FEATURE ARTICLES

TAMING A 'MANY-HEADED MONSTER': TARRICONE'S TAXONOMY OF METACOGNITION

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Abstract

The research field of metacognition sees a community lacking in rigour, continuity and shared understandings (Schraw, 2009; Shaughnessy, Veenman & Kleyn-Kennedy, 2008). The publication in 2011 of Pina Tarricone's conceptual framework and taxonomy of metacognition offered a 'comprehensive and systematic overview of the literature on metacognition' (Moshman, 2010, cited in Tarricone, 2011, p. xv), finally giving some necessary synthesis to the field. In this paper we briefly introduce some of the difficulties that continue to attribute to the inconsistency of metacognition as a concept and give an overview of Tarricone's taxonomy of metacognition. We also describe how the taxonomy contributes to deeper understandings of one popular model in gifted education. Current research is making strong links between metacognition and giftedness (Veenman, 2008), but importantly there is growing evidence that metacognition is an 'aspect of intelligence that can be more easily promoted by education' (Cornoldi, 2010, p. 257). Due to the complexity and detail of Tarricone's work and the actual taxonomy itself, it is acknowledged that this paper presents only a brief review and discussion of some of the aspects of the taxonomy, such as the supercategories of declarative, procedural and conditional knowledge. The importance of the interconnectedness of these aspects of Tarricone's framework is discussed in relation to how they underlie the metacognition and epistemic beliefs of a student to facilitate or inhibit learning.

Introduction

> Metacognition has been labelled as 'a buzzword', 'ill-defined', 'obscure', 'fuzzy', 'vague', 'faddish', 'messy', 'a many headed monster' and an 'epiphenomenon'. (Tarricone, 2011, p. 3)

These descriptions suggest the need for a clear definition of the term and research evidence about its value. As Robinson and Lai (2006) advise, 'Good teaching and good decisions are based on high-quality information, not taken-for-granted assumptions' (p. 6). In recent years a growing trade in books and teaching resources claiming to teach metacognition has entered the education market. Many of these books are filled with interesting activities and ideas claiming to promote thinking skills, metacognition and self-reflection in students. However, what many lack are clear articulated links with theory and empirical research. This situation is not surprising as metacognition as a field of research is a good example of scholarly tribalism, in the sense that different schools of knowledge, such as philosophy, cognitive and developmental psychology, have pursued this concept through the lenses of their own research and practice. This parochialism in turn explains why similar concepts have different labels and meanings across different research fields. In recent years metacognition has become a focus for researchers working in neuroscience, psychology and education and attempting to bridge links between theory and practice. But with multiple historical and scholarly fronts, it is not surprising that as a concept and research field, metacognition is described by many authors with terms such as 'complex' and 'lacking coherence' (Efklides, 2001; Perfect & Schwartz, 2002; Schraw, 2009; Tarricone, 2011; Veenman, Van Hout-Wolters & Afflerbach, 2006; Wilson, 1999; Winne & Nesbit, 2010).

Some have traced the genesis of metacognition back to ancient Greece to the famous inscription at the Oracle of Apollo in Delphi, 'Know Thyself', while others have traced the philosophical genealogy of reflection back to Socrates (469–399 BC), who is attributed with the quote 'life without enquiry is not worth living' (Dunlosky & Metcalfe, 2009; Perfect & Schwartz, 2002;

Tarricone, 2011). In the modern era, metacognition has emerged from 'two parallel roots, one through cognitive psychology of the 1960s and the other in the post-Piagetian developmental psychology of the 1970s' (Perfect & Schwartz, 2002, p. 2).

What's in a name?

While metacognition as a concept did not begin with John Flavell, it was his seminal piece (Flavell, 1979) titled 'Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry', that is extensively acknowledged as the birth of the term 'metacognition' (Dunlosky & Metcalfe, 2009; Griffith & Ruan, 2005; Hacker, Dunlosky & Graesser, 1998; Helms-Lorenz & Jacobse, 2008; Jausovec, 2008). And therein lies another piece of the puzzle contributing to the 'fuzziness' and 'obscurity' of the concept. The choice of Flavell's label of 'metacognition' has been problematic since its original inception, as first highlighted by Brown (1978). 'Meta', the Greek stem used in English prefixes, signifies 'beyond' or 'focusing on' the core aspect of the category being described. For example, *metalanguage* is the language used to describe language. Therefore, *metacogniti*on has been literally defined as 'knowledge about cognition' which in turn has led to the use of overly simplistic and erroneous definitions such as 'thinking about thinking' that continue to be used. This literal definition fails to acknowledge the part of metacognition that deals with the cognitions themselves, as will be discussed, and simplistic definitions of metacognition tend only to reflect declarative knowledge, discussed further below.

Tarricone's taxonomy and conceptual framework of metacognition

In her book *The Taxonomy of Metacognition* Australian academic Pina Tarricone (2011) published her Doctoral dissertation presenting an extensive review of the literature and theories of metacognition which in turn led to her development of a conceptual framework and taxonomy of metacognition. Professor David Moshman, a renowned researcher in the field, deemed Tarricone's work to be 'an unrivalled overview of the concept of metacognition, and will remain thereafter the definitive record of how psychologists thought about metacognition in the opening decade of the twenty-first century' (Moshman, 2011, p. xv). One strength of Tarricone's work lies in her amalgamation of the many categories and elements proposed by previous authors. The taxonomy offers clear and concise links between models of cognitive and developmental psychology and is claimed to be a valuable framework for educational research (Moshman, 2011, p. xv). The following sections give a very brief overview of some of the theoretical and empirical research that formed the basis of the conceptual framework upon which the final taxonomy was designed.

Tarricone's taxonomy of metacognition comprises two core-components of metacognition, these being *Knowledge of Cognition* or knowing about one's own cognitive processes, and *Regulation of Cognition* involving the *use* of one's own cognitive processes (Brown, 1978; Dunlosky & Metcalfe, 2009; Larkin, 2010; Pressley, Borkowski & O'Sullivan, 1984; Veenman, Kok & Blote, 2005). The taxonomy then connects the related supercategories and subcategories of metacognition, presented in Figure 1 below.

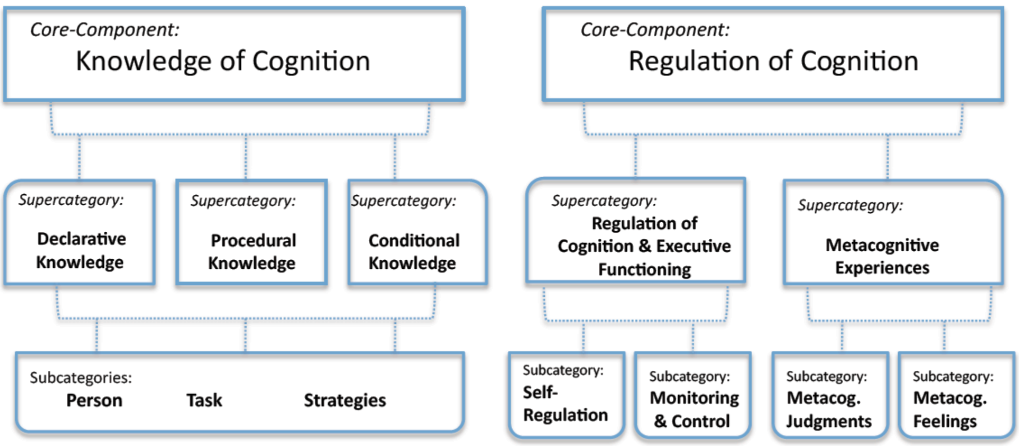

Figure 1: Adaptation of Tarricone's subcomponents, categories, supercategories, subcategories and key elements of metacognition as presented in the conceptual framework

Core-Component: Knowledge of Cognition

Knowledge of Cognition, sometimes known as *self-knowledge* (Baker & Brown, 1984; Brown, 1985) or *metacognitive knowledge*, represents the understanding of one's own and others' cognitive interactions and abilities, including how the mind works and the domain-specific strategies used during the completion of a task (Baker, 2005; Ruan, 2004; Flavell, 1979; Helms-Lorenz & Jacobse, 2008; Paris, 1987; Veenman et al., 2005). It is considered a higher-order function requiring reflective skills of self-awareness, self-appraisal and reflection to judge one's ability and knowledge (Tarricone, 2011).

This knowledge:

- can be implicit or explicit
- requires rich semantic knowledge
- assists in recall and the reconstruction of information
- is influenced by developmental, learning and task experiences
- is essential for memory development and
- requires inferential reasoning and judgement (Tarricone, 2011, p. 197)

Knowledge of Cognition is comprised of the three supercategories of *knowledge: declarative* (knowing that), *procedural* (knowing how) and *conditional* (knowing when, where and why).

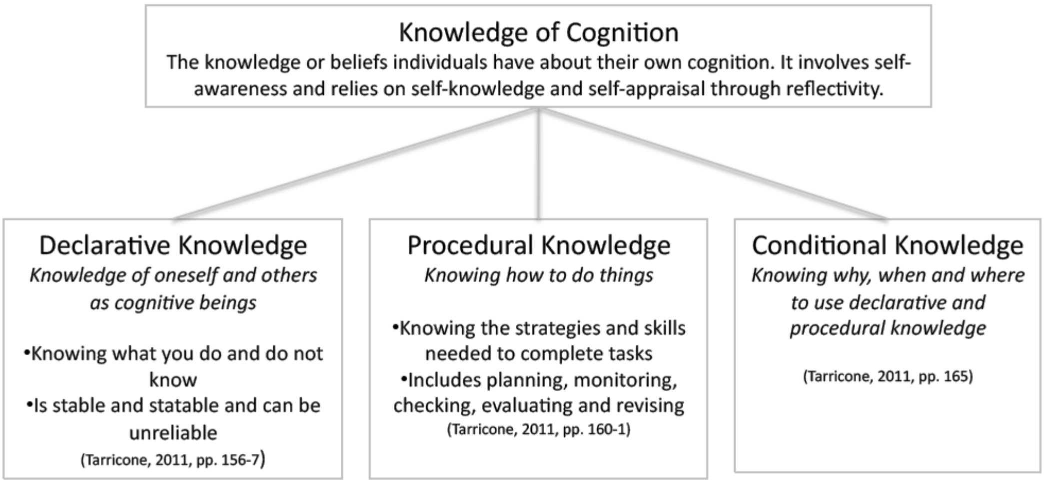

Figure 2. Definitions of Tarricone's core-component of Knowledge of Cognition and the supercategories Declarative, Procedural and Conditional Knowledge

Supercategory: Declarative knowledge

Declarative knowledge is the understanding of oneself and others as cognitive beings (Tarricone, 2011, p. 156). It is knowing what one does know and relies on reflection and verbalisation (p.157). As such it is described as 'stable and statable' (Brown, 1978; Griffith & Ruan, 2005; Helms-Lorenz & Jacobse, 2008; Tarricone, 2011) although importantly, it is also acknowledged as being unreliable, as 'facts known about cognition can be incorrect' (Tarricone, 2011, p. 157). Paris, Lipson and Wixon (1994) describe declarative knowledge as the 'that', 'how', 'when' and 'why' of metacognition. There are two forms of Declarative Knowledge: domain knowledge and cognitive knowledge. Domain knowledge includes the knowledge bank of information about different knowledge domains. Cognitive knowledge focuses specifically on one's 'stored assumptions, hypotheses and beliefs about thinking' (Kluwe, 1982, p. 203). Feelings and beliefs impact on and inform declarative knowledge (Tarricone, 2011, p. 157) as shown in Figure 3 (see next page).

Supercategory: Procedural knowledge

Also recognised as *Strategic Knowledge*, Procedural Knowledge is 'knowing how' to do things, or the strategies and skills needed to complete tasks. Griffith and Ruan (2005), echoing the work of Baker and Brown (1984), believe these skills are not necessarily stable, and are difficult for young children. Procedural Knowledge involves an understanding of the strategies one uses during the completion of a task and is considered an essential tool in effective problem solving (Baker & Brown, 1984; Chi, Feltovich & Glaser, 1980; Larkin, 2010; Ruan, 2004). Procedural Knowledge includes planning, monitoring, checking, evaluating and revising (Baker & Brown, 1984) which is also reflected in the second core-component of Regulation of Cognition.

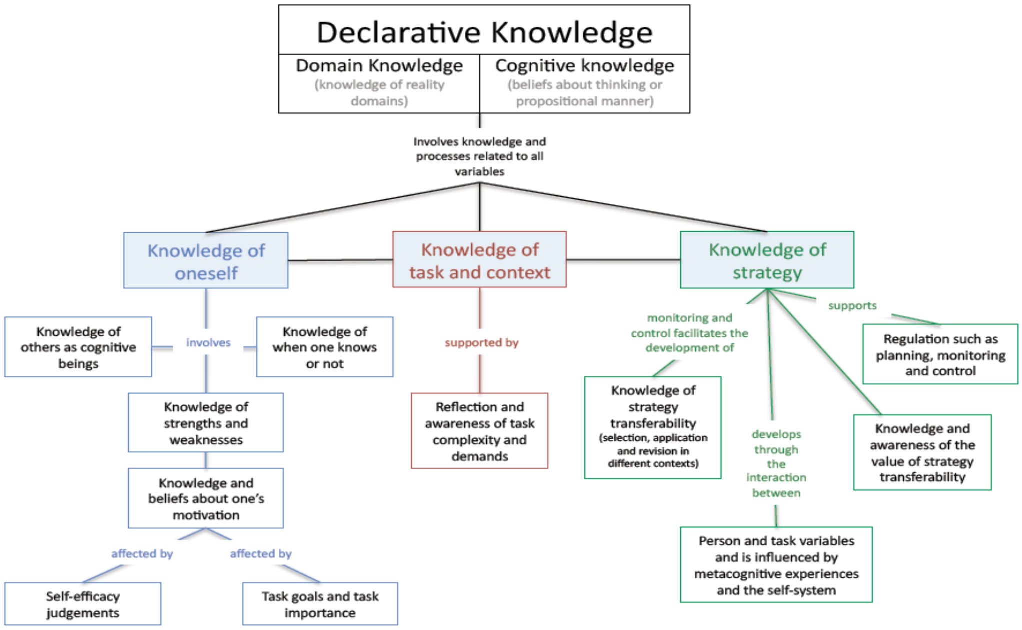

Figure 3. Tarricone's (2011, p. 161) amplification of declarative knowledge

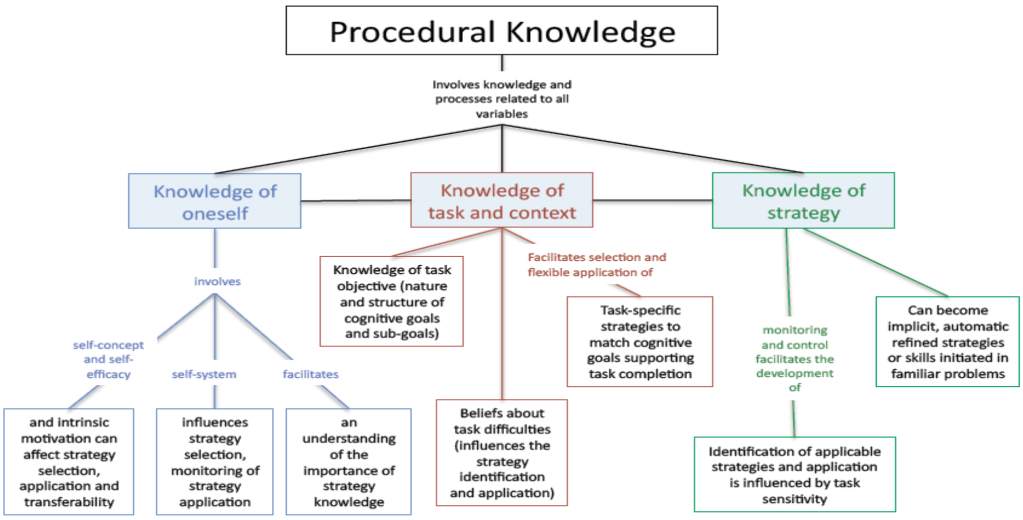

Figure 4. Tarricone's (2011, p. 164) amplification of procedural knowledge

Supercategory: Conditional knowledge

Conditional Knowledge is 'knowing when and why to use declarative and procedural knowledge' (Schraw, 1998, p. 114, cited in Tarricone, 2011, p. 165). See Figure 5 (next page).

Subcategories (Variables)

Flavell (1979) identified three variables that impact on one's knowledge of cognition. Within her conceptual framework and taxonomy, Tarricone (2011) integrated these three variables labelling them 'subcategories' spanning across each of the supercategories of declarative, procedural and conditional knowledge. The inter-reliance of each of the variables supports Tarricone's claim that the taxonomy should not be considered hierarchical, but interconnected, 'a classification or nomenclature of metacognition' (Tarricone, 2011, p. 7).

(i) The first variable, *knowledge of self and others* is labelled 'Person' in the model reflecting Flavell's (1979) variables, and includes understandings and knowledge about one's own cognitive abilities 'intra-individual', and others' abilities 'inter-individual'. These understandings require skills of comparison and judgement and include 'beliefs and intuitions, understandings, misunderstandings, perceptions and conceptions regarding abilities, properties and processes of oneself and others' (Tarricone, 2011, p. 158). The taxonomy identifies knowledge of oneself and others 'as the person subcategory of declarative knowledge' (p. 185). Beliefs about one's capabilities are developed through reflection, feelings (including self-doubt and false beliefs) and experiences, which in turn influence one's motivations. Thinking and critical reflection rely on self-knowledge. Self-knowledge 'develops in, and is affected by complex problem-solving' (p. 185).

(ii) The second variable, *knowledge of tasks,* includes the demands of tasks, context and sensitivity to task requirements and goals. With task complexity come influences on the 'reconstruction of schemata, connotative knowledge, strategy knowledge and application in problem-solving situations' (p. 185). Reflection is necessary to ensure the selection of appropriate strategies and understanding how to use these flexibly to meet task and cognitive goals and ensure task completion.

(iii) The third variable, *knowledge of strategy,* requires a 'level of sensitivity to the task itself and the identification of appropriate and applicable strategies' (p. 163). Strategy knowledge requires sensitivity to the task at hand and develops as a result of the 'interaction between person and task variables' (p. 186). Procedural knowledge, such as the purposeful application of strategies, enables refined strategy usage and can lead to automaticity in familiar contexts (p. 186). Once again, critical reflection and verbalisation are essential for the development of strategy knowledge, and develop through the interaction of person and task variables.

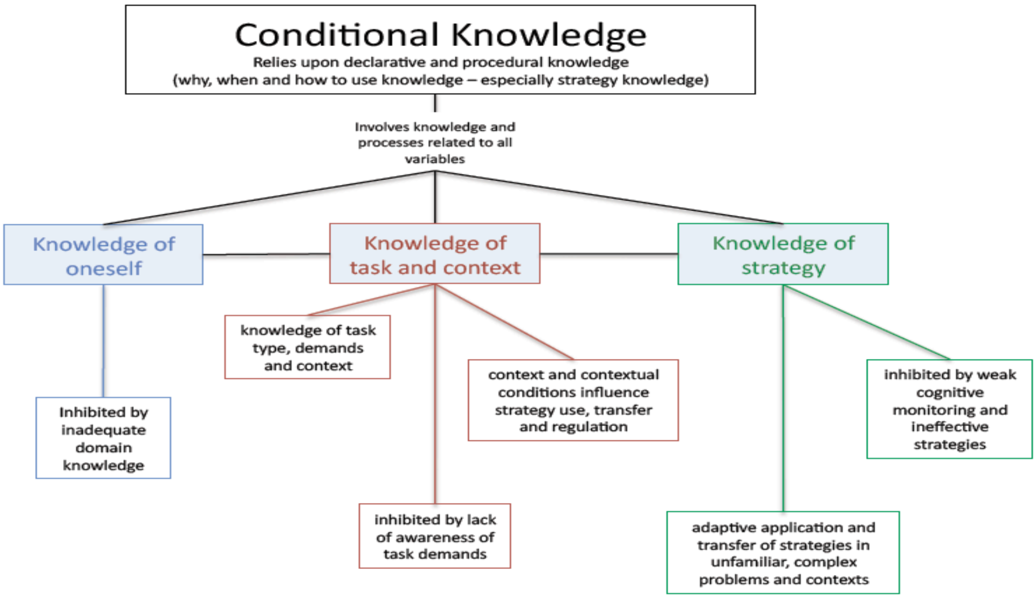

Figure 5. Tarricone's (2011, p.167) amplification of conditional knowledge

Core-component: Regulation of Cognition

The second core-component of the taxonomy is Regulation of Cognition (RoC), sometimes known as *Metacognitive Control* in other models. This component directly involves monitoring, regulating and controlling one's cognition and learning, which includes 'frontal lobe functioning or executive functioning' (p. 186). In contrast to Knowledge of Cognition, Regulation of Cognition is the actual use of those strategies (Pintrich, 2002). There are clear links between this core-component and the sub-component of Procedural Knowledge, however, knowing about how to monitor and control cognition is not the same as actually performing these skills. The question could be asked, if learners exhibit monitoring and control, without necessarily being aware, does this mean they 'have' Procedural Knowledge? This is an important question asked by many researchers working in the field of metacognition, and particularly relevant when working with young children. See Figure 6 (next page).

Supercategory: Regulation of cognitive–metacognitive experiences

The first category within the core-component of RoC refers to metacognitive skills and includes metacognitive experiences. These are broken down further into categories of monitoring and control, self-regulation and metacognitive experiences. These processes are subsequently

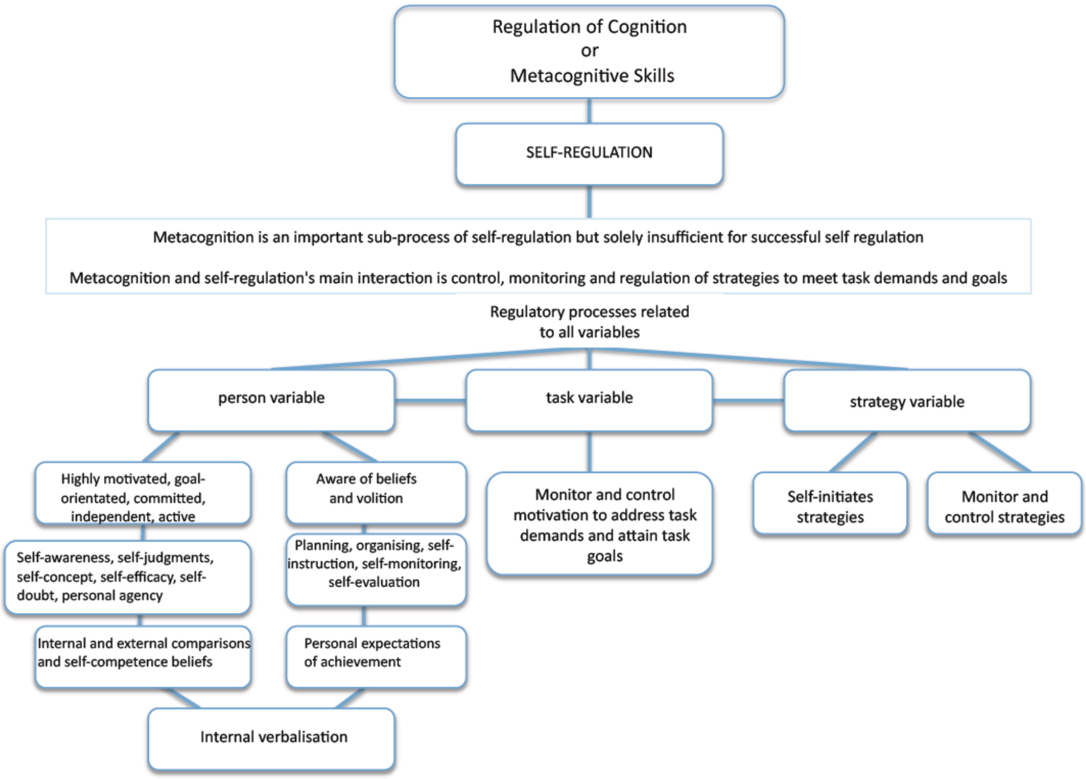

Figure 6. Tarricone's (2011, p. 171) amplification of core-component Regulation of Cognition

linked with executive and frontal lobe functioning. Another aspect supporting the taxonomy as an interactive rather than hierarchical model is that self-knowledge and awareness (situated within the core-component Knowledge of Cognition) both influence and are essential for the core-component Regulation of Cognition.

Subcategory: Monitoring and control

Monitoring and control include the frontal lobe/executive functioning involved in goal setting, control, planning, regulation and organisation of information, monitoring clarity and accuracy. They are modifiable and adaptable and stimulated by past control experiences (Tarricone, 2011, p. 208).

The variables of person, task and strategy also modify and contribute to each subcategory. Within monitoring and control the regulation of person knowledge is categorised as (i) intra-person monitoring and control (involving self-regulatory processes); (ii) inter-person monitoring and control (inter-regulatory processes) and (iii) intra- and inter-reflection and reasoning (monitoring and control) (pp. 208–209). This categorisation has implications for teaching and learning as self-correction and self-monitoring can be difficult concepts for students (Cornish & Garner, 2009). In light of the taxonomy, self-correction is a self-regulatory process requiring executive functioning. Therefore, it should not be assumed that any student is able to complete self-correction tasks without careful scaffolding and prior teaching of the specific skills required.

Subcategory: Self-regulation

Self-regulation is included in the taxonomy as an element of the core-component of Regulation of Cognition. However, Tarricone clearly makes the point that 'metacognition is a subprocess of self-regulation' as it is 'insufficient for successful self-regulation' (p. 208). Self-regulation interacts with metacognitive processes and 'many self-regulation processes are metacognitive such as self-knowledge' (p. 208).

Subcategory: Metacognitive experience

Metacognitive experiences include metacognitive feelings (not the same as emotions or affect) and metacognitive judgments (estimates of learning; or feeling-of-knowing judgments) (p. 211). Metacognitive experiences are gained during 'the monitoring of cognitive and task situations' (p. 187). They are necessary for both retrieving and applying knowledge. Metacognitive experiences are influenced by 'academic self-concept, especially self-efficacy and self-perception' which in turn 'inform metacognitive knowledge' (p. 187).

Implications for the Classroom

This section of the taxonomy reveals the interconnectedness and importance of metacognitive feelings and judgments to the epistemic beliefs of a learner, and in turn how these elements allow or hinder students in the development of their own learning. As Pintrich (2002, p. 6) explains:

> If for example a student realises that she does not know very much about a particular topic, she might pay more attention to the topic while reading and use different strategies to make sure she understands the topic being studied. … Students who lack knowledge of their own strengths and weaknesses will be less likely to adapt to different situations and regulate their own learning in them.

Thus it is important to teach students to monitor their learning and to engage in on-going self-assessment.

Metacognition and giftedness

Some researchers have made attempts to find connections between metacognition and giftedness. For example, Alexander, Carr and Schwanenflugel (1995) reflect on Cheng's (1993) argument that there exists an 'unequivocal close relationship between metacognition and giftedness' (cited in Alexander et al., 1995, p. 2). Alexander et al. also quote Shore (1986), who claimed that 'metacognitive research will lead us to a new meaning of giftedness in cognitive and academic terms' (p. 27). After two decades this result still has not been realised. Alexander et al. (1995) go on to make several assumptions regarding gifted children and metacognition. One assumption declares gifted children develop metacognitive skills faster than 'non-gifted' as a result of advanced information processing that is believed to have been enriched by parents (Borkowski & Kurtz, 1987; Borkowski & Peck, 1986). As a consequence gifted children enter school with 'more' metacognitive knowledge than their age peers. These authors also note that while both intelligence and information-processing theories predict advanced metacognition in gifted students, how this ability develops has been hypothesised but not empirically investigated.

More recently several authors have continued the search for connections between metacognition and giftedness (Carr & Taasoobshirazi, 2008; Cornoldi, 2010; Shore, 2000; Snyder, Nietfeld & Linnenbrink-Garcia, 2011; Veenman, 2008). A recurring issue is the measuring of metacognition and the need for 'calibration accuracy' (Snyder et al., 2011, p. 193). With measurement limitations acknowledged, recent research continues to identify strong evidence about the differences between how gifted (essentially, students scoring above the 90th percentile on standardised tests) and typical learners utilise metacognition when attending to tasks and activities. Snyder et al. note that while gifted students do not always complete tasks more quickly than typical students, they do spend more time at the planning stage (p. 189). They also found gifted students to be less impulsive compared with typical students, hypothesising that this may be due to past successes that in turn reinforce epistemic and motivational beliefs (as discussed in the next sections).

Veenman (2008) continues to encourage research in the field of metacognition, and recently established the Springer Journal series 'Metacognition and Learning' devoted entirely to current research in this field. Veenman supports the hypothesis that both intelligence and metacognitive skills are necessary for the development or acquisition of expertise; however, 'metacognitive skills do not necessarily develop parallel to intellectual skills. Intelligence only gives students a head start in metacognition, but it does not further affect its developmental course' (p. 216).

Cornoldi's (2010) recent research casts a shadow on previously held beliefs that life experiences, culture and educational efforts influence the development of metacognition. Cornoldi states that intelligence is affected by the three variables of culture, experience and metacognition, and that metacognition is the 'most critical variable as it affects the core components of intelligence' (p. 274).

The literature on metacognition and giftedness is still in its infancy. Education-based research into metacognition continues to be frustrated owing to contextual and situational aspects such as different research being conducted across different core learning areas, e.g., science, mathematics, and literacy. In addition, the limitations and problems of using adult testing tools in determining the levels of metacognition in young children are well known.

In a recent study (Bannister-Tyrrell, 2012) examining the metacognitive behaviours of young talented readers from 7 years of age through to 12 years, I found strong evidence of metacognitive skills, behaviours and strategies employed by talented readers compared with same-age typical readers — talented readers employed declarative, procedural and conditional knowledge in their responses more often. In addition, regulatory knowledge was also superior in the talented readers compared with their typical peers as they planned, monitored and controlled their responses during the answering process. While both talented and typical readers demonstrated varying degrees of metacognitive behaviours during reading tasks, it was the talented readers who were observed consistently drawing on a wider set of metacognitive strategies with more frequency and in greater depth compared with their typical peers.

Sternberg's componential theory of intellectual giftedness and metacognition

Sternberg's (1981) early componential theory of intellectual giftedness identified a number of strong links between metacognitive ability and intellectual giftedness. The theory highlights six metacomponents employed by gifted students that allow for the successful completion of tasks, including recognising the nature and demands of a task; knowing the necessary steps required to perform the task; selecting an effective strategy that will allow for successful completion of the task; having the necessary understandings and domain-specific knowledge to enable task completion; allocating their limited resources competently to meet the demands of the task; and monitoring their progress using fix-up strategies as necessary (Sternberg, 1981). There appears to be a close correlation between Sternberg's metacomponents and some of Tarricone's (2011) assertions. Some comparisons have been collated in Table 1 (below).

These comparisons add to the supposition that gifted students use metacognitive processes in their successful execution of tasks. Also, by comparing Sternberg's theory with Tarricone's Taxonomy some insight is gained as to how these metacognitive processes might be employed to enable such success.

Table 1: Comparison of Sternberg's (1981) componential theory of intellectual giftedness and Tarricone's (2011) taxonomy of metacognition assertions (Bannister-Tyrrell, 2012).

Sternberg's (1981) Componential theory of intellectual giftedness	**Tarricone's (2011) Taxonomy of metacognition assertions** (pp. 156–181)
1. Gifted individuals are better able to recognise the nature and demands of the task to be performed.	Knowledge of task and context including sensitivity to task is categorised as the task subcategory of declarative knowledge or task metacognitive knowledge. [DK-T]
	Relying upon declarative and procedural knowledge, conditional knowledge determines why, when and where to use this knowledge (especially strategy knowledge). [CK]
2. Once the nature of the task is recognised, gifted individuals are better able to generate or retrieve from long-term memory the necessary steps for performing the task.	The self-system influences strategy selection and monitoring of strategy application and facilitates understanding the importance of strategy knowledge especially in complex, novel problems. [PK-P]
	Conditional knowledge supports the adaptive application and transfer of strategies to unfamiliar, complex problems and contexts. [CK-T]
3. Gifted individuals are more capable of organising these steps into a proper sequence, selecting an effective strategy for successful execution of the task.	Strategy knowledge relies upon understanding, reflection and awareness of the value and transferability of different strategies in various contexts and tasks. It is especially important for complex problem solving. [DK-S]
	Task sensitivity influences the identification of appropriate and applicable strategies and subsequent strategy application. [PK-S]
4. Gifted individuals are more likely to have a larger variety of and more effective	Procedural task knowledge facilitates the selection and flexible application of task-specific strategies to match cognitive goals supporting task completion. [PK-T]

representations for information that facilitate task completion.	Declarative knowledge includes two forms: domain knowledge (knowledge of reality domains) and cognitive knowledge (beliefs about thinking or propositional manner). [DK]
5. Gifted students are more competent at allocating their limited resources to aspects of the task that count.	Self-knowledge involves self-awareness, knowledge of strengths and weaknesses, knowledge of when one knows and does not know, knowledge of strategies and applicability in various contexts. [DK-P]
	Context and contextual conditions influence strategy use, transfer and regulation. [CK-S]
6. Gifted students are extremely capable of monitoring progress in task completion and are able to keep track of how well their plan is doing, and if it fails, are able to identify what went wrong and to revise the plan accordingly.	Monitoring and control facilitate the development of strategy knowledge, specifically their selection, application and revision in different task contexts. [DK-S]
	Strategy knowledge supports regulation such as planning, monitoring and control. [DK-S]
	Goal specification involves planning goals related to one's knowledge, process monitoring is monitoring planning goals, monitoring clarity is awareness of the extent of clarity of that knowledge, and monitoring accuracy is determination of the degree of accuracy knowledge. [RoC]
	Self-regulated learners self-initiate strategies, and monitor and control them and their motivation to address task demands and attain desired goals. [RoC]
DK = Declarative Knowledge; PK = Procedural Knowledge; CK = Conditional Knowledge; S = Strategy; T = Task; P = Person; RoC = Regulation of Cognition	

Metacognition and Gagné's DMGT 2.0

As a number of education departments across some Australian states and territories acknowledge Françoys Gagné's (2008) Differentiated Model of Giftedness and Talent (DMGT 2.0) (see Figure 7) within their gifted policies, it is prudent to look briefly at where and how metacognition sits within this model.

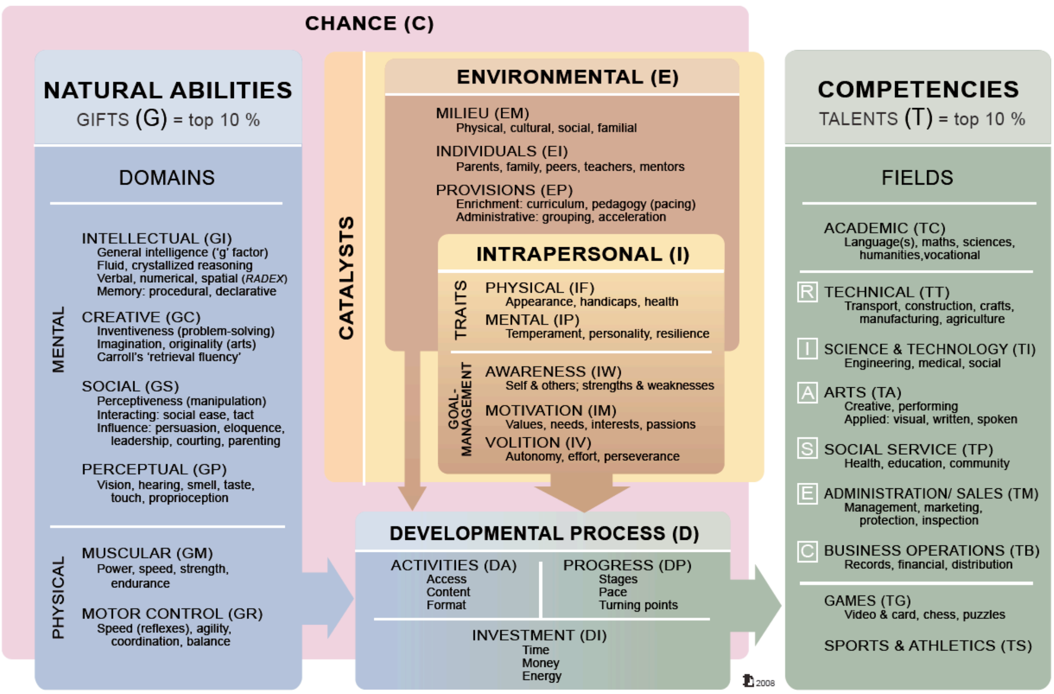

Figure 7: Gagné's (2008) Differentiated Model of Giftedness and Talent (DMGT 2.0)

As Figure 7 shows, metacognition is not labelled as such, but is recognised within the DMGT's Catalysts, specifically within the Goal-Management dimension, that being the three subcomponents of *awareness* (IW), *motivation* (IM) and *volition* (IV).

Important aspects of metacognition identified in Tarricone's (2011) taxonomy are clearly evident in Gagné's DMGT 2.0. For example, within the Intrapersonal (I) catalysts Awareness (IW) of oneself and others, including our own strengths and weaknesses, reflects Tarricone's subcategory of knowledge of self and others within the supercategory of Declarative Knowledge. Another example is Gagné's motivation (IM) and volition (IV) elements reflect Tarricone's core-component of Regulation of Cognition and the supercategory of Regulation of Cognition.

This review of Tarricone's *Taxonomy of Metacognition* has highlighted a conceptual framework that offers researchers and classroom teachers an opportunity to further investigate important theoretical and practical links between metacognition and gifted pedagogy, that may open pathways for better understanding the teaching and learning needs of our highly able students. As stated at the beginning of this review, research into metacognition and gifted education is still in its infancy and this potentially symbiotic relationship deserves further attention and investigation.

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