides "a quantitative method and a set of rules to determine if a particular experimental effect is reliable" (Kazdin, 1975: 286). However, certain data do not conform to a Gaussian curve and therefore the assumptions of normal distributions, means and standard deviations do not apply. Consequently different statistical approaches are required that will deal with non-normal curve data taking the singular characteristics of such data into account; this is known as non-parametric statistics (Leedy, 1989). The Wilks test (Lehmann, 1975) was used to test the data of the current research for normality and it was found that the data of the current study fell within the confines of non-parametric statistics due to their non-normal nature. The system of non-parametric statistics requires larger samples in order to yield the same level of significance as parametric testing (Leedy, 1989). For this reason, the current study had large sample sizes - 45 teachers and therapists and 790 pupils.

For the teacher/therapist group, the Wilcoxon signed rank test (Lehmann, 1975) was used to compare the pre versus post scores for the six categories of the questionnaire. The Wilcoxon signed rank test was also used to compare the pre and post values of the age, language and qualification groups. Descriptive statistics in terms of means and frequencies were obtained for each of the above groups.

For the pupils, the dataset of results obtained from the first pupil group could not be used alone as there was too much dependency in the data which was not accountable. It was therefore merged with the dataset comprising the results of the second pupil group and procedures were applied to account for the dependency, as a result of which dataset three was formed. The Friedman test (Lehmann, 1975) was done on dataset two in order to establish the historical longitudinal data trend. This is a two-way analysis of variance procedure because the data were dependent. In order to establish the particular differences, a multiple comparison test based on Friedman sums was done.

Due to the structure of the data in dependent and independent subsets in the third pupil group, a combination test based on the Wilcoxon signed rank test (Lehmann, 1975) and the Wilcoxon rank sum test (Lehmann, 1975) was carried out. This testing was purer in that it made provision for the independent and dependent data. Descriptive statistics such as means, standard deviations and frequencies for the above two datasets were also established. This testing was used to establish the longitudinal trends of academic results in the remedial primary schools in general, per phase, per standard, and finally, intralongitudinally per subject.

The statistical results for both groups of subjects - the teachers/therapists, and the pupils - were represented using bar graphs for interpretation purposes.

4.9. SUMMARY

This chapter describes the planning and the implementation of the research, which investigates the efficacy of the MMA as an alternative approach to facilitate geodesic learning.

The aims and hypotheses are based on the premise that the MMA is an effective framework, underpinned on a model of geodesic learning, that will effect a change from traditional to the preferential geodesic learning. The tectonic structure of the research design, an adapted ABA design, is presented. The selection of the subjects is explained. The procedure is then described in terms of six phases, namely: the pilot study; the pre questionnaire; the training of the teachers and therapists; the exposure of the pupils to the MMA methods; the post questionnaire; and the collection of the pupils' academic results. Finally, the collection, recording and analysis of the data are elaborated on.