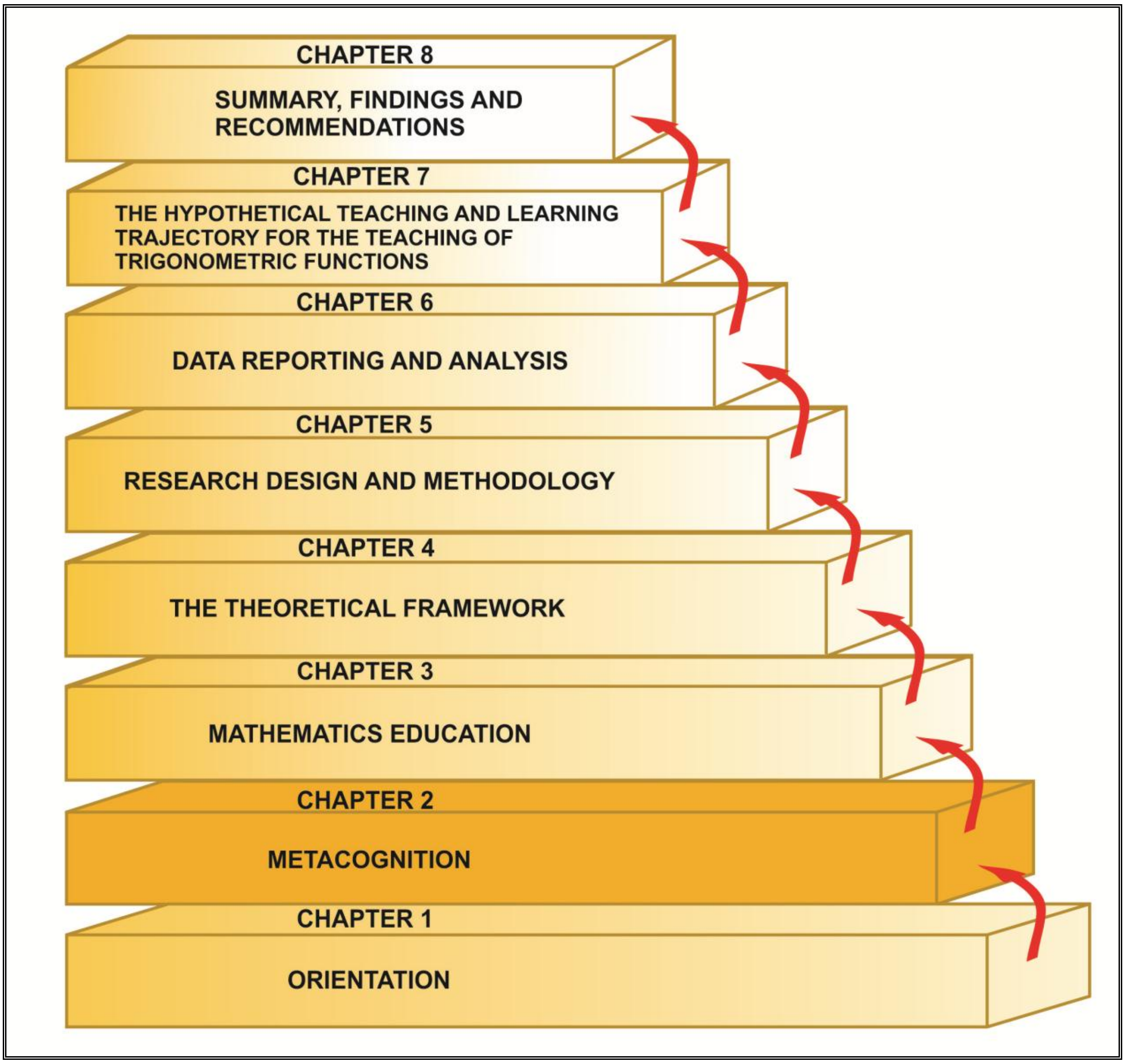
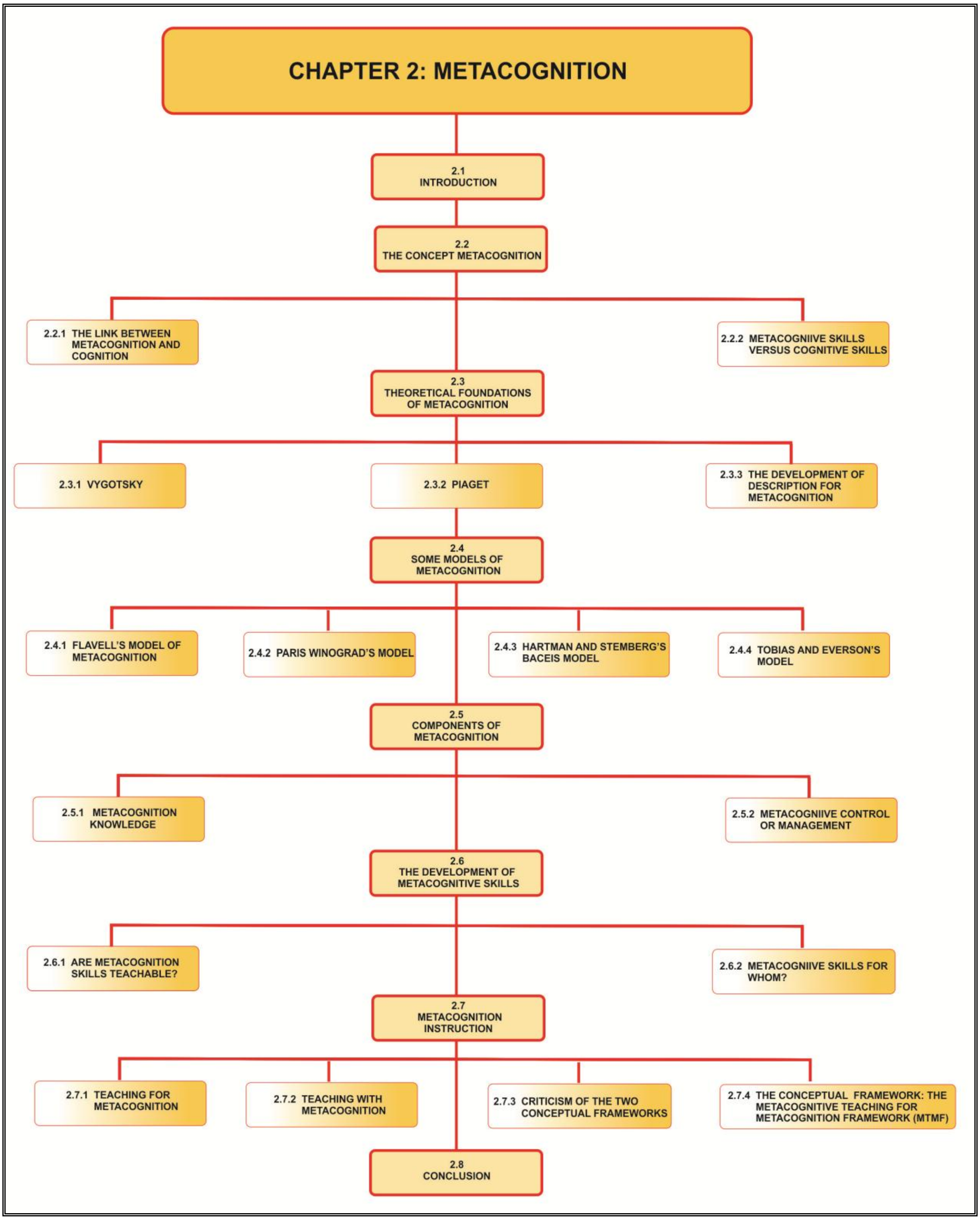
CHAPTER 2:

METACOGNITION

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2.1 INTRODUCTION

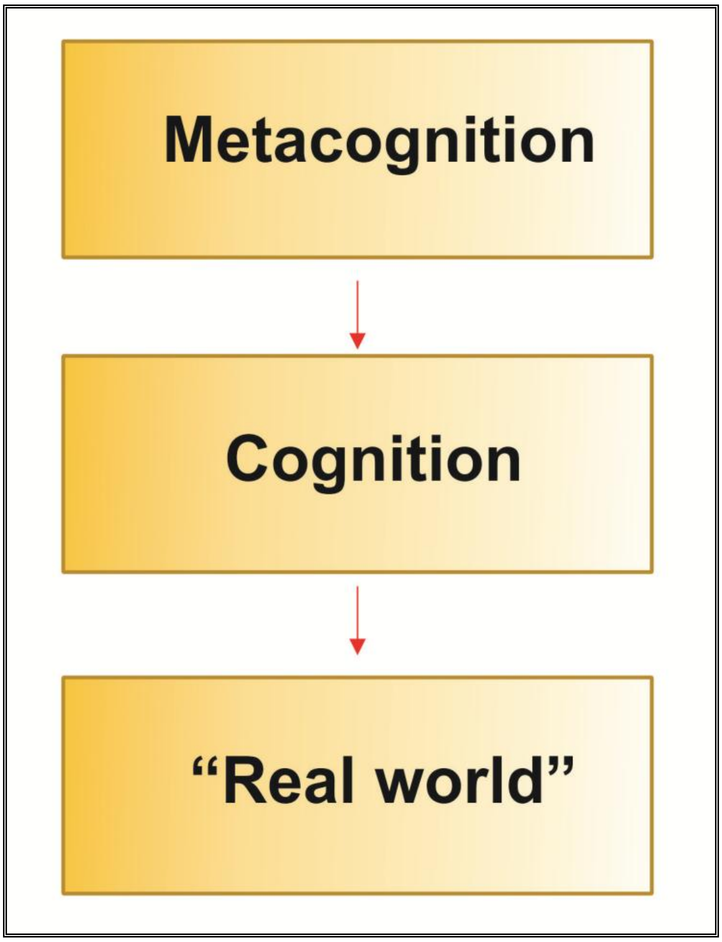
Metacognition is often defined as "thinking about thinking" (Lai, 2011; Larson, 2007) which might sound simplistic at first. But, if one really thinks carefully about what it is that is actually implicated by this phrase, that the brain that is doing the thinking is also that which is being thought about, this seemingly simplistic process becomes complicated, even complex. In this chapter the concept metacognition is firstly investigated (§2.2) complemented by a discussion of the link between metacognition and cognition (§2.2.1) and a differentiation between cognitive and metacognitive skills (§2.2.2). The work of theorists such as Vygotsky (§2.3.1) and Piaget (§2.3.2) as forerunners to metacognition are then addressed. This discussion is then furthered by the development of a description of metacognition over four generations (§2.3.3). Some models underpinning metacognition are next discussed (§2.4), followed by a discussion of the components of metacognition (§2.5). Since this study focuses on the metacognitive skills of the teacher, the development of metacognitive skills are then discussed (§ 2.6). Metacognitive instruction (§2.7) is subsequently discussed and includes both teaching *for* and teaching *with* metacognition. A summary (§2.8) of this first chapter of the literature review is then offered.

2.2 THE CONCEPT METACOGNITION

Conceptualizing "metacognition" is not easy. Various authors (Roebers, Cimeli, Röthlisberger, & Neuenschwander, 2012; Rowlands, 2009) ascribe this complexity to the fact that several terms such as self-regulated learning, reflective learning, executive control, and meta-memory are often used interchangeably for the same phenomenon. It is because of this difficulty with defining the concept that most researchers shy away from formal definitions and rather choose to describe metacognition according to its functioning and characteristics (Monteith, 1990). However, the Greek word *meta* means to transcend or go beyond a level while *cognition* refers to thinking which imply the observation, understanding, processing and recall of information (Kendall, Hudson, Gosch, Flannery-Schroeder, & Suveg, 2008; Papaleontiou-Louca, 2008). Notwithstanding this confusion, descriptions of the concept metacognition emphasize an executive function in the overseeing and regulation of thought processes. As Papaleontiou-Louca (Papaleontiou-Louca, 2008) succinctly states that metacognition essentially means cognition about cognition, the following section discusses the link between metacognition and cognition.

2.2.1 The link between metacognition and cognition

In order to distinguish between metacognitive and cognitive thinking, it is necessary in the very first instance to identify the fundamental ideas behind these concepts (Van der Walt, 2006). There is a link between the two concepts as both kinds of thinking play essential roles in effective learning but each has a distinctive role to play. These two concepts can never be separated but can be distinguished from one another. Metacognition entails one's own thinking on the thinking of observation, understanding, processing, storing and recall of information (Kendall et al., 2008; Papaleontiou-Louca, 2008). Metacognitive thinking does not flow forth from one's own immediate, external reality; rather, the core lies in one's own thinking and ideas on the representations of reality which are in turn determined by the person's knowledge, skills and feelings of his or her own thinking (Hacker, Keener, & Kircher, 2009).



Source: (Noushad, 2008, p. 6)

Figure 2.1: The relationship between metacognition, cognition and the 'real world'

For Noushad (2008, p. 5) cognition mediates between the learner and the experiential world where the objects of cognition are real objects, ideas and abstractions. Figure 2.1 shows a presentation of this relationship.

Metacognitive thinking is intentional, planned and directed at the successful completion of stated cognitive tasks (Hacker, Dunlosky, & Graesser, 1998). According to Lai (2011), cognition (knowledge about it and how to monitor it) is a paramount part of metacognition (Flavell, 1979; Schraw et al., 2006). Therefore, metacognition literally means higher order thinking about the normal cognitive processes through which knowledge is acquired.

2.2.2 Metacognitive skills versus cognitive skills

For Bondy (1984) the difference between cognitive skills and metacognitive skills lies in the consciousness of thinking and of control. Cognitive skills lie in a person's sub-conscience and are carried out automatically. These skills help learners with the processing, manipulation and storing of information (Georghiades, 2004; Papaleontiou-Louca, 2008). Examples of these skills are performing simple arithmetic operations such as adding or multiplying numbers (Papaleontiou-Louca, 2008), reading, taking notes, completing a diagram or answering a question (Ormrod, 2008). Metacognitive skills (self-testing, evaluation) on the other hand, are used in order to monitor cognitive progress on a cognitive task (Flavell, 1979; Georghiades, 2004). Metacognitive skills require conscious monitoring and regulation of cognition and are therefore often referred to as self-regulating skills. Schraw et al. (2006) agrees with this by stating that cognitive skills are essential in carrying out tasks whereas metacognitive skills are necessary in understanding how the task is carried out. The next example clarify the distinction between cognitive and metacognitive skills in the context of this study: When learners are working with a triangle they are using cognitive skills whether or not a drawing of a triangle exists in their sight. Metacognitive skills are used only when problems based on the triangle need to be solved and become more challenging. Hence the strong link of metacognitive skills with problem solving (Noushad, 2008) because, while cognitive skills are used for solving the problem, metacognitive skills are used in the process of problem solving. Thus, a person may or may not exert control over cognitive processes such as doing arithmetic, remembering, paying attention, understanding and use of language.

The next sub section focuses on the theoretical foundations of metacognition.

2.3 THEORETICAL FOUNDATIONS OF METACOGNITION

Various theories of cognitive development undoubtedly pioneered an approach to metacognition that cannot be disputed (Papaleontiou-Louca, 2008). Brown (1987) points out in a review of the origins of metacognition, that the process of metacognition, although informally, was documented and advocated by educational psychologists such as Thorndike (1914) and Dewey (1910), well before the emergence of the term 'metacognition'. According to Noushad (2008) early psychologists used ‘introspection’ to find answers to psychological questions which can be seen as the first sign of interest in metacognitive processes.

Two examples of theorists, the work of Piaget (1957) and his concept of “concrete operational thought”, and the work of Vygotsky (1978) and his concept of the “Zone of Proximal Development (ZPD)” and “language of thought”, will be briefly discussed.

2.3.1 Vygotsky

According to Papaleontiou-Louca (2008) Vygotsky had an influence on metacognitive theory primarily through his discussion of transference from other-regulation to self-regulation in children. This means that supportive others, such as parents, teachers, peers, initially act as interrogators, leading the child to more powerful generalisations and guiding the novice towards mastery; and there seems to be a systematic regularity in how this guidance works. This process is better described in Vygotsky’s theory of learning, the “Zone of Proximal Development” (1978, p. 86). Rowlands (2009) agrees that the emphasis has to be on the impact of the teacher for the potential development of the learner. Vygotsky (1978) defines the ZPD as:

> *The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.*

During the last two decades Vygotsky’s ideas became a major force in cognitive development. In an attempt to understand the relationship between word and thought, Vygotsky (2004) discovered that the key to understanding the nature of human consciousness is thinking and speech. According to Papaleontiou-Louca (2008) Vygotsky’s theory plays an important role in thinking and directing the individual’s cognitive endeavors and is also of the opinion that this mediating role of language, together with Vygotsky’s emphasis on social interactions, stresses the sociocultural basis of cognitive functions even more.

2.3.2 Piaget

Piaget was the first theorist to note that the cognitive functioning of a child differs from that of an adult (Flavell, 1996). Piaget's cognitive structural theory is a good example of a constructivist theory. According to this theory, children construct knowledge from their experiences (Piaget, 1957). This knowledge is not isolated, but forms an integrated whole of how the world functions. Piaget's theory is characterized by assimilation and accommodation when the child interacts with the world (St. Clair, 2005) but it is developmental in nature (Fox & Riconscente, 2008). According to St. Clair (2005) Piaget distinguished four periods in which humans develop cognitive structures, namely;

(i) The sensorimotor intelligence phase which runs from birth to approximately 1,5 years;

(ii) The pre-operational thought phase from approximately 1,5 to 6/7 years of age;

(iii) The concrete operational thought phase from approximately 6/7 to 11 years of age and

(iv) The formal operational thought phase from approximately 11 years through adulthood.

The next section on the development of a definition for metacognition is divided into four subheadings in which some researchers were selected from each of the generations in timeframes of ten years. The list of researchers is by no means exhaustive, but aims to give a timeline of how different researchers contributed to the development of some definition for metacognition.

2.3.3 The development of a description for metacognition

From research on metacognition, different generations of researchers who attempted to conceptualize metacognition can be distinguished. Table 2.1 provides a tabular representation of how metacognition as concept developed. It shows four generations of researchers who attempted to conceptualize metacognition:

Table 2.1: Four generations of researchers on metacognition

	First Generation (1970 – 1979)	Second Generation (1980 – 1989)	Third Generation (1990 – 1999)	Fourth Generation (2000 – 2009)
Researchers	Flavel(1976) Brown (1978) Livingston (1979)	Kluwe (1982) Kurtz and Borkowski (1984) Wellman (1985)	Paris and Winograd (1990) Ertmer and Newby (1996)	(Vos & De Graaf, 2004) Martinez (2006) Van der Walt (2006) Nouchad (2008)
Contribution to concept and definition of metacognition	Primarily focused on the relation between the individual's knowledge of his or her memory, and memory capabilities.	Focused on metacognition as a component of memory, understanding, problem solving and self-control in gifted learners.	Focuses on the relation between metacognition and self-regulated learning and add that reflective thinking is key aspect of metacognition; self-appraisal' and 'self-management' of cognition.	Metacognition comprises knowledge of the structure of cognition, information on a task, comprehension of that information, knowledge of self and of other, self-regulation, metacognitive experiences and reflection.

2.3.3.1 The first generation

The seventies marked the first generation of researchers who attempted to define metacognition. Researchers from this generation primarily focused on the relation between the individual's knowledge of his or her memory, and memory capabilities (Monteith, 1990). These attempts were aimed at describing the terms meta-memory and metacognition and their influences on memory (Kuhn & Dean, 2000). Correlative methods were primarily used in determining this relation between memory and retention capabilities. One good example of the first generation of researchers is Flavell (1976) who coined the term metacognition (Flavell, 1976; 1979). Flavell (1976) initially describes metacognition as a person's knowledge and the regulation of his or her own cognitive processes, but in the light of further research he primarily emphasises the knowledge aspect thereof (Flavell, 1979). For example, I am engaging in metacognition… if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as a fact. Metacognition further relates to the individual's ability to use this awareness of thought in order to control his or her actions.

This definition of metacognition is a broad conceptualisation on what the person's knowledge is on the nature of the cognitive task and the strategies involved in mastering the task, while the task or act of thinking is being carried out (Flavell, 1976; Hacker et al., 1998; Livingston, 1979; Schneider & Lockl, 2008).

Brown (1978) further developed Flavell's framework by adding two concepts, namely knowledge of cognition and regulation of cognition (Schneider & Lockl, 2008). Knowledge of cognition includes declarative, procedural and conditional knowledge. Regulation of cognition is indicative of planning, monitoring and evaluation of cognition (Schraw, 2001). Brown's definition emphasises the most important aspect of the consciousness of self-knowledge and understanding. If, for example, learners (or their teachers) cannot understand a specific cognitive activity, they will not be able to apply knowledge or talk about the activity. Schneider and Lockl (2008) noted that there are different levels of understanding. Per illustration, learners or teachers can sometimes use knowledge effectively, but might not understand why they acted in a certain manner. For Brown (1978), metacognition refers to the concept of self-knowledge which is reflected in the effective use of overt descriptions of cognitive activity.

2.3.3.2 The second generation

The second generation researchers on metacognition is characterised through a theoretical deepening and research on metacognitive strategies (Kluwe, 1982). Definitions of metacognition became more detailed as the concept broadened. Research on metacognition in the eighties focused on metacognition as a component of memory, understanding, problem solving and self-control in gifted learners (Manning, Glasner, & Smith, 1996).

Kluwe (1982) adds a further dimension to Flavell's (1979) definition of metacognition through the identification of the following two general characteristics of metacognition. Firstly, the individual possesses knowledge of his or her own thinking as well as of other people's thinking, and secondly, an individual can monitor and regulate his or her own thinking (Hacker et al., 1998).

Metacognition is described as as higher-order cognition and the intentional control of cognitive activity (De Klerk, 1995; Romainville, 1994; Wenden, 1989). Kurtz and Borkowski (1984) and Schraw (2001) divides metacognition into two related components, namely metacognitive knowledge and metacognitive control. Metacognitive knowledge refers to the skills, strategies and resources which are necessary in order to master a task. Metacognitive control refers to strategies such as comprehension monitoring, predicting outcomes, planning of learning activities and revision. Therefore it is necessary for the learner to know how and when to apply these skills and strategies in order to ensure the successful mastering of the task (metacognitive control).

For Kurtz and Borkowski (1984), metacognition is more closely related to strategy use than it is to memory. According to these researchers, metacognition focuses on the choice and application of strategies and therefore metacognition is a prerequisite for effective strategy use. Feedback is important during strategy use, especially feedback on the usefulness and transferability of strategies in other contexts (Kurtz & Borkowski, 1984).

Wellman (1985) defines metacognition as higher-order thinking that manage cognitive processes. For Pressley, Borkowski, and Schneider (1987) and Schneider and Lockl (2008), metacognition is more related to interactive components such as strategy use, motivation, general knowledge of the world, and the purposeful selecting of learning strategies. According to these researchers, metacognition focuses on the choice and application of strategies and is therefore a prerequisite for effective strategy use. As strategies are carried out, their effectiveness is monitored and evaluated, leading to expansion and refining of specific strategy knowledge (Schneider & Lockl, 2008).

2.3.3.3 The third generation

Ertmer and Newby (1996) add reflective thinking as an essential cognitive strategy and a key aspect of metacognition (Ertmer & Newby, 1996; Wirth & Aziz, 2010). The distinction made by Minott (2008) and Ertmer en Newby (1996) between the dual role of reflection, namely reflection-on-action and reflection-in-action, suggests a strong correlation with metacognition, especially in the identification of the capacity to plan, monitor and evaluate own learning (Minott, 2008). *Reflection-on-action* indicates an active process which helps the individual make sense of previous experiences with the objective of improving current and future thinking and actions. *Reflection-in-action* indicates control of the learning process through planning, monitoring and evaluation while the learning process is taking place (Ertmer & Newby, 1996). Therefore, reflection is also considered to be a strategy or skill that works along with other strategies. Ertmer and Newby (1996) describe the reflection process as a personal experience of sorts which is executed by comparing various strategies with one another. Personal feedback takes place within the learning activity. Because of this feedback with reflection, the person, behaviour and environment change during the learning process (Zimmerman & Schunk, 2002). For instance, teachers might reconsider plans before including them in the learning task, assess strategies, and make deductions and new action plans while the task is being carried out. Reflection leads to improved learning actions in the future when teachers apply the new knowledge that they have acquired with reflective thinking in other new situations (Ertmer & Newby, 1996).

Thus metacognitive knowledge can be seen as static knowledge and reflection as an active process of exploration and discovery (De Jagger, Jansen, & Reezigt, 2005; Ertmer & Newby, 1996).

2.3.3.4 The fourth generation

Kramarski and Mevarech (2003) explain metacognition as an individual's thinking and feelings of their cognitive state and process, as well as their self-regulation processes which are used to achieve cognitive objectives.

According to Vos and De Graaff (2004), metacognition comprises knowledge of the structure of cognition, information on a task, comprehension of that information, knowledge of self and of other, self-regulation, metacognitive experiences and reflection. Vos and De Graaff's definition of metacognition corresponds with that of Kluwe and Flavell, except on the premises that the former emphasises the use of reflection in metacognitive thinking (Vos & De Graaff, 2004). Reflective thinking uses existing knowledge to acquire new knowledge;

therefore it is the link between metacognitive knowledge and metacognitive control (Van der Walt, 2006).

Martinez (2006) considers metacognition to be self-evaluation; to evaluate whether thinking and ideas are accurate, coherent and complete. Martinez (2006, p. 696) identifies three main categories of metacognition:

i. Meta-memory and meta-comprehension,

ii. Problem solving, and

iii. Critical thinking.

i. Meta-memory and meta-comprehension

Meta-memory and meta-comprehension are grouped together because they refer to an individual's knowledge of his or her own cognition; thus self-insight. The illusion often exists amongst individuals that they know and understand a piece of work while this is not actually the case (Martinez, 2006). Meta-memory corresponds with declarative knowledge, for example factual knowledge such as naming the sides in a right-angled triangle. An individual either knows it or does not know it (Martinez 2006). This implies that individuals can therefore be accurate in determining their own factual knowledge. This self-insight on existing knowledge is important for future learning by that individual (Martinez, 2006; Tobias & Everson, 2002).

Meta-comprehension could either be good or poor during reading or listening. The more critical question is whether the individual knows whether his or her comprehension is good or poor. An individual's evaluation of his or her comprehension is often inaccurate. This way many learners may, for instance, read a textbook without understanding any of the content and not realise that they do not understand it. When learners think they understand but they actually do not, academic achievement may be inhibited. The situation worsens when learners fail to consider their own comprehension, not making simple notes, and reading or listening mechanically (Martinez, 2006).

ii. Problem solving

Problem solving, exclusively a human and intentional cognitive act, is applied on a daily basis, especially in a complex community where the adherence to existing rules and procedures is not enough for survival (Ormrod, 2008). Problem solving can simply be defined as the achievement of an objective when the way in which the goal can be achieved is doubtable or when an obstacle has to be overcome.

For Martinez (2006), problem solving is what learners do when they do not know what to do. Problem solving is not algorithmic, but it does entail the generation and consideration of possible solutions, choices and evaluation of results. The problem solving process can be compared to finding a path in a maze (Martinez, 2006). Problem solving involves more than just cognitive thinking. Learners or teachers must take a step back, and frequently ask themselves: What do I want to achieve? What is the best way in which I can achieve my objective? Does this strategy that I am using to achieve my objective, work?

iii. Critical thinking

Critical thinking and problem solving are different concepts, but they do supplement each other. Critical thinking refers to the evaluation of ideas for feasibility, quality and especially whether the idea makes sense or not (Snowman & Biehler, 2000). Many cognitive rules exist which can be applied to critical thinking, for example: has this idea been clearly stated? Do these ideas follow upon each other logically? Is the message logical, rational and coherent, or is it contrastive and does it contain vague generalisations? (Amalathas, 2010; Martinez, 2006).

Martinez's (2006) description of problem solving and critical thinking indicates similarities with what Paris and Winograd (1990) call self-management and what other researchers call metacognitive control. Metacognition also requires emotional and motivational considerations during challenging situations, for example problem solving in challenging situations when emotional control is required above uncertainty and possible failure. Perseverance may also be difficult during problem solving. Metacognitive thinking can improve perseverance and focus when learners or teachers encourage themselves to remain focused. Together with perseverance, coherence will convince learners or teachers that effort rather than specified skills is what determines success. Metacognition may, for example, involve positive emotions such as goal orientation, success, overcoming obstacles, and creative solutions. Effective learners realise that they can learn anything with enough effort (Martinez, 2006).

Schneider (2008) defines metacognition as knowledge and consciousness of own cognitive, emotional and motivational processes and the skills to actively control these processes. For Ormrod (2008) metacognition literally means thinking on one's own thinking. Metacognition contains the learner's comprehension and convictions about his or her own cognitive processes, the learning content to be mastered as well as the conscious attempts to use behaviour and thinking patterns to learn and to improve memory.

Papeleontiou-Louca (2008) notes that metacognition cannot be equated to learning or development, but that it can be done so with conscious and purposeful regulation of learning and development.

2.3.3.5 Recent approaches to metacognition

Recent definitions of metacognition have been extended to not only thinking about cognition, but also to affective conditions such as motivation, intention and the ability to consciously and intentionally monitor and exert control over self-knowledge and effective conditions. Most recent thoughts on the role of metacognition in problem solving recognize metacognition as one of the most relevant predictors of accomplishing complex problems (Roebers et al., 2012; Van der Stel & Veenman, 2008; Veenman et al., 2006).

2.3.4 Summary

In summary, initially Kurtz and Borkowski (1984) and Shraw (2001) divide metacognition into two relating components: firstly, knowledge of the skills, strategies and resources which are necessary in order to master a task. Secondly, it is necessary for the learner (or the teacher) to know how and when to apply these skills and strategies in order to assure the successful completion of the task (metacognitive control). Metacognitive control refers to strategies such as comprehension monitoring, predicting outcomes, planning of learning activities and revision.

The previously mentioned examples of definitions and descriptions of metacognition are only a few of many definitions and examples which can be found in literature, and which can be used to introduce the different approaches to metacognition. A formal definition was further complicated by debates amongst researchers on the differences between cognitive and metacognitive strategies. In fact, it is because of these differences and sometimes diverging premises that metacognition is often described as a fuzzy concept (Livingston, 1979; Vos & De Graaff, 2004). Although discrepancies exist in abovementioned definitions, two components are emphasised: namely the individual's knowledge of cognition and of self, and the individual’s control in the regulation of cognitive processes. Thus, metacognition basically deals with an individual's thinking on their own thinking and the use of higher-order thinking during the active control of cognitive processes when learning takes place. However, the abovementioned definitions of metacognition are unanimous in that metacognition provides personal insight regarding own thinking, and that independent learning as a result can be promoted.

These definitions and descriptions of metacognition were originated from various theories of metacognition, offering different evidences and explanations of metacognition as a phenomenon. In the following section some models on metacognition will be discussed, which will offer more information on a) the variables that influence metacognition, and b) the role of cognitive knowledge and control of individuals.

2.4 SOME MODELS OF METACOGNITION

The importance of metacognitive theory within the education arena has resulted in metacognition being placed high on educational research agendas (Noushad, 2008; Roebers, et al., 2012; Van der Stel and Veenman, 2010). Although there is no shortage of models which can be found in literature that attempts to explain the process of metacognition, only four models are discussed here because of their popularity in the education field. They are Flavell's model (1997), Paris and Winograd's model (1990), Hartman and Sternsberg's model (1993) and lastly Tobias and Everson's model (2001). Table 2.2 shows the metacognitive components accentuated in each of the four different models relating to metacognition:

Table 2.2: Four models relating to metacognition

Metacognitive component	Flavell (1997)	Paris & Winograd (1990)	Hart & Sternberg (1993)	Tobias & Everson (2001)
Metacognitive Knowledge and skills	Flavell's model of metacognitive knowledge focuses on three variables: the person, the task, and the strategy (Flavell, 1979; Hacker et al.,1998; Papeleontiou-Louca, 2008). The person variables entail the nature of the individual's self and his or her beliefs about other people as cognitive beings (Flavell, 1979; Livingston, 1979). The task variables imply knowledge on how challenging the task is, which items are to be learnt, and how much time is required in order to master a task (Flavell, 1979; Schneider & Lockle, 2008; Papeleontiou-Louca, 2008:13). The task variables also refer to the selection of effective strategies in order to complete the task (Flavell, 1979; Schneider & Lockle, 2008;Vos en De Graaff, 2004). Flavell (1987) extends his description of task variables to focus on the individual's reflections on task requirement. Learners or teachers will, for example because of personal experience, consider whether tasks are easy or difficult,	Paris and his co-workers united and refined the knowledge aspect and management aspect as described by Flavell (1979) and Brown (1987) by referring to these concepts as self-appraisal and self-management of cognition (Van der Westhuizen, 1989) and (De Klerk, 1995; Georghiades, 2004; Papaleontiou-Louca, 2008). Self-appraisal is personal reflection or assessment by individuals on their own knowledge and skills, their affective views of their knowledge, motivation and properties (Paris & Winograd, 1990). Three forms of knowledge fall under self-appraisal. Self-appraisal answers individuals' questions about what they know, how to act, and when and where their knowledge and strategies can be applied (Paris & Winograd, 1990).	Within this model, individuals' questions which are directed at higher-order thinking play a determining role regarding comprehension, comprehension monitoring, self-assessment and self-control. As a metacognitive activity, questioning is less effective when it is regulated externally by the educator (Gourgey, 1998). Affect and metacognition mutually influence one another. Learners with poor metacognitive skills are, for example, passive pertaining to planning and task analyses and are dependent on teachers for that. When help is not available with, for instance, the analysis and execution of a learning task, such learners will easily throw in the towel, unable to grapple with the problem themselves in order to solve it (Gourgey, 2002). The reason for this is the learner's inability to carry out internal dialogue by means of self-questioning. Learners with such poor metacognitive skills do not possess methods with which to construct their own understanding. For such learners metacognitive skills development will strongly count to their advantage, because their	Metacognition is compilation of skills and knowledge, knowledge of cognition, monitoring of own cognition and learning processes and control of these learning processes. Knowledge monitoring is requirement for activation of metacognitive skills. The knowledge monitoring evaluation technique which is used for this model evaluates the differences between individuals' approximations of their descriptive and procedural knowledge according to their academic performances (Tobias & Everson, 2002). Findings indicate that individuals, who can accurately distinguish between what they know and what they do not know, generally make use of strategic learning. The same approach that is used in this model has been used in research on meta-memory, intelligence and aptitude tests (Tobias & Everson, 2002).

Metacognitive component	Flavell (1997)	Paris & Winograd (1990)	Hart & Sternberg (1993)	Tobias & Everson (2001)
	whether they have sufficient information at their disposal to complete the task, whether the information is poor- or well-organised, and at what rate the task should be completed (Papeleontiou-Louca, 2008:13). The strategy variables refer to the most effective strategies and objectives to complete the learning outcome (Flavell, 1979; Georghiades, 2004; Papeleontiou-Louca, 2008).		performance, self-efficiency and motivation to learn will be improved. The result will be that those learners will be equipped with metacognitive skills so that they can rely on their own intellectual resources to create new intellectual cognitive possibilities (Gourgey, 2002).	
Metacognitive Experience	Metacognitive experiences activate strategies which are directed at cognitive or metacognitive objectives (Flavell, 1979; Livingston, 1979) Metacognitive experiences influence cognitive objectives, metacognitive knowledge and metacognitive strategies. Firstly, it can lead to the determining of new objectives, revision or adaptation of the objectives which failed in previous objectives, or confusion about the stated objective (Flavell, 1979). Secondly, metacognitive experiences	According to Paris and Winograd, metacognition can offer individuals knowledge and confidence which will enable them to regulate self-learning. The metacognitive actions of setting goals, planning, strategy decisions, monitoring and evaluation form the different steps for self-regulating individuals (Monteith, 1990). Consequently it is clear that metacognition and self-regulated learning are interdependent. Metacognition lies at the fundaments for sub-processes of self-regulated learning and is an important precondition for self-regulated	The affective system includes motivation, affective self-regulation and attitudes. Affective self-regulation entails the self-regulation of values, expectations, beliefs and attitudes which are necessary for effective functioning (Hartman, 2002a).	

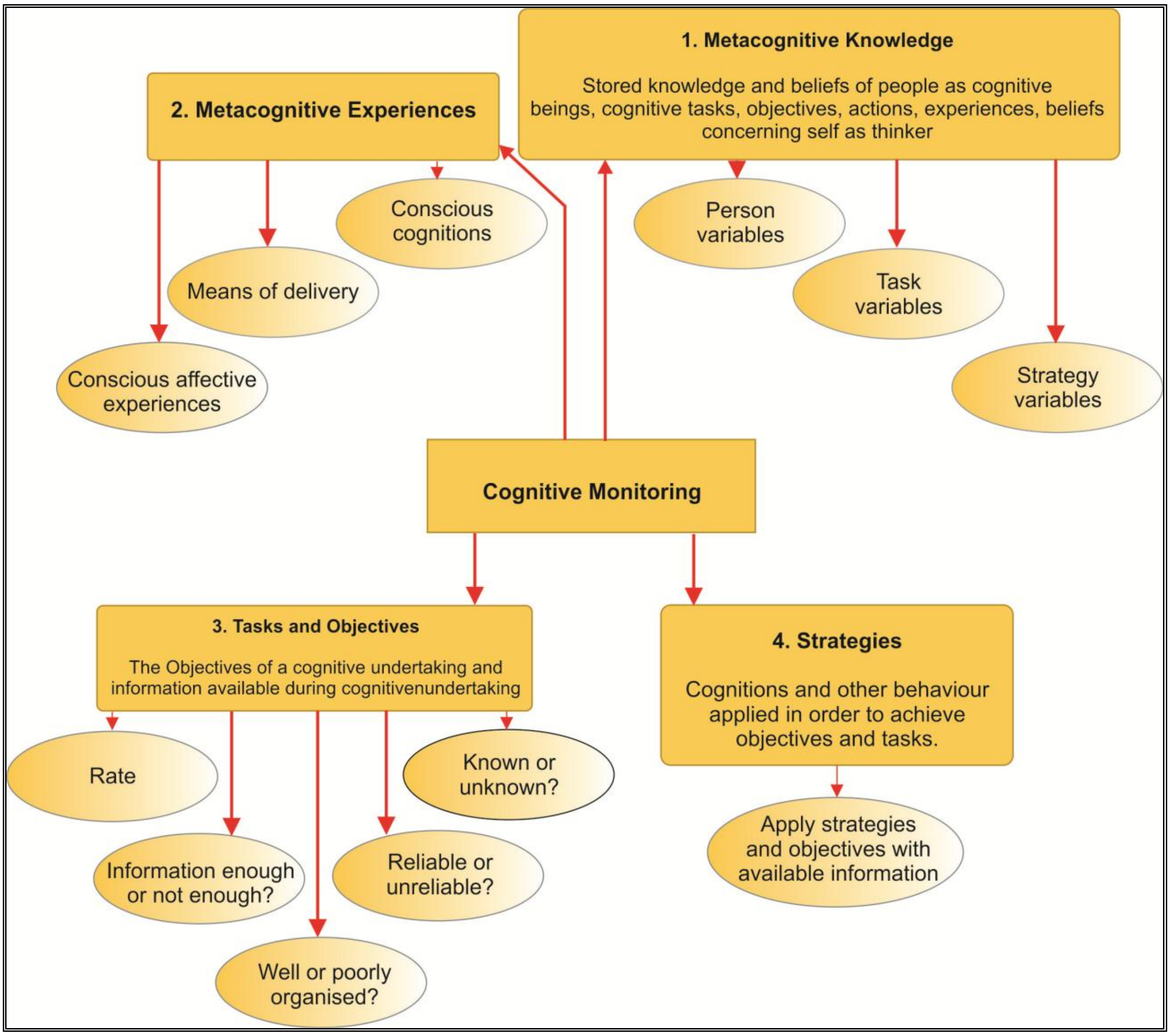
Metacognitive component	Flavell (1997)	Paris & Winograd (1990)	Hart & Sternberg (1993)	Tobias & Everson (2001)
	influence the metacognitive knowledge base by adding new knowledge, revision, or exclusion of existing ideas (Flavell, 1979). Thirdly, metacognitive experiences activate strategies that are aimed at cognitive or metacognitive objectives (Flavell, 1979; Livingston, 1979).	learning (Monteith, 1990).		
Cognitive monitoring and control	Cognitive monitoring takes place by means of actions and interaction between a) metacognitive knowledge, b) metacognitive experiences, c) objectives or learning tasks, and d) actions and strategies (Flavell, 1979; Papeleontiou-Louca, 2008; Georghiades, 2004). Cognitive strategies are created in order to develop and promote knowledge and thinking, and metacognitive strategies (self-testing, evaluation) are used to monitor cognitive progress. The same strategy can be used to achieve both cognitive and metacognitive	Planning concerns decisions on how a certain action is to be carried out. Evaluation involves determining how to progress with a certain task or problem. Regulation refers to adaptations or changes in strategies that follow when, through evaluation, it has been determined to which extent the cognitive task or problem has been successfully completed or solved (Paris en Winograd, 1990). The two dimensions of metacognition, namely self-appraisal and self-management, mutually affect one another. The impression that a teacher obtains on his or her own	The cognitive system includes obtaining and processing information, and has three application possibilities namely critical thinking, creativity, and learning strategies. The metacognitive system consists of executive control and strategic knowledge.	According to the model, knowledge monitoring is a requirement for the activation of other metacognitive skills (Tobias en Everson, 2002). Knowledge monitoring is the individual's ability to know what it is that he or she does and does not know. For Tobias and Everson (2002), knowledge monitoring is a prerequisite for metacognition and effective learning. They argue that if individuals do not know their own knowledge bases, it is not possible to expect the individuals to carry out more advanced metacognitive activities such as evaluation, planning and control of learning. If the individuals can

Metacognitive component	Flavell (1997)	Paris & Winograd (1990)	Hart & Sternberg (1993)	Tobias & Everson (2001)
	objectives. Questioning will, for instance, improve knowledge (cognition), even though the objective of the questioning was initially meant to monitor whether knowledge has grown. The memory storage of metacognitive knowledge contains knowledge on metacognitive strategies as well as cognitive strategies (Flavell, 1979).	knowledge and capabilities by applying self-appraisal determines his or her actions when it comes to self-management. In turn, the extent of success or failure during self-management could then either have a positive influence or a negative influence on the individual's self-appraisal (Cross & Paris, 1988).		distinguish between their pre-knowledge and knowledge that they still have to acquire, they can focus better on cognitive resources and learning material (Tobias en Everson, 2002). Control takes place from the second level onward where individuals evaluate their work, select strategies to achieve outcomes, and plan how to complete a learning task. Learners or teachers control or monitor, for example, their knowledge and comprehension of assignments and lessons. They look for extra help from other learners, teachers or from literature to improve their knowledge, adapt strategies and plan further action.

Metacognitive component	Flavell (1997)	Paris & Winograd (1990)	Hart & Sternberg (1993)	Tobias & Everson (2001)
Objectives, task's & strategies	Objectives and tasks involve comprehension, capturing facts in the memory, problem solving or simply just improvement of knowledge on a matter. The successful achievement of an objective in the end supports both metacognitive knowledge and metacognitive experiences (Flavell, 1979).			Selecting strategies to achieve outcomes, and plan how to complete a learning task lies at the second level onwards.

2.4.1 Flavell's model of metacognition

According to Flavell (1979), cognitive monitoring takes place by means of action and interaction between a) metacognitive knowledge, b) metacognitive experiences, c) objectives or learning tasks, and d) actions and strategies (Figure 2.2) (Flavell, 1979; Papeleontiou-Louca, 2008; Georghiades, 2004).



Source: Flavell (1979, p. 906)

Figure 2.2: Four classes of Cognitive Phenomenon

2.4.1.1 Metacognitive knowledge

The category metacognitive knowledge contains further subcategories under person variables namely: *intra-individual* individual variables such as knowledge, beliefs on interests, abilities and attitudes; *inter-individual* variables provide comparisons between an individual and another. The universal subcategory deals with generalisations of an individual pertaining to learning in general (Papeleontiou-Louca, 2008).

2.4.1.2 Metacognitive experiences

Metacognitive experiences activate strategies which are directed at cognitive or metacognitive objectives (Flavell, 1979; Livingston, 1979). Metacognitive experiences are any conscious, cognitive or affective experiences which involve intellectual activities. Examples of cognitive, affective and intellectual awareness include awareness of pre-knowledge, learning outcomes, personal resources (such as textbooks, internet, a quiet place to study), task requirements, how the learning task will be evaluated, motivations and anxiety levels (Livingston, 1979).

Metacognitive experiences can be long or short, simple or complex in content, for instance moments of confusion which learners and teachers could ignore, or during which they wonder whether they understand others' intentions (Flavell, 1979; Papeleontiou-Louca, 2008). The experiences can happen before, after or during a cognitive task. Examples are feelings that make learners or teachers fail in a task, or a feeling of success in a similar, previous task. Feelings and thinking before, after or during the time in which the task is undertaken, are included in metacognitive experiences (Flavell, 1979; Georghiades, 2004). In certain literature, Flavell and other researchers refer to metacognitive experience as metacognitive monitoring and self-regulation (Romainville, 1994).

Some metacognitive experiences involve metacognitive knowledge such as recalling strategies, and others do not. Some knowledge is consciously used, and others not (Flavell, 1976; Papeleontiou-Louca, 2008). The learner or teacher's feeling that he or she is still far from the set objective is not an aspect of metacognitive knowledge. The action of the individual according to feeling is, however, guided and influenced by metacognitive knowledge (Flavell, 1979).

2.4.1.3 Objectives or tasks

Objectives or tasks comprise the third category in Flavell's (1979) model. Metacognitive objectives and tasks are the expected outcomes of a cognitive action. Objectives and tasks involve comprehension, capturing facts in the memory, problem solving or simply just improvement of knowledge on a matter. The successful achievement of an objective in the end supports both metacognitive knowledge and metacognitive experiences (Flavell, 1979).

2.4.1.4 Strategies

Metacognitive strategies are interdependent of objectives and tasks and are used to monitor cognitive processes and to ensure that the objective (for example solving a mathematical problem) is achieved. Self-questioning is an example of a strategy that can be used to test one's own knowledge, to monitor comprehension, and to evaluate whether new work has been understood (Flavell. 1979).

2.4.2 Paris Winograd's model

Most researchers marry Flavell's and Brown's definitions into one definition. This familiar dichotomy of thought is consistent with information processing views on descriptive and procedural knowledge and contains two essential aspects in Paris and Winograd's (1990) model of metacognition, namely self-appraisal and self-management of thinking (Paris & Winograd, 1990).

Affective and motivational features of thinking are included under self-control of cognition (Monteith, 1990).

2.4.2.1 The self-appraisal of cognition

There are apparent similarities between Flavell's (1979) metacognitive knowledge regarding person variables, task variables and strategy variables, Hart's declarative, procedural and conditional knowledge (Hart, 2002), and Paris and Winograd's (1990) personal assessment questions with self-appraisal of cognition.

In Flavell's model, declarative knowledge includes knowledge of person variables and task variables, while procedural and conditional knowledge include strategy variables. Questions on "what individuals know" are called declarative knowledge because it confirms what an individual already knows (De Klerk, 1995). Questions on “how" fall under procedural knowledge because it indicates an individual's knowledge on strategies or procedures that can be applied or followed by means of a specific task. Questions on "when and where" are called conditional knowledge because it indicates conditions under which certain knowledge, strategies, or procedures should be followed (De Klerk, 1995).

2.4.2.2 The self-management of thinking

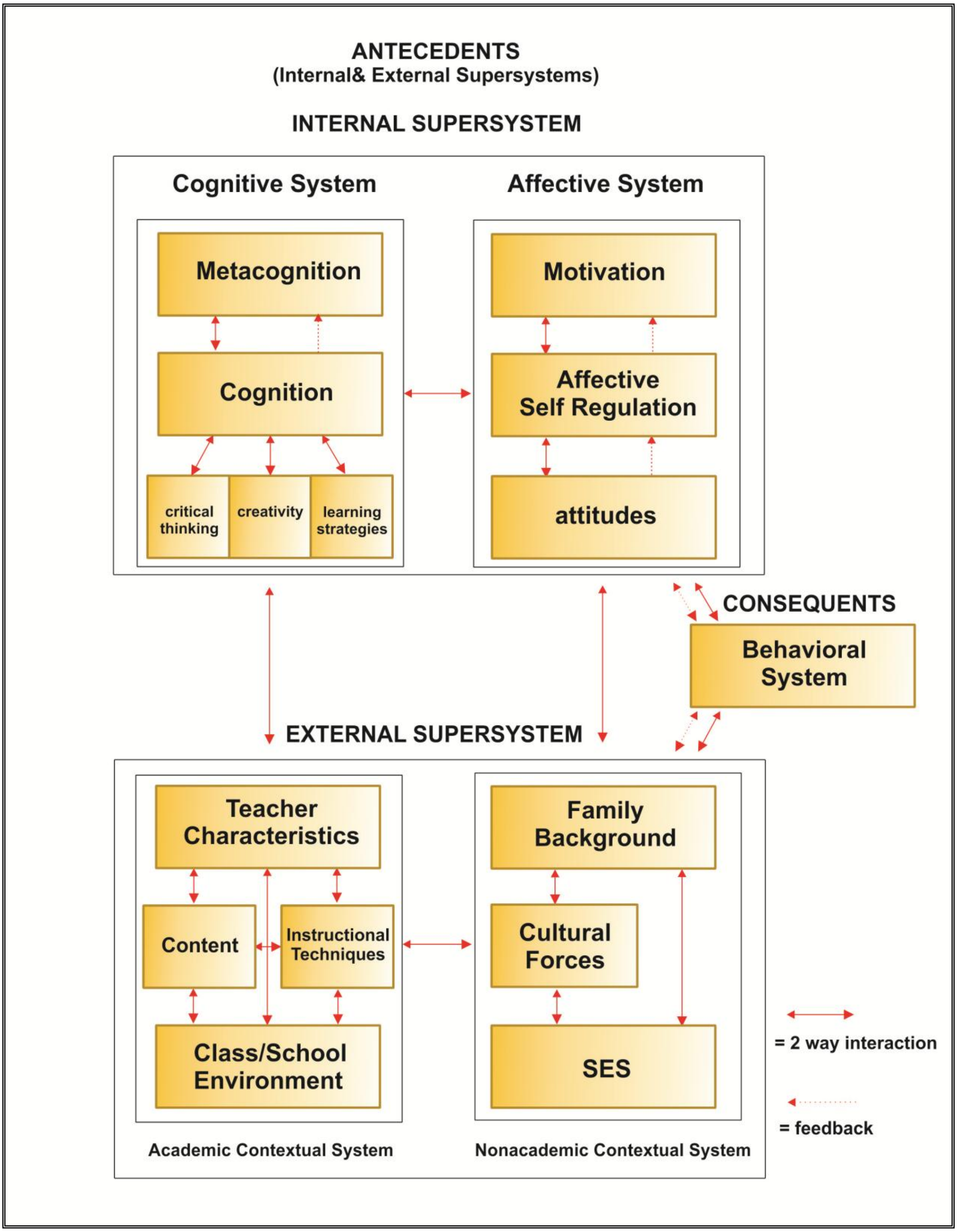
Self-management consists of plans, strategies and adaptations which can be used for achieving objectives and solving problems (Paris & Winograd, 1990). Self-management of thinking is reflected in planning before a cognitive task is undertaken. The executive actions in control of thinking are subdivided under planning, evaluation and regulation.

2.4.2.3 The affective nature of self-appraisal and self-management

Flavell (1979) refers to the affective nature of self-appraisal as metacognitive experiences. These metacognitive experiences colour an individual's own views of their emotions such as shyness, uncertainty, helplessness, confidence and pride (Paris & Winograd, 1990). Similarly, self-appraisal and self-management contain personal assessments of effect in contrast to the view of Brown *et al*., (1983) quoted by Paris and Winograd (1990:240) who view metacognition as "cold". The affect and emotion involved in learning may, for example, result in individuals looking forward to a learning task and approaching it with fervour and confidence, or on the other hand, the individuals not looking forward to a learning task, and approaching it with negativity.

2.4.3 Hartman and Sternberg's BACEIS model

(Hartman & Sternberg, 1993) extended on the profile of metacognitive skills with their BACEIS model (Figure 2.3), which emphasises the interaction between the cognitive, metacognitive and affective components of learning.



Source: (Hartman, 2002b, p. 45)

Figure 2.3: Hartman and Steinberg's BACEIS model

The BACEIS model is a comprehensive framework of internal and external factors which relate to one another, and with the effectiveness of an individual's learning and thus also the individual's academic performance (Gourgey, 2002; Hartman, 2002b). Internal factors refer to the individual's cognition and affect, while external factors refer to the individual's academic and non-academic environment in which the metacognitive skills function (Hartman, 2002b). All of these factors relate to one another and work interactively.

2.4.3.1 The internal super system

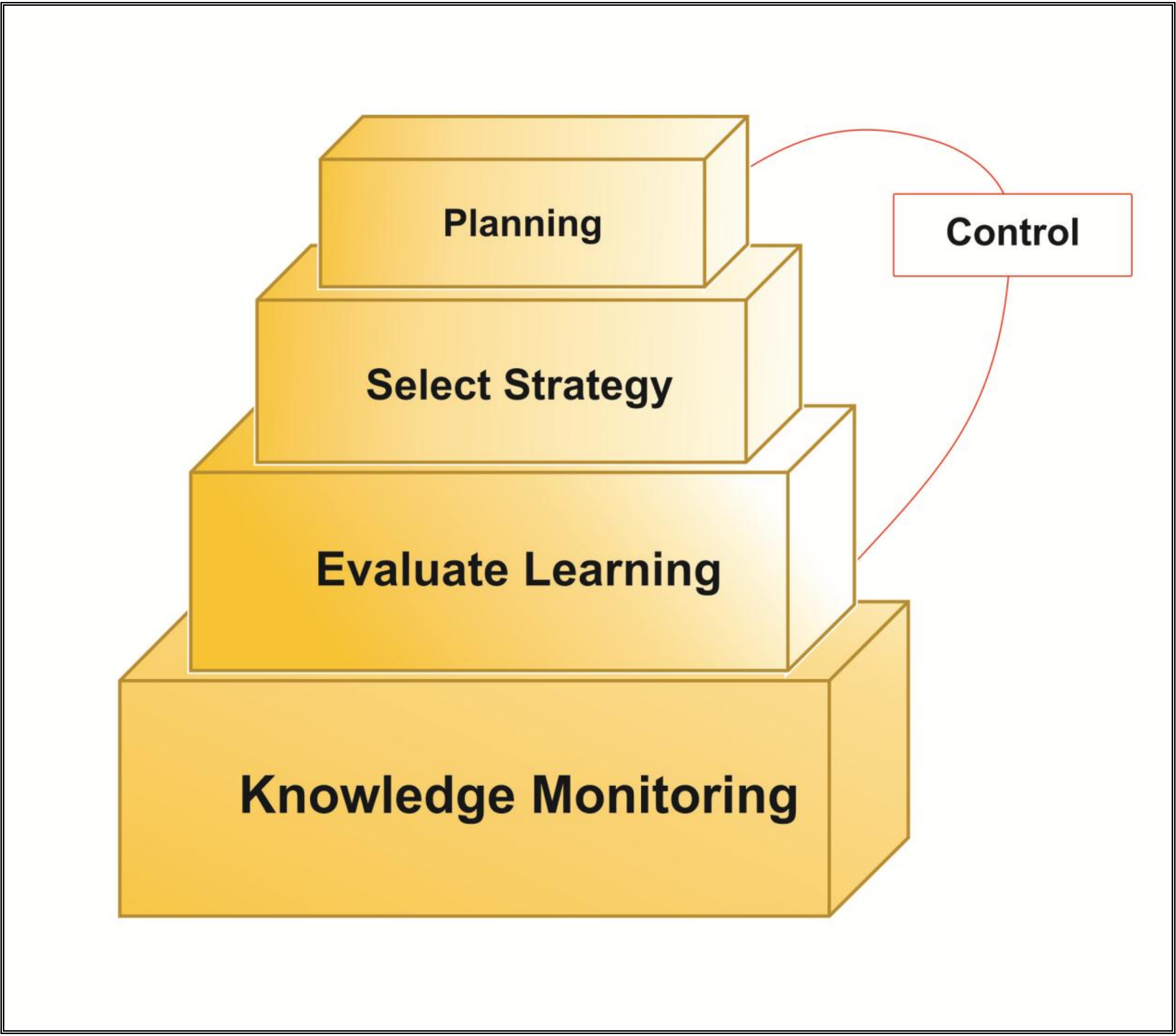
The internal system consists of cognitive and affective components while the cognitive system consists of a cognitive and metacognitive component (Figure 2.3).

2.4.3.2 The external super system

The external super system includes the environmental contexts, for example the academic system in the classroom and the non-academic system. The academic system includes the learning content, the educator, the teaching methods and the school/class environment. The non-academic system includes the culture, socio-economic status and family relationships (Hartman, 2002b). The environmental contexts interact with the cognitive and affective systems which cause behavioural changes relating to academic performance.

2.4.4 Tobias and Everson's model

Tobias and Everson (2002) consider metacognition to be a compilation of skills and knowledge, knowledge of cognition, monitoring of own cognition and learning processes, and control of these learning processes. They organise these components into a hierarchical model (Figure 2.4). At the first level is knowledge, at the second level the evaluation of learning, at the third level the selection of strategies and at the highest level in the hierarchy is planning.



Source: Adapted from Tobias and Everson (2002, p. 1)

Figure 2.4: A hierarchical model of metacognition.

Along with the previous models by Flavell (1979), Paris and Winograd (1990), Hartman and Sternberg (1993), various cognitive, metacognitive and affective components are integrated in comprehensive ways in order to understand and improve academic performance of individuals. In their models, all the researchers emphasise the role of cognitive knowledge and the management of this knowledge by means of planning, monitoring, selecting strategies, and evaluation during the execution of learning tasks.

In contrast with Hartman and Sternberg's (1993), Tobias and Everson (2002), Flavell (1979) and Paris Winograd's (1990) models neglect to include the influences of family background, cultural influences and socio-economic circumstances. Hartman and Sternberg's model is well-extended and encompasses a wide variety of variables on individuals' affects and performances. Even teachers' personal traits, teaching methods, the learning content and the properties of the institution are taken into account with the BACEIS model. Thus, the model makes provision for the role of teachers relating to the development of the individual's metacognitive skills.

Tobias and Everson's (2002) model only focuses on one aspect of metacognition namely the individual's knowledge monitoring abilities. In contrast to the models by Flavell, Paris and Winograd, and Hartman and Sternberg, the affective domain and influences of environmental knowledge in this model are ignored. All the aforementioned models offer an understanding of variables which influence metacognitive thinking and learning.

From the aforementioned varying definitions and models, a unique definition has been conceptualised for the purposes of this study. Consequently, the concept "metacognition" which will serve the purposes of this study will refer to an individual's conscious thinking on his own thinking, as well as knowledge and reflection on learning tasks and activities. Metacognition comprises the individuals' conscious attempts to use and control their cognitive processes, behaviour, dispositions and surroundings in order to improve thinking processes, learning and memory with the structuring of learning opportunities and completion of learning tasks.

Metacognition does not take place in isolation. Individuals develop metacognitive skills in context with other behaviour, skills and attitudes. Alongside for instance cognitive processes, metacognitive processes are influenced by individuals' self-knowledge of their motivations, attitudes, family backgrounds, social and economic circumstances, and the academic context within which they learn. Metacognition consists of two main components, namely metacognitive knowledge and metacognitive control. Metacognitive knowledge comprises declarative, procedural and conditional knowledge of the individual. Metacognitive control requires the process of planning, monitoring, evaluation and reflection during and after the structuring of a learning session or completion of a learning task.

These components of metacognition, namely metacognitive knowledge and metacognitive control and management, will subsequently be discussed.

2.5 COMPONENTS OF METACOGNITION

Several researchers emphasise the different components of metacognition. For example, Brown (1978) distinguishes between planning, monitoring and evaluation, while Flavell (1976; 1979) places greater emphasis on four categories namely metacognitive knowledge, metacognitive experiences, objectives and tasks as well as strategies. With cognitive knowledge, Flavell (1979) emphasises three aspects, namely the person, the task and the strategy. Shraw's (2006) view, on the other hand, is that metacognition comprises two key aspects; firstly, knowledge of self, and secondly, knowledge of executive control strategies of the process. Although many more specific components of metacognition have been distinguished, there seems to be disagreement about the nature of those components. However, according to the classic models (§2.4) metacognition primarily consists of metacognitive knowledge and metacognitive control or regulation. These two components are discussed in more detail next.

2.5.1 Metacognitive knowledge

Metacognitive knowledge refers to the knowledge about the cognitive tasks, strategies and knowledge individuals possess about themselves and other people (Flavell, 1979). This knowledge of cognition is often refined under personal-, task-, and strategy variables, and is sometimes also referred to as declarative-, procedural- and conditional/contextual knowledge (Fernandez-Duque, 2000; Hartman, 2002a; Schraw et al., 2006; Vaidya, 1999). The difference between these three kinds of metacognitive knowledge is best explained by Hartman (2002b: 57) in the following example in which she did some error analysis with her teacher students:

1. *Identify what their wrong answer was and what the correct answer is (declarative knowledge).*

2. *Determine specifically why they got the answer wrong (contextual knowledge) and*

3. *Formulate an action plan on how they have now learned and understood the material and how they will remember this information (procedural knowledge).*

As these kinds of knowledge have already been discussed under the different models, only a brief distinction between them will follow:

2.5.1.1 Declarative knowledge

Declarative knowledge entails the individuals' knowledge of themselves and of the factors that influence their performance (Fernandez-Duque et al., 2000; Shraw, 2006; Vaidya, 1999). This type of knowledge involves factual knowledge, concepts within a subject or field, as well as presuppositions that certain task properties and personal properties exist in order to complete learning tasks (Fernandez-Duque et al., 2000; Hartman, 2002b; Vaidya, 1999). Additionally, declarative knowledge includes information which can help individuals set objectives and adapt to accommodate changing circumstances under which a task is to be carried out (Paris & Winograd, 1990; Schraw, 2001).

2.5.1.2 Procedural knowledge

Procedural knowledge, derived from the word "procedure" which indicates the manner of carrying out a task, refers to that kind of knowledge necessary to execute the task and therefore answers the question of how the task is to be carried out (Hartman, 2002b; Shraw, 2006).

2.5.1.3 Conditional knowledge

Conditional knowledge is also referred to as contextual knowledge by Hartman (2002a). Papaleontiou-Louca (2008) does not acknowledge this third kind of knowledge as a kind of metacognitive knowledge. For him this knowledge about what to do or when to do it, is considered to be a mixture of metacognitive awareness and declarative knowledge (Desoete & Roeyers, 2003), or as being part of metacognitive skills (Noushad, 2008).

2.5.2 Metacognitive control or management

An individual's control in the regulation of cognitive processes is called metacognitive control. Metacognitive control refers to the implementation of planning, monitoring and evaluation and includes the plans that learners or teachers make before learning tasks or problem solving is initiated, and the adjustments that are made during the execution of a learning task, as well as revision of the solution at the end of the task. Metacognitive control is made possible by internal and executive metacognitive processes namely planning, monitoring, and evaluation which enable individuals to plan, monitor progress in a learning task, and to evaluate during and after the execution of the learning task (Gourgey, 2002; Schraw, Crippen & Hartley, 2006). Reflection connects metacognitive management processes as well as the knowledge and management aspects of metacognition.

Metacognitive control enables an individual to determine the nature of the learning task or problem, choose strategies with which to carry out the task, select resources, plan time, recall relevant pre-knowledge and pay attention to feedback as the task progresses. Personal feedback is then used to improve understanding during the execution of the task or for future learning tasks. Thus, metacognitive control enables an individual to use knowledge and strategies in order to perform academically (Filcher & Miller, 2000; Gourgey, 1998; Sharp, Fonagy, & Goodyer, 2006). It can therefore be concluded that the individual's ability to evaluate own knowledge and skills, plan specific strategies, monitor and regulate is assumed under this dimension of metacognition. Metacognitive control or management is therefore an active process capacitating individuals to experience, observe and reflect on their own cognitive thinking in order to promote learning and memory (Paris & Winograd, 1990). During this dynamic process metacognitive thinking is transmitted into actions (Jacobs & Paris, 1987).

The basic control strategy of metacognitive planning, monitoring and evaluation, as well as the role of reflection within metacognition, follows in the subsequent discussion.

2.5.2.1 Planning

Planning involves setting objectives, task analysis such as projection, text skimming and self-questioning on the requirements of the task, choosing strategies or procedures to attain the objective, and the identification of possible stumbling blocks that may inhibit the successful mastering of the learning context (Ertmer & Newby, 1996; Filcher & Miller, 2000; Paris & Winograd, 1990; Schraw et al., 2006).

According to Simpson and Nist (1990) and Peirce (2003), individuals ought to ask the following questions for planning in order to complete a learning task:

- What is the nature of the task?
- What is my goal?
- Which information and strategies do I need?
- How much time and resources do I need?

2.5.2.2 Monitoring

Metacognitive monitoring is the process which enables individuals to experience, observe and reflect upon their own cognitive thinking (Kolb, 1984). Learners can, for example, be aware that they have mastered a task, or understand a text that they are reading at a given moment. Monitoring informs the learner on the state of his or her progress regarding the objectives to be achieved, and whether the chosen learning strategy is suitable for the mastering of the learning task (Kolb, 1984; Pressley et al., 1987). In turn, teachers can for instance ascertain whether a specific learning opportunity has successfully been presented. Monitoring then informs the teacher about the extent to which the stated objectives have been achieved and whether the chosen teaching strategies were suitable for the learning opportunity.

Consequently, monitoring entails awareness or understanding of the learning task, identifying the objective, the position into which it fits in the sequence of steps: a) self-monitoring, b) self-questioning, c) self-testing and d) self-assessment (Filcher & Miller, 2000; Pressley et al., 1987; Schraw et al., 2006). With monitoring, the individuals should ask themselves whether they know what to do, what the sequence of the steps is, whether the work is understood, and whether the set objectives will be achieved (Pressley et al., 1987). Self-questioning is an effective manner in which to reflect. When individuals learn to ask questions while they are busy with the learning task or learning session, their thinking is purposefully directed at areas where they are uncertain and where help and direction are required (Lane, 2007).

Individuals who lack self-monitoring and self-regulating skills are over-eager to choose a strategy to apply without evaluating whether the strategy is suitable and effective to achieve the learning objective (Gourgey, 1998; Schoenfeld, 1987). In contrast to this, effective individuals will spend a great deal of their time analysing the problem and ensuring that they understand the task requirements to solve the problem (Gourgey, 2002). Effective individuals test various strategies and approaches, ask themselves whether the strategies will work, and alter their strategies if they do not work (Gourgey, 2002).

Metacognitive internal dialogue is an important monitoring skill which comprises four categories:

- Correction of a self-discovered error in a task (for example, think about this again - it is wrong);
- Dealing with and processing frustration, boredom and errors in a self-directed task (it's difficult, but I must pull through);
- Strengthening of thinking and behaviour during progression of the task and performance (well done!);
- Problem solving of a task, awareness and assurance that the task and components of the task are accurate (I know this is the answer).

2.5.2.3 Evaluation

With evaluation the results and effectiveness of the learning process are more closely considered. With evaluation the individuals ought to ask themselves the following questions (Jacobs & Paris, 1987; Peirce, 2003; Pressley et al., 1987; Schraw et al., 2006; Simpson & Nist, 1990):

- Have I achieved my goal?
- Which strategy worked?
- Which strategy did not work?

These questions enable an individual to re-evaluate objectives, draw conclusions and alterations regarding further planning, manage resources and time, gather information, use other and better strategies which promote achievement of objectives, and revise work. By means of metacognition the individual remains actively involved with his or her learning progress by promoting, monitoring and adjusting according to the objectives and requirements of the task or learning session (Jacobs & Paris, 1987; Pressley et al., 1987; Schraw et al., 2006).

Monitoring skills can be developed with training and practice, and Bondy (1984:234) sets apart the following metacognitive skills:

- *Prediction of consequences of an action*
- *Monitoring an action (Did it work?)*
- *Monitoring progression with the activity (How am I doing?)*
- *Test to reality (Does it make sense?)*

2.6 THE DEVELOPMENT OF METACOGNITIVE SKILLS

Regarding the development of metacognitive skills, most researchers agree that emerging metacognitive skills can be observed from the early age of three years and onwards. However, these skills have been found not to be easily differentiated (Lyons & Ghetti, 2011; Roebers et al., 2012). Between the age of five and eight years, children's explicit awareness of certainty/uncertainty as well as the reliability and validity of monitoring increases gradually (Lyons & Ghetti, 2011; Roebers et al., 2012; Schneider, 2008, 2010; Schneider & Lockl, 2008). Between the age of seven and eight approximately, a systematic association between item difficulty (in terms of ease of recall or recall accuracy) and monitoring judgments for incorrect responses (i.e., lower confidence judgments for harder items when item responses turn out to be incorrect) has been documented, indicating that from that age on individuals take recall properties into account, an important and useful heuristic for monitoring (Krebs & Roebers, 2012; Serra & Metcalfe, 2009). With a delay, children then also improve with respect to metacognitive control skills, (i.e. their ability to act upon monitoring).

2.6.1 Are metacognitive skills teachable?

According to Lai (2011), several researchers offer evidence that metacognition is teachable (Cross & Paris, 1988; Haller, Child, & Walberg, 1988; Hennessey, 1999; Kramarski & Mevarech, 2003). In a longitudinal study with 32 grade 3 and 4 learners by Desoete (2007) to investigate learners' metacognitive skills, the data suggested that metacognitive skills must explicitly be taught and cannot be just assumed to develop during a lesson. Desoete (2007) argues that the mathematics teaching-learning process might be improved if more time is allocated to metacognitive instruction. Metacognitive skills can therefore be taught through the implementation of a meta-curriculum or through formal courses in learning strategies and study methods. With a meta-curriculum the learning strategy is taught along with the learning content. The educator could, for example, first explain what the nature of the learning content is and how it can be studied (Zohar, 1999).

2.6.2. Metacognitive skills for whom?

Metacognitive skills are usually seen as higher order thinking skills and as such are usually used by higher achieving learners. Contradictory to this, Lee *et al.* (2001) attempted to find out how effective a metacognitive approach towards mathematical problem solving would be for weaker learners. Although there were some indications of increased confidence in mathematical problem solving among the learners, no concrete evidence could be found for the effectiveness of such an approach. However, according to Schneider (2010), numerous intervention studies have shown that “normal” learners as well as those with especially low mathematics performance do benefit substantially from metacognitive instruction procedures. According to De Jager *et al*., (2005), educators need to teach learners with poor metacognitive skills how to regulate their learning processes before making these learners take responsibility for their own learning. Although studies related to metacognitive skills are usually done with learners, Kozulin (2005) explored the cognitive and metacognitive skills of teachers in his study. Mitchell (2008, p. 17) is of the opinion that “the hardest part is not getting new ideas into teachers’ heads: it’s getting the old ideas out”.

The most popular opinion on metacognitive instruction amongst researchers is that, with the help of constructivist models of instruction such as reciprocal teaching, facilitation of procedures and cognitive craftsmanship, teaching of metacognitive skills is more effective (Peirce, 2003; Simpson & Nist, 1990).

Metacognitive skills should maintain a credible and continued presence in curriculums and assessment methods (for example with reflection in assignments).

2.7 METACOGNITIVE INSTRUCTION

Metacognition lies at the heart of metacognitive instruction (Goh, 2008). As mentioned earlier on in Chapter one (§1.2.1), studies in metacognition are usually done in the context of the learners and not their teachers. Therefore there is limited evidence of what a “metacognitive teacher” does or should do, how and when he or she should do it or what the processes are that would develop metacognition in teachers. This dearth in literature is exacerbated by the fact that studies in metacognitive instruction center on language instruction more than on mathematics instruction. Available literature, however, argues that like learners, teachers will be able to accomplish teaching tasks more effectively if they approach these with metacognition (Duffy, 2005, p. 303):

> *Just as we must pay attention to pupils’ incomplete understandings, misconceptions and naive understandings and be responsive in helping them create more mature understandings, we must similarly attend to teachers’ incomplete understandings, misconceptions, and naive understandings and be responsive in helping them become better teachers*.

Metacognitive instruction implies *teaching metacognitively* which involves teaching *with* metacognition and teaching *for* metacognition (Hartman, 2002b). It is important to differentiate between teaching *for* metacognition and teaching *with* metacognition, although both should be considered for effective teaching. Teaching for metacognition requires the teacher to think about his/her teaching in order to develop the metacognitive skills of the learners. In this regard, Schofield (2012) argues that explicit teaching is required for learners to acquire and apply metacognitive skills. Teaching with metacognition is also important as it will give an explanation of why teachers teach the way they do and give reasons for the specific strategies they are using.

2.7.1. Teaching for metacognition

McKeachie (1988) and Commander and Valerie-Gold (2001) noted that teachers give a lot of feedback on the correctness of the learning outcomes, but that they give little guidance on how to achieve the outcomes. They suggest that learners should explain, step-by-step, how they will go about completing the learning task. Learners should also be asked to describe their thinking processes (Peirce, 1878; Pierce & Fontaine, 2009).

Kriewaldt (2009) suggests creating a class atmosphere which will promote the development of metacognitive skills and which will encourage an active and constructivist learning process. Learners should be able to trust one another, be respected as individuals, and team and cooperative relationships should be developed.

Some researchers also suggest modelling for the development of metacognitive skills (Hartman, 2002b; Kriewaldt, 2009; Pierce & Fontaine, 2009). Teachers should verbalise their own thinking and encourage learners to think out loud while they solve problems. Thinking out loud and verbalisations are also referred to as cognitive modelling or "making thinking heard". Learners must feel at liberty to question the educator's thinking and problem solutions. With the use of conferences as strategy, learners can also be encouraged to explain their reasons for their thinking and strategies to one another (Kriewaldt, 2009).

According to Schraw and Moshman (1995), dialogue during group interactions is a golden opportunity for the development of metacognitive skills. During facilitation of group interactions learners should be lead to think critically. In this way the learner’s spoken reasons and thinking are made known to one another. During cooperative group work learners have the opportunity to explain and justify their thinking and strategies amongst one another. It is important to allow enough time for reflection during these group discussions.

Reflection is encouraged by the use of journals (Kriewaldt, 2009). Zohar (1999) suggests creative workshops and reflection workshops for teachers. During these workshops teachers should be made aware of the basic theoretical aspects of higher-order education and should be taught how to design a learning activity of their own which they will be able to use in their own classrooms.

Self-assessment should be incorporated with learning tasks to create opportunities for self-regulated learning. With self-assessment learners monitor their own levels of knowledge, performance, learning, abilities, thinking and strategies (Kriewaldt, 2009). With peer assessment learners have the opportunity to reflect upon the work of other and to make connections with their own experiences.

Hartman (2002b), Kriewaldt (2009), Pierce and Fontaine (2009) and Simpson and Nist, (2000), suggested that teachers should emphasise the following five aspects pertaining to metacognitive strategies:

- the significance and use of a strategy should be discussed and explained
- examples of applications of a strategy which indicate all of the decision making processes such as when, where and why the strategy can be applied, and suggestions on how learners can monitor and evaluate their understanding and progress.
- Supervision and practice of strategies, as well as feedback, are emphasised (Martinez, 2006).
- Examples of metacognitive strategies include the use of a learner's portfolio (Commander & Valeri-Gold, 2001), an individual learning plan (Chiang, 1988), and learners' evaluation and reflection of their own exam papers in order to improve self-knowledge (Weimer, 2002).

When the learners have the opportunity to practise and are placed in situations that require metacognitive skills, the meaning and the value of metacognitive skills are understood and learners become focused on mastering the skill (Martinez, 2006).

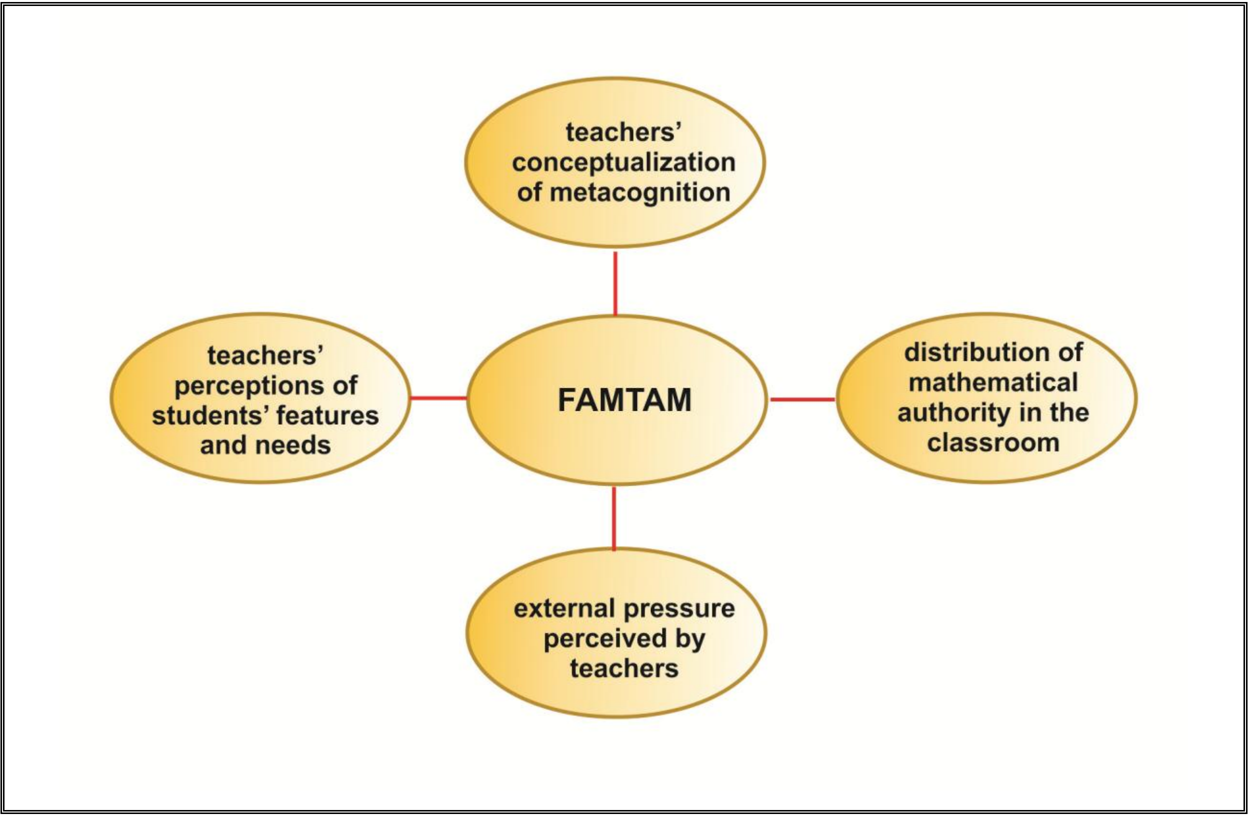
St Clair (2005) developed the following table in which a parable is formed between the novice learner and the expert learner in line with the metacognitive functions.

Table 2.3: Metacognitive functions of novice and expert learners

Planning the Learning Experience	Novices do not really plan their activities. They do not think out the process of learning. They do not think about thinking.	Expert learners are good planners and pre-planners. They organize the learning experience.
Identification of what is known from unknown	Novices do not stop to think about what they already know so that they can differentiate the known from the unknown in the learning experience	Experts know how to use past knowledge in evaluating new situations. They try to ascertain what it is that is different about the new learning experience
Thinking Strategies	Novice learners do not reflect on what strategies they are going to use in the learning experience. They muddle through each situation.	Expert learners think things through. They ask questions about their new experience and they try to develop successful strategies that will enable them to learn the new ideas, forms, or performance tasks. Expert learners feel that they need one or more cognitive maps and thinking strategies on how to use those cognitive maps
Monitoring	Novice learners do not monitor what they are doing in order to improve their learning experiences. They do not take an active role in the learning experience.	Successful learners constantly monitor their own abilities to perform a task or to understand a situation. They use cognitive maps that they have developed in order to visualize what they are doing and how well they are doing it.

Source: St. Clair (2005, p. 2)

The following conceptual framework was used to assess teaching for metacognition in a study conducted by Ader (2013).



Source: Ader (2013, p. 24)

Figure 2.5: A framework for Analysing Mathematics Teaching for the Advancement of Metacognition (FAMTAM)

2.7.1.1 Teachers' conceptualization of metacognition

Drawing on theoretical considerations from literature it is evident that teachers need to have a profound knowledge about the concept of metacognition (Ader, 2013). McElvany (2009) asserts that this knowledge involves not only the definition of metacognition, but also an understanding of the construct and the main characteristics of metacognitive processes and having a good repertoire of metacognitive strategies as well as how and when to use these strategies in the classroom.

2.7.1.2 Distribution of mathematical authority in the classroom

Ader (2013) views mathematical authority as where the responsibility for the evaluation of the mathematical work in the classroom lies as well as the comment on the plausibility thereof. For Ader (2013, p. 29) mathematical authority is embedded in metacognition in the sense that learners can use knowledge, planning, monitoring and evaluation of their cognition, because she argues that *"conceptualisation of authority of the discipline here also embodies metacognition as a norm for mathematical problem solving".* Schoenfield (1987; 1992 & 2006) agrees with this notion when he claims that the authority lies within the mathematical ways of working that are accepted by mathematical communities.

2.7.1.3 Teachers' perceptions of students' features and needs

Teachers need to know their learners. This knowledge is imperative when teaching for metacognition. It is usefull for teachers to keep a diary in which they document particular needs and valuable information about their learners. Ader (2013, p. 27) is of the opinion that "sensitivity to students" promotes metacognition in the teaching of mathematics.

2.7.1.4 External pressures perceived by teachers

Every teacher's situation is unique. Teachers immerse themselves in the day-to-day teaching of real-time classrooms (Duffy, 2005) with various factors that influence the teaching that is done daily. In the study done by Ader (2013), external pressures perceived by teachers influenced metacognitive instruction both positively (in the sense that the project in which the study was done advocated the use of metacognitive strategies) and negatively (for example the available time).

2.7.2 Teaching with metacognition

Balcikanli (2011) posits that it is believed that a good starting point for change in teacher development is when teachers know about their own teaching (metacognitive awareness). St Claire (2005) maintains that any teacher or mentor is engaging in a metacognitive act whenever he/she assists a child in learning. For Harpaz (2007) metacognition is a characteristic of what it means to think and learn, and not just a skill to be taught. Wilson and Bai (2010) argue for the explicit awareness of teachers' metacognition and their ability to think about, talk about, and write about their thinking and their teaching. Statements like the above raise the question as to what extent teaching is a metacognitive act. The Metacognitive Awareness Inventory (MAI) was modified to develop a new inventory specifically for teachers, the Metacognitive Awareness Inventory for Teachers (MAIT) which is considered to help teachers realise their metacognitive levels in teaching. This is one of the indicators that levels of teacher metacognition do exist, and are an important factor in teaching and learning. Considering the fact that the teacher is seen as key to quality education and determines the success or failure of any curricular innovation (Dori & Herscovitz, 2005; Hewson, 2007), metacognition has a definite role to play in quality education. Schofield (2012, p. 58) reports evidence, although very little, of the following teaching strategies regarding metacognitive instruction:

- *'Teasing thinking out of students' through questioning, getting students to clarify, predict and summarise.*
- *Modelling how to think, 'thinking out loud'.*
- *Having background knowledge of students.*
- *Using assessment information as well as self- and peer-assessment.*
- *Guiding students with less teacher involvement.*
- *Use of acronyms and mnemonics.*
- *Graphic organisers such as a spidergram.*
- *Making links to prior knowledge.*

Metacognition brings to the learning process an awareness of the process of learning, the structures, involved in that process, the use of skills, and the monitoring of those activities as a way of improving the educational process (St. Clair, 2005). But it is not that simple: Developing the skills for applying metacognition, however, is not clear-cut. Lin et al. (2005) argue that conventional metacognitive instruction falls short when it comes to the challenges teachers often face and they agree with Bransford et al. (2000) that each teacher's situation is different and is influenced by his/her environment. Lin *et al*. (2005) therefore are of the opinion that adaptive metacognition, rather than conventional metacognition, will be of more value in effective teaching (Lin et al., 2005; Swartz & Parks, 1994). Adaptive metacognition, according to Lin *et al*. (2005), involves both the adaptation of one's environment and one's self in response to a wide range of classroom changeability. The development of metacognitive skills will thus to a large extent depend on the unique situation of the teacher.

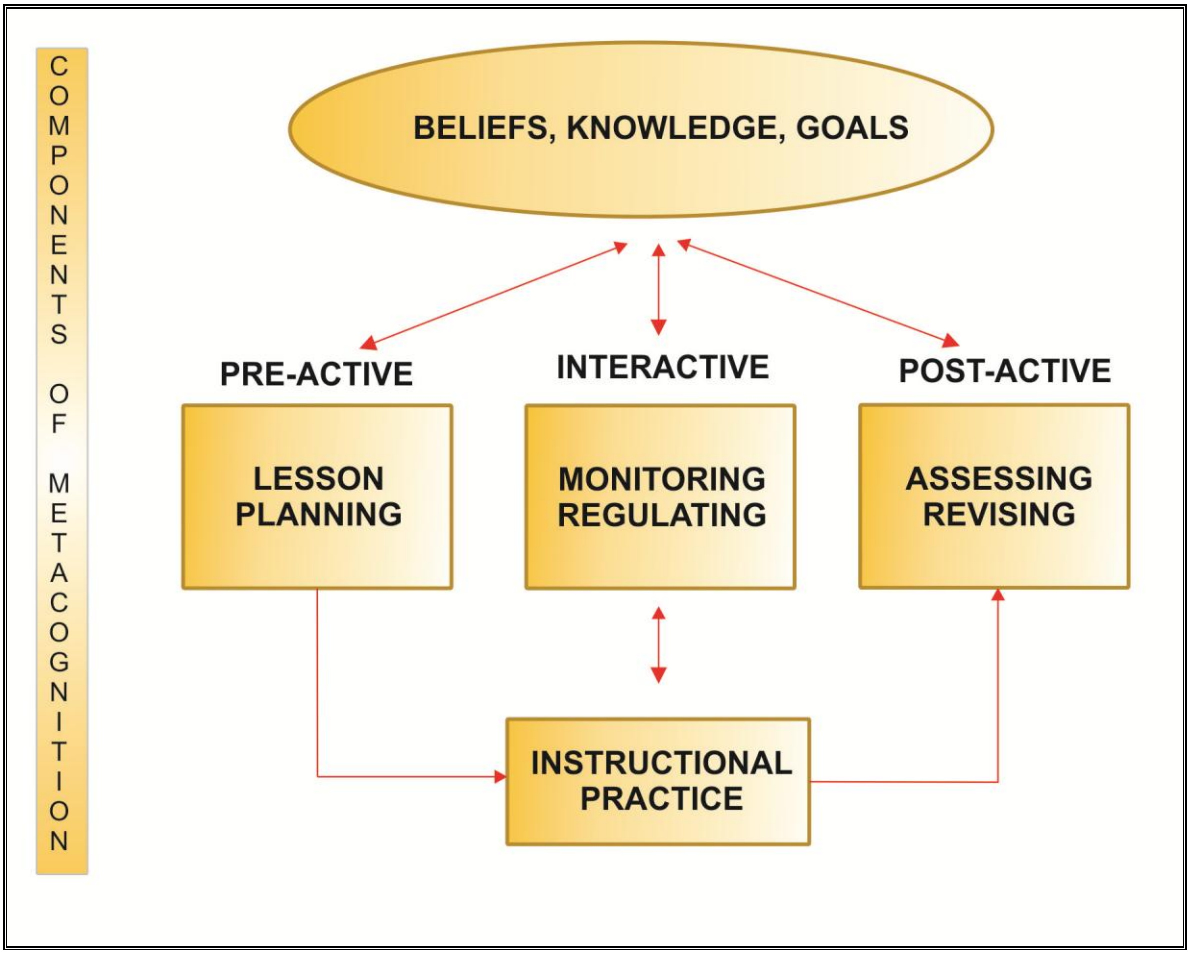
As a result of the limited literature on teacher metacognition no table that indicates some form of attributes of metacognitive teachers could be found and hence the researcher compiled a table from extant literature on what it means to be seen as a metacognitive teacher. The results of a study conducted by Wilson and Bay (2010) reveal that a rich and complex understanding of metacognition and metacognitive thinking strategies is required.

Table 2.4: A comparison between metacognitive and non-metacognitive teachers

Metacognitive Functions	The Non-Metacognitive teacher	The Metacognitive teacher
Setting of goals	These teachers usually set taken-for-granted goals that are aimed to induce almost the same activity from everybody.	Metacognitive teachers are setting varied teaching and learning goals.
Metacognitive knowledge	Teachers have a limited understanding of metacognition and metacognitive thinking strategies.	Teachers have a rich understanding of metacognition and metacognitive thinking strategies.
Planning activities	Teachers attempt to directly teach strategies for solving problems that aim to control learners' behavior only	Teachers plan appropriate activities and observing activities engaged by others with different values or sociocultural backgrounds
What teachers do during the lesson	Teachers tend to just hand out sheets and tell learners what to do, do not review previous work and gives only 5 minutes at the end of the lesson to think.	Teachers listen to learners and explain them what to do, review at least one question from previous work and give learners time to think, at least 10 minutes during the lesson.
Feedback	Teachers only write "good work" or "well done" at learners' work.	Teachers give thorough feedback about what learners need to do better.
Assessment and training of metacognition	Teachers are less analytic and reflective about their own teaching than another person's teaching.	Teachers strive to use more social, collaborative situations in the assessment and training of metacognition
Other sources of information	Teachers usually do not detect absence of the important information very well because they fail to develop the habits of gathering more information so that they can determine what strategies and solutions to apply	Teachers use computers to help their metacognition by giving them both (a) a set of experiences and (b) opportunities to appreciate what other sources of information are important to consider and to reflect on

Source: adapted from Lin et al. (2005, p. 253), Schofield (2012, p. 59) and Wilson and Bai (2010, p. 269)

Artzt and Armour-Thomas (2002) used the conceptual distinctions of pre-active, interactive and post-active stages of teaching from Jackson (1968) to develop the Teacher Metacognitive Framework (TMF) and examined the mental activities of seven experienced teachers and seven novice teachers in a study in which they had selected eight components of metacognition for their study: Knowledge, beliefs, goals, planning, monitoring and regulating, assessing and revising (Figure 2.6). Their study provided insight into the relationship of specific components of teacher metacognition:



Source: Artzt & Armour-Thomas (2002, p. 130)

Figure 2.6: A framework for the examination of teacher metacognition related to instructional practice in mathematics

Artzt and Armour-Thomas (2002) posit that beliefs, knowledge and goals inform the lesson and that the different components of metacognition manifest during the lesson with the planning happening in the pre-active phase, monitoring and regulating in the interactive phase while there is a great deal of assessing and revising in the post-active phase. All three of these phases then form part of the instructional practice of the teacher. This framework will be used in the analysis of the lessons which will be offered in this study by five participating teachers.

2.7.3 Criticism of the two conceptual frameworks

Although both of the above frameworks were developed for mathematics teaching, the FAMTAM focuses on teaching mathematics for metacognition (TfM) only as Ader (2013) refers to it as a “tool for offering insights into promotion of metacognition” within learners. TMF on the other hand, concentrates on teaching mathematics with metacognition (TwM). The FAMTAM focuses on developing metacognition in learners without taking into account the importance of teachers using metacognitive skills themselves effectively, while the TMF concentrates solely on the metacognitive skills used by teachers at the expense of the learners’ metacognitive skills usage. Both frameworks also do not acknowledge the importance of mathematical language in metacognitive instruction.

2.8 CONCLUSION

Metacognition basically deals with individuals' thinking on their own cognition and with higher-order thinking in active control of cognitive processes when learning takes place. These forms of thinking could be on what the individual knows (metacognitive knowledge), what the individual can do at any given moment (metacognitive skills), or what the individual's current cognitive or affective state is (metacognitive experience). Metacognitive thinking is deliberate, planned and aimed toward the successful completion of tasks. This chapter addressed the concept ‘metacognition’ and how it was developed. It then compared different models of metacognition, before it shifted its focus to the components of metacognition. Next the chapter addressed the development of metacognitive skills and last but not least it focused on metacognitive instruction.

In conclusion, crystallizing the understanding of their own metacognition for learners seems to include teaching for metacognition as much as teaching with metacognition. I am of the opinion that teachers need to use their metacognitive skills and mathematical language in order to develop the learners’ metacognitive skills and their use of mathematical language for effective mathematics teaching. Hence the next chapter focuses on mathematics education in order to identify principles to guide the development of a hypothetical teaching and learning trajectory that focuses in particular on the use of metacognitive skills and mathematical language for the teaching of trigonometric functions.