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Dear Readers,

International Electronic Journal of Elementary Education (IEJEE) devoted this special issue for an important topic: Metacognition. The comprehensive research within the area of cognitive science during the last three decades revealed that not only cognition, but cognition about cognition, in other words thinking about our own thinking processes is important. We can not avoid this cognitive process for development of self regulation, reflection, working memory, attention, planning, organising, execution and monitoring. Metacognition is also related to learning strategies and learning. Metacognition is like a fresh air. It is invisible, but we know that it exists and it is important for us. Those of us who have been working with teaching-learning issues in ordinary schools and with children or adults with special needs due to i.e. dyscalculia, dyslexia and ADHD/ADD, we have been experienced the importance of metacognition for their academic learning and developing of basic skills like reading or reading comprehension.

Metacognition also has been one of the main topics at many scientific conferences. Metacognition has been among the research areas which necessitated interdisciplinary collaboration. Despite the substantial amount of research on this topic, we still need help to increase our knowledge and insight about metacognition.

This special issue of IEJEE is meant to accomplish this task: Making research based knowledge and ideas accessible and comprehensible for broader circles by the help of more competent colleagues: Dr. Annemie Desoete of Ghent University, Belgium, and Dr. Gokhan Ozsoy of Aksaray University, Turkey. I want to thank both of them from my heart. Without their extraordinary efforts, this special issue would not be materialized.

I also want to express my thanks and appreciation to Dr. Turan Temur of Dumlupinar University, Turkey, who always has been my closest friend, colleague and most active member of the editorial board of IEJEE.

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IEJEE is increasing its scientific reputation. IEJEE gradually is being accepted as a scientific journal by an increasing number of scientific indexes. Due to this happy development, I, as a chief editor, started to get more and more congratulation mails.

My metacognition about what's going on with IEJEE, made me to think once more about the invaluable job Annemie, Gokhan and Turan have done. This reminded me a Russian proverb: '*It's not the horse which draws the cart, but the oats*'. So, thanks to all of those who feed IEJEE with their knowledge, research and papers.

Prof. Dr. Kamil Özerk, Editor in Chief
University of Oslo
Department of Education
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# Introduction: Metacognition, more than the lognes monster?

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Metacognition is one of the promising contemporary research fields in psychology and education. The concept has been introduced to describe and explain how people gain control over their learning and thinking, particularly in the case of cognitive failures and difficulties they meet when dealing with information processing and problem solving (Efklides & Sideridis, 2009; Flavell, 1976). However, although every one agrees that there has to be something as 'metacognition' (like the lognes monster?), no one agrees as to what exactly metacognition is about. In addition researchers currently use different concepts for overlapping phenomena (Desoete, 2007; 2008; Desoete & Roeyers, 2006; Desoete & Veenman, 2006). Is self-regulation the same as metacognitive skills? How does calibration fit in?

Before looking at these questions, a brief description of the **conceptual model** and the facets of metacognition will be made in order to highlight the complexity of notion of metacognition and its relations with cognition. Metacognition has been described as having three facets, namely metacognitive knowledge, metacognitive experiences and metacognitive skills (Efklides, 2001, 2008; Flavell, 1979). 'Metacognitive knowledge' has been described as the knowledge and deeper understanding of cognitive processes and products (Flavell, 1976). According to Efklides (2008) ***metacognitive knowledge*** is declarative knowledge stored in the memory. It encompasses information about people (including one's self), as well as information about tasks, strategies, and goals. In addition, ***metacognitive***

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***experiences*** are what the person is aware of and what she or he feels when coming across a task and processing the information related to it (Efklides, 2008). They take the form of metacognitive feelings, metacognitive judgments/estimates, and online task-specific knowledge. Metacognitive feelings have an affective and cognitive character. The affective character of metacognitive experiences can be explained by two feedback loops. The first one is related to the outcome of cognitive processing and detects the discrepancy from the goal set. Error detection (as discrepancy from the goal) and feeling of difficulty (as lack of processing fluency) are associated with negative affect (Efklides, 2006). Metacognitive judgments/estimates include judgment of learning, estimate of effort expenditure, estimate of time needed or spent, but also estimate of solution correctness. When people are asked to make a judgment about their confidence there are two sources of information on which they rely, according to Efklides (2008), namely their estimate of solution/response correctness (as discrepancy of the response to the goals) and their feeling of difficulty (as cue that the response might not be correct). Metacognitive experiences, in essence, make the person aware of his or her cognition and trigger control processes that serve the pursued goal of the self-regulation process (Efklides, 2008; Koriat, 2007). However, the person can feel highly confident, even if the outcome of cognitive processing is not correct, just because the solution was produced fluently, thus endangering appropriate control decisions. This is particularly true for persons who are not aware of their ignorance (Efklides, 2008; Kruger & Dunning, 1999). Finally ***metacognitive skills*** refer to the voluntary control people have over their own cognitive processes (Brown, 1980; Efklides, 2008).

There are different methods of **assessing** metacognition (Desoete, 2008; 2009). Self-report questionnaires are frequently used to assess metacognitive knowledge and self-ratings are usual measures for metacognitive experiences (Efklides, 2008). In addition to the self-report measures, think-aloud protocols or systematic observation of behaviour can take place to measure metacognitive skills (Veenman & Elshout, 1999). Recently often multi-method techniques are being used. These techniques combine measurements of metacognitive experiences and/or knowledge (e.g., Dermitzaki & Efklides, 2003). For example, students are asked, before and after the processing of a task, to assess the difficulty they experience, the correctness of the solution (conceived or produced), the effort required, and to make subjective estimations about the use of problem-solving strategies. In addition, in calibration studies a comparison is made of whether the prediction before the tasks or the evaluation after a task corresponds with the actual performance on the task. Calibration studies are therefore most closely related to the assessment of metacognitive experiences and refer to the reliability of metacognitive experiences.

Finally, several studies point to the fact that metacognition can be **trained** (e.g., Desoete, Roeyers, & De Clercq, 2003), but needs to be taught

explicitly in order to develop. However, additional research is needed on how metacognitive training can promote mathematical problem solving, reading comprehension, spelling skills etc.

To conclude, several problems still remain unresolved in the conceptualisation, assessment and training of metacognition. On the one hand, there seem to be various facets of metacognition to be assessed with different techniques. On the other hand, from mathematical problem-solving research, we know that how we test influences what we find (Desoete, 2008). The present special issue of IEJEE aims to devote additional insight in the conceptualisation, assessment and training of metacognition, since metacognition deserves attention by more researchers, educators, trainers, coaches and therapists. We are aim to create a channel for dissemination of research based knowledge and to communicate what we know with each other as researchers and with the practitioners within the fields of teaching, training, coaching and treatment.

We are delighted to have such distinguished members of the field as contributors for the special issue of *International Electronic Journal of Elementary Education* on metacognition. We are thankful to the researchers for their insights and efforts. Contributors to this special issue addressed a range of themes about metacognition: conceptual models, training programs, assessment, relationship issues, and problems and prospects for teaching and research.

Stolp and Zabrucky examine the contributions of metacognitive and self-regulated learning theories to research on students' calibration of comprehension. Karably and Zabrucky's article emphasizes the development of children's metamemory and provides practical implications of research findings for the classroom. Besides, Cubukcu's article focuses on learner autonomy, self-regulation and metacognition.

Kramarski's article reports the investigation of the effects of two reflection support programs on elementary school mathematics teachers' pedagogical problem solving view. Caviola, Mammarella, Cornoldi and Lucangeli investigate whether sequential-spatial working memory could be improved by training of fourth-grade children using metacognitive strategies. In addition, Lloret, Aguilar and Lloret report their research on the effect of a multimedia computing program on the production of activities and self-regulated learning processes.

Kitsantas, Steen and Huie's article reports how prior achievement and self-regulation processes contribute to fifth and third grade students' GPA and standardized test scores. In her study, Desoete aims to investigate whether adults with mathematical and reading disabilities show a similar profile of mathematics deficits compared with adults with isolated mathematical disabilities and if eventual differences can be explained through the severity or cognitive subtype hypothesis.

**Table.** Articles in special issue

| Author(s) | Title | Focuses on | | | | |
|---|---|---|---|---|---|---|
| | | Conceptual model | Different Assessment techniques | Training programs | Relationship issues | Age group (children/ adult) |
| Stolp & Zabrucky | Contributions of metacognitive and self-regulated learning theories to investigations of calibration of comprehension | ● | | | | |
| Karably & Zabrucky | Children's metamemory: A review of the literature and implications for the classroom | ● | | | | Children |
| Cubukcu | Learner autonomy, self regulation and metacognition | ● | | | | |
| Kitsantas, Steen & Huie | The role of self-regulated strategies and goal orientation in predicting achievement of elementary school children | ● | | | | |
| Desoete | Mathematics and metacognition in adolescents and adults with learning disabilities. | | ● | | | Adults |
| Lloret, Aguilar & Lloret | Self-regulated learning using multimedia programs in dentistry postgraduate students: A multimethod approach | | ● | ● | | Adults |
| Caviola, Mammarella, Cornoldi & Lucangeli | A metacognitive visuospatial working memory training for children | | | ● | | Children |
| Kramarski | Developing a pedagogical problem solving view for mathematics teachers with two reflection programs. | | | ● | | Adults |
| Ozsoy, Memis & Temur | Metacognition, study habits and attitudes | | | | ● | Children |
| Sarac & Tarhan | Calibration of comprehension and performance in L2 reading | | | | ● | Adults |
| Battistelli, Cadamuro, Farneti & Versari | Do university students know how they perform? | | | | ● | Adults |

Sarac and Tarhan's aim was to examine students' accuracy of calibration of comprehension and calibration of performance in L2 reading. They also aim to investigate the intercorrelations between different calibration measures, and to examine the relationship between L2 readers'

metacognitive knowledge and their calibrations. Ozsoy, Memis and Temur's article investigates the relationship between fifth grade students' metacognitive knowledge and skills, and their study habits and attitudes. Besides, their study is also dealing with investigating how this relationship changes with students' GPA levels. Finally, aim of the Battistelli, Cadamuro, Farneti and Versari's study is to investigate the ability to self-evaluate performance in tests of reasoning of a linguistic, mathematical and formal nature, in a group of University students.

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# Contributions of metacognitive and self-regulated learning theories to investigations of calibration of comprehension

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**Abstract**

In this paper we examine the contributions of metacognitive and self-regulated learning theories to research on students' calibration of comprehension. Historically, cognitive psychologists have studied calibration of comprehension within a purely metacognitive framework, with an emphasis on the role of text and task factors but little consideration of factors of self. There has been a recent trend, however, towards incorporating a social cognitive perspective to the study of calibration of comprehension, with factors of self such as motivation and affect being examined more often. Among the factors of self that have been examined, self-efficacy has played a major role as it may be all but impossible to disentangle its influence on students' calibration of comprehension. Other variables of self that have been examined include ability, familiarity, ego and goal-orientation, goal setting, personality traits and susceptibility to social and cultural influences. Broadening the context in which calibration of comprehension is assessed allows a more complete examination of the rich set of interrelated processes that affect students' performance.

**Keywords:** Calibration, Metacognition, Self-Regulated Learning

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## Introduction

Over the last several years psychologists have become increasingly interested in students' metacognition or awareness of cognitive processes (Veenman, Van Hout-Wolters, & Afflerbach, 2006) and its role in learning. In an early and influential paper on the topic of metacognition, Flavell (1979) suggested that awareness of cognitive processes consisted of both metacognitive knowledge and metacognitive experiences. Flavell's early conceptualization of metacognition proved to be quite durable and influential and remains the most commonly used one today. And, importantly, students' metacognition has been linked to increased learning, improved performance and greater achievement of educational goals (Dunlosky & Lipko, 2007; Lunderberg, Fox, Brown, & Elbedour, 2000; Miesner & Maki, 2007; Moore, Zabrucky, & Commander, 1997; Pintrich, 2002; Rickey & Stacey, 2000; Thiede, Anderson, & Therriault, 2003; Tobias & Everson, 2002-2003; Wiley, Griffin, & Thiede, 2005; Zabrucky & Moore, 1994).

Metacognitive knowledge refers to the general knowledge students have about their own or others' cognitive processes. This knowledge is typically acquired incrementally through experience and is relatively stable. For example, students are likely to continuously know that a simpler text is easier to comprehend than a more complex text and that certain strategies, such as rereading, can assist in clarifying difficult to understand passages. Metacognive experiences include the processes of evaluating and regulating one's ongoing cognition and are not necessarily stable. For example, when students ask themselves questions during reading, they are evaluating their understanding**.** If students opt to reread one or more sentences or paragraphs because they are having difficulty understanding, then students are regulating their understanding**.** As teachers are all too aware, students may not always correctly identify the extent of their comprehension or consistently use the most appropriate strategies (or, indeed, any strategies) to overcome comprehension failures. Thus, although metacognitive knowledge can lead to enhanced metacognitive experiences and improved performance, it need not necessarily do so. Knowing that a difficult passage needs to be reread does not guarantee that it will be. Intuitively, students must also possess the necessary motivation to engage in and successfully complete a task.

In the present paper we examine students' calibration of comprehension. Traditionally, the calibration paradigm has been used to measure students' ability to evaluate their level of text understanding and is, as such, a particularly critical component of students' metacognitive experiences (see Lin & Zabrucky, 1998, for a review). Calibration of comprehension is a measure of the relationship between students' perceived competence and their actual performance. Traditionally, calibration skills have been assessed in a controlled environment in which students are asked to read a series of texts and then predict how well they expect to perform on

a comprehension test to follow (Glenberg & Epstein, 1985; Glenberg, Sanocki, Epstein & Morris, 1987; Glenberg, Wilkinson, & Epstein, 1982; Lin, Zabrucky, & Moore, 2002; Maki & Berry, 1984; Maki & Serra, 1992a, 1992b; Weaver, 1990). Students' calibration accuracy is then determined by comparing their predicted performance to their actual performance. The term calibration of comprehension was first coined by Glenberg and Epstein (1985) who found that students' predictions were generally unrelated to their performance.

Students' post-hoc predictions of confidence have been termed calibration performance or postdiction (Glenberg et al. 1987). These confidence judgments differ from calibration of comprehension judgments in that they are assessed after students have read a text and completed a comprehension test. Research suggests that students are generally more accurate at postdictions than predictions, presumably because the additional feedback obtained from taking a test is useful in later assessments (Glenberg & Epstein, 1985; Hacker, Bol, Horgan & Rakow, 2000; Maki, Jonas, & Kallod, 1994; Zabrucky, Lin, & Moore, 2009).

More recently, students' calibration skills have been studied in a classroom setting by examining their calibration accuracy for classroom tests (Hacker et al., 2000; Lin-Agler, Moore, & Zabrucky, 2004) or for course grades (Finney & Schraw, 2003; Garavalia & Gredler, 2002; Zimmerman, Bandura & Martinez-Pons, 1992). Recent findings have been more optimistic than earlier ones suggesting that students' perceived and actual performances were unrelated (Glenberg & Epstein, 1985, 1987; Glenberg et al., 1982). Still, current findings suggest that students are, at best, only moderately able to calibrate their comprehension (Hacker et al., 2000; Lin, Moore & Zabrucky, 2001; Lin & Zabrucky, 1998; Magliano, Little, & Graesser, 1993; Maki, Foley, Kajer, Thompson & Willert, 1990; Maki & Serra, 1992a, 1992b; Weaver, 1990; Weaver & Bryant, 1995) although performance can be improved under certain conditions (Rawson, Dunlosky, & Thiede, 2000; Thiede & Anderson, 2003).

Traditionally, the calibration paradigm has been used to measure students' metacognitive skills for comprehension. Evidence suggests that high achieving students, who, intuitively, should be the most aware of what they do and do not know, are more accurately calibrated than their lower achieving peers (Bol & Hacker, 2001**;** Glover, 1989**;** Hacker et al., 2000; Maki & Berry, 1984**;** Pajares & Kranzler, 1995). On the other hand, it has been suggested that poor calibrators either lack knowledge about cognition, or ability to regulate cognition, or both (Schraw & Graham, 1997). Of course, it is also possible that poor calibrators possess the necessary metacognitive knowledge or skills, but lack the motivation to consistently or effectively use them (Borkowski & Cavanaugh, 1979).

In an interesting series of studies that extend the findings on calibration discussed so far, Kruger and Dunning (1999) attempted to

explore the underlying mechanisms involved in individuals' poor calibration skills. Across four studies, Kruger and Dunning found that participants who scored at the bottom quartile on tests of various domains (e.g., ability to recognize humor, knowledge of grammar and logical reasoning skills) were not only more likely to overestimate their abilities but also incorrectly assume that they were above average in skill levels. On the other hand, participants who scored at the top quartile on the same tests underestimated their abilities and overestimated the abilities of others. Across studies Kruger and Dunning demonstrated that students with less knowledge not only lacked the necessary skills to calibrate successfully but also lacked the ability to recognize that their performance was poor. Further, unlike high performing students, students who performed poorly failed to adjust their perceptions of their own competence by observing the behavior of others (see, also, Kruger and Dunning, 2002).

In the present paper we examine variables of self that have been found to impact the accuracy of students' calibration of comprehension. Traditionally, cognitive psychologists have studied calibration of comprehension with little consideration of factors of self. However, there has been a recent trend towards incorporating a more social cognitive perspective within investigations, with factors of self such as motivation and affect being examined more often (Chen, 2003; Finney & Schraw, 2003; Pajares, 1996; Pajares & Kranzler, 1995; Zimmerman et al. 1992). Thus, we examine the calibration literature emerging from *both* a cognitive and a social cognitive perspective. Theories of self-regulated learning will be discussed from a social cognitive perspective with a special emphasis on the construct of self-efficacy, as it may be all but impossible to disentangle its role on students' calibration of comprehension. In addition to self-efficacy beliefs, we examine ability, familiarity, ego and goal-orientation, goal-setting, personality traits, and susceptibility to social and cultural influences.

*Calibration of comprehension within a self-regulated learning context*

According to Zimmerman (1990), researchers need to abandon the practice of examining metacognition *solely* as the reflection of one's cognitive abilities. Rather, he suggests that metacognition must also include the complex interactions among the social psychological variables of motivation, emotion, and behaviour. Furthermore, he proposes that these variables can not be eliminated from the equation because they account for the necessary humanistic nature of metacognition. For instance, by excluding these variables it is rather difficult to explain why a typically high performing student may inaccurately evaluate his or her comprehension or neglect to regulate his or her learning, especially when knowing it is advantageous to do so. However, by allowing for these additional factors, it is easier to comprehend how an upcoming soccer match, a fear of appearing ill-prepared, an unlikable course or professor, or an unusually poor score on a previous quiz may affect a student's ability to effectively monitor learning.

Any one of these everyday situations can affect a student's monitoring by acting as a competing goal or by altering affective states by producing anxiety or despondency. Thus, the motivational or affective states of students should not be ignored. By examining metacognition with consideration of such factors as motivation, behaviour, and affect, researchers shift their focus from a cognitive to a social cognitive perspective. According to Jost, Kruglanski, and Nelson (1998), social cognitive psychologists have long contributed to the research of metacognition but have yet to receive the proper acknowledgment for their contributions.

Self-regulated learning is a process that involves setting goals, implementing strategies to achieve goals, monitoring performance towards reaching goals, and, finally, an evaluation of the task (Butler & Winne, 1995). Ultimately metacognitive and self-regulated learning theories are both mechanistic approaches to understanding how one most effectively learns. Metacognitive and self-regulated learning theories both explore the acquisition, evaluation and regulation of knowledge (Puustinen & Pulkkinen, 2001). An assumption shared by both models regarding cognition is that the acquisition of new knowledge in an unfamiliar domain requires extra cognitive effort, so that very few cognitive resources remain to be spent on monitoring (Puustinen & Pulkkinen, 2001). Metacognitive and self-regulated learning theories share consonant views of the learner as being capable of monitoring his or her own learning. Similarly, both agree that the learner benefits from such tasks as setting goals, and evaluating and regulating one's progress. However, self-regulated learning models *also* incorporate one's ability to control aspects of personal agency, such as motivation and affect.

Boekaerts (1995) suggests that metacognitive awareness should not be studied without a consideration of the learner's self-referenced thoughts and affective states within a specific domain because these variables of self can assist in explaining how metacognition and self-regulated learning develop and why they fail to develop. Efklides (2008) has also discussed the need for a more inclusive and comprehensive approach to the study of metacognition, suggesting that the critical role played by metacognition in self- and co-regulation of behaviour "make it necessary to reconsider the notion of metacognition and, particularly, its facets and their interrelationships, as well as the relationship of metacognition with cognition at the individual and social level, and the relationships of metacognition with affect" (p. 277). Efklides (2008; 2009) notes the need to understand affective as well as cognitive factors that play a role in metacognition and has developed a multifaceted model that outlines the role of cognitive and emotional regulation at a nonconscious level as well as the role of metacognitive knowledge, metacognitive experiences and metacognitive feelings (largely ignored by others) at the personal and social levels. Her ideas stress that metacognition is an important and multi-faceted component of self-

regulated learning. Similarly, Bandura (1982) suggests that the concept of self-referent thoughts helps us understand how and why a student takes acquired knowledge and, in turn, translates that knowledge into action, because self-referent thoughts mediate the relationship of knowledge to action through motivation, behaviour and affect. By bridging the gap between cognitive and social cognitive research, researchers are better equipped to understand the full range of influences on calibration.

According to Zimmerman (1990), self-regulated learners are aware of what they do and do not know, which intuitively suggests that they are more accurate calibrators. Furthermore, evidence suggests that self-regulated learners are typically high achieving students (Butler & Winne, 1995; Pintrich & de Groot, 1990; Zimmerman, et al., 1992), as are accurate calibrators (Bol & Hacker, 2001; Hacker et al., 2000; Maki & Berry, 1984). The distinction between the two constructs is that self-regulation is a process of learning, whereas calibration is the result, or measurement of the learning process. During the process of self-regulated learning, critical errors can occur that may affect calibration accuracy. For example, evaluation errors can occur when students become over or under confident in their comprehension. Such errors can affect students' motivation to persist on tasks and ultimately can deter students from reaching their intended goals (Butler & Winne, 1995). Self-efficacy beliefs, goal setting, and goal orientation are among the most common variables of self to be studied in conjunction with self-regulated learning (Stone, 2000). In addition to the role of affect, each of these variables has been found to influence the processes of self-regulated learning (Bandura, 1986; Zimmerman, 1990).

Currently there is not an agreed upon cohesive definition of self-regulation. This is largely due to the fact that the two most basic components of self-regulated learning, metacognition and motivation, have traditionally been studied in isolation from one another (Puustinen & Pulkkinen, 2001). Although there is a general consensus among self-regulated learning theorists that metacognition is composed of both metacognitive and motivational components, there are also a few who argue that metacognition contains a metamotivational component. In fact, Wolters (2003) proposes that a metamotivational component, which he refers to as the regulation of motivation, must be present in order for effective learning to occur. He suggests that, conceptually, the regulation of motivation and the regulation of cognition are alike yet they work towards different goals. While the regulation of cognition is primarily responsible for students' effective use of strategies, the regulation of motivation is mostly responsible for ensuring that students maintain the necessary motivation to complete a task, or to construct meaning. Furthermore, Wolters posits that these processes most often work simultaneously, making it difficult to discriminate one from the other. The distinguishing feature between motivation and metamotivation is students' awareness and purposeful

control of the latter. In other words, the regulation of motivation is concerned with the deliberate thoughts and actions of students to control their motivation. Students may avoid or disengage from learning activities because the activities do not invoke efficacious feelings. Although students' self-efficacy beliefs may affect such decisions as choice, effort and persistence, students may not consciously understand or control these decisions. Thus, the influences of self-efficacy beliefs are considered motivational, unless students intentionally managed some part of their actions, in which case the processes would be considered the regulation of motivation.

Similarly, Boekaerts' (1995) adaptable learning model suggests that metamotivational skills are similar to, and just as important as, metacognitive skills in the process of self-regulated learning. According to her model, metamotivation is divided into two components: motivation control and action control. Boekaerts refers to motivation control as the ability to conjure up positive self-referent cognitions, or positive feelings of affect, which assist in setting goals. In other words, it is during the process of motivation control that goal selections are made. She refers to action control as the ability to maintain control over the learning environment, such as blocking competing interferences, in order to reach the established goals. Boekaerts refers to this latter component as a volitional process in assisting students in protecting and pursing their goals. According to her model, students must possess both the necessary metacognitive and metamotivational self-regulatory skills in order to be effective learners.

*Self-efficacy beliefs*

By examining students' self-efficacy beliefs, researchers have been able to study the impact of self-referenced thoughts on calibration accuracy (Chen, 2003; Finney & Schraw, 2003; Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1995; Schunk, 1990; Zimmerman, 1990, 1995, 2000). Students' self-efficacy beliefs are judgments of their capability to organize and execute their actions to accomplish specific tasks (Bandura, 1982). Research suggests that self-regulated learners typically possess more efficacious beliefs and set more challenging goals than others (Pintrich & de Groot, 1990; Zimmerman, 1990; Zimmerman et al., 1992). It has been suggested that, when students meet their goals, their self-efficacy beliefs increase, which, in turn, sustains their motivation and use of strategies (Bandura, 1986; Schunk, 1990). By setting goals and by routinely re-examining success or failure in meeting these goals, students create a learning environment in which they are more likely to monitor their own comprehension. Self-efficacy beliefs have also been reported to increase effort expenditure, persistence and academic achievement (Bandura, 1986; Pajares, 1996; Pintrich & De Groot, 1990; Pajares & Miller, 1995; Zimmerman & Bandura, 1994; Zimmerman et al., 1992). Still, overconfident self-efficacy beliefs may result in a false sense of preparedness which can have a negative affect on performance. On the other hand, it has been

suggested that under confident self-efficacy beliefs can also hinder performance by generating motivational deficits (Bandura, 1986). Regardless, it is reasonable to assume that not all students with low self-efficacy beliefs have within them the requisite knowledge or skills necessary to perform a particular task.

According to Bandura (1986), self-referent thoughts mediate the relationship of knowledge to action through *motivation, behaviour and affect*. In fact, Bandura suggests that self-efficacy beliefs are a better predictor of achievement than ability because self-efficacy beliefs determine how students use their skills and knowledge. Studies using path analyses have revealed that ability and self-efficacy beliefs make independent and direct contributions to performance (Chen, 2003; Pajares & Kranzler, 1995; Zimmerman & Bandura, 1994; Zimmerman et al., 1992). Thus, self-efficacy beliefs have been found to contribute to performance beyond the contributions of ability, skill level, and prior experiences. Sources of self-efficacy beliefs include mastery experiences (past performance), vicarious experiences (watching others), social/verbal persuasion, and physiological or emotional states (Bandura, 1986). Although it is possible to access students' self-efficacy beliefs at any specific moment in time (e.g. in the calibration paradigm), it is much more difficult to access the origins and on-going sources of these beliefs (Klassen, 2004).

Self-efficacy is not a global construct, such as academic self-concept, but is instead uniquely related to specific tasks (Bandura, 1986; Finney & Schraw, 2003; Pajares, 1996; Zimmerman, 1990). Thus, when students make performance predictions they are assessing their self-efficacy beliefs or making judgments about their specific capabilities for performing a precise task (Finney & Schraw, 2003; Klassen, 2002; Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1995). For example, students may perceive themselves as being generally good students, while simultaneously maintaining low efficaciousness in their ability to perform specific algebraic equations. Thus, although these students have high academic self-concepts, they still maintain low self-efficacy beliefs for specific algebraic tasks.

Similarly, metacognitive skills are recognized as being domain-specific rather than domain-general (Boekaerts, 1996; Schraw, 1997). According to the domain-specific hypothesis, students' confidence judgments will be related to performance on a specific test but not to predictions or performance on unrelated tests (Schraw, 1997). Per this perspective, students' regulatory skills increase as their knowledge increases within a domain. In other words, regulatory skills originate within a specific domain and will be at best mildly useful in unrelated domains. In contrast, the domain-general hypothesis suggests that regulatory skills such as knowing to reread a chapter, creating a good study environment, or asking inference questions are skills which can be accessed independently of domain-specific knowledge (Schraw, 1997). Thus, regardless of how familiar students are with any domain, their regulatory skills should not be any better or any

worse in any other domain. Similarly, regardless of domain, students' confidence judgments should not vary much from one test to another.

In order to accurately measure self-efficacy beliefs, two essential precepts must be met. First, students must assess their capabilities for performing specific tasks (Pajares, 1996). These tasks must be similar but not identical to the actual tasks on the criterion test. Second, the criterion test should be administered immediately after students have completed their self-assessments (Bandura, 1986). In order to test the validity of these precepts, Finney and Schraw (2003) examined the task specific and variable nature of self-efficacy beliefs. In their study, two scales were developed to measure students' self-efficacy for statistics beliefs over the course of a semester. Both scales identified students' self- perceived competencies for task specific skills (i.e. distinguish between a population parameter and a sample statistic) and were administered along with a third measure of self-efficacy for general mathematics, immediately prior to the criterion test. The first scale, current statistics self-efficacy (CSSE), measured students' confidence in their ability to perform specific statistical tasks, while the second, self-efficacy to learn statistics (SELS), measured students' perceived competence for learning specific statistical tasks. As predicted, performance was more closely related to students' current statistics self-efficacy (CSSE) beliefs than to their self-efficacy for general mathematics beliefs. The researchers suggest that although there are overlapping skills associated with both statistics and general math abilities, self-efficacy beliefs are more predictive of performance when they assess competency for the specific tasks that are to appear on the criterion test. The relationship between performance and current statistics self-efficacy (CSSE) was also found to be greater than that between performance and self-efficacy to learn statistics (SELS). Thus, students' self-perceived judgments of their current competencies for specific tasks were more predictive of performance than were their judgments about their future competencies to learn. Over the course of the semester, self-efficacy beliefs for statistics scores were found to significantly increase. This finding suggests that self-efficacy beliefs are not static and are subject to change over time. Due to the variable nature of efficacy beliefs, students' self- evaluations should be assessed in as proximal time as possible to the administration of the criterion test.

Prior to the research findings of Glenberg and colleagues (1982) psychologists largely assumed that older students (e.g., those in college) were quite capable of monitoring their own comprehension. As researchers began to examine variables that might influence students' calibration accuracy, they first turned to factors of text (Commander & Stanwyck, 1997; Maki & Swett, 1987; Weaver & Bryant, 1985) and task (Glenberg et al., 1987; Maki & Berry, 1984; Maki, Foley, Kajer, Thompson & Willert, 1990; Lin et al., 2002; Maki & Serra, 1992a; Weaver, 1990) for insight into students' calibration skills). Later, the role of self was examined (Bouffard-Bouchard, 1991; Glenberg & Epstein, 1987; Karabenick, 1996; Kroll & Ford,

1992; Lin, Moore & Zabrucky, 2001; Lin-Agler et al., 2004; Zabrucky et al., 2009), a trend we would like to see continue.

Prior knowledge is probably the most obvious variable of self to impact calibration accuracy because students' prior experiences within any given domain vary so greatly. It seems logical to assume that as students become more familiar with a domain the ease at which they process information should increase, making it easier for them to acknowledge what they do and do not know. Interestingly, research suggests that students' domain familiarity is positively related to confidence judgments but not necessarily to performance (Glenberg et al. 1987). Thus, possessing a subjective sense of knowing may be all that is needed to generate feelings of confidence. In fact, overconfidence may stem from false feelings of knowing that occur in response to a familiar cue (Jost, et. al., 1998). Students' overconfidence has been termed "illusion of knowing" by Glenberg et al., (1982).

As familiarity increases, students are more likely to have, and to view themselves as having, greater domain expertise. In a study conducted by Glenberg and Epstein (1987) the role of expertise and its effect on calibration was studied using students majoring in either music or physics. Students were asked to read a series of texts, which included a text sample from their major area of concentration (music or physics), and to rate their confidence in being able to infer the gist of each text before answering inference questions. As expected, both music and physics majors' predicted better comprehension and performed at higher achieving levels within their respective areas of expertise. Although confidence and performance were found to increase within each groups' domain of expertise, students were actually better calibrated across domains. Thus, students were least accurate at calibrating within their domain of expertise.

Glenberg et al. (1987) argued that students' predictions are based on their prior experiences with a domain rather than on their comprehension of a text. If this is so, then students' predictions should not improve after reading a text because they do not use the specific information gained from reading a text when making comprehension evaluations. Rather, students' predictions are based on their assessments of how familiar they are with a domain topic, termed the domain familiarity hypothesis. In fact, Glenberg and colleagues suggested that students' predictions may be nothing more than reflections of their sense of familiarity with the title or the main principle of a passage.

In an attempt to test the domain familiarity hypothesis, Maki and Serra (1992a) had students read the titles and a one summary sentence about each text, from a series of texts, prior to predicting performance on inference tests. Students were then asked to predict their performance again but this time after reading each text entirely. According to results, following exposure to full texts, students' performance predictions improved,

which suggests that students actually used the knowledge gained from the texts when making comprehension evaluations.

Some research suggests that students are generally better calibrated towards the end of a semester (Finney & Schraw 2003; Hacker et al., 2000; Lin-Agler et al., 2004). Students' improved calibration accuracy over the course of a semester may reflect their increased knowledge, increased use of monitoring skills, or increased self-efficacy beliefs (Finney & Schraw, 2003; Schraw, 1997). According to Pfeifer (1994), as domain familiarity increases, so does domain knowledge, which is reflected in students' ability to more accurately calibrate comprehension. Still, as mentioned earlier, clearly not all research supports a positive relationship between familiarity and improved calibration accuracy (Glenberg & Epstein, 1987; Glenberg et al., 1987).

It is possible that studies on familiarity and calibration accuracy yield different results depending on the circumstances under which they are conducted. For example, in a laboratory setting, where students read as many as 16 texts from varying domains, students may assign higher confidence judgments to passages with which they are more familiar in comparison to those with which they have had little or no exposure, because it may be easier to assess familiarity than comprehension (Glenberg et al., 1987). In contrast, research conducted in the naturalistic setting of a classroom may reduce such problems, thus, reflecting students' metacognitive judgments more accurately. Because students have more time in which to build a richer knowledge base, their judgments may reflect more accurate or experience-based judgments than judgments based on feelings of competency or familiarity. Also, it has been suggested that laboratory studies do not offer a strong enough incentive to motivate students to make accurate judgments (Hacker, et al, 2000). This may be especially critical if motivation is a necessary component of the process of self-regulated learning (Boekearts, 1995; Schunk, 2003; Wolters, 2003; Zimmerman, 1990). In fact, it has been suggested that without the proper motivation, students will not engage in using strategies to monitor their learning (Zimmerman, 2000). Thus, it is possible that concerns of ecological validity may be warranted regarding laboratory studies.

Although task difficulty can be considered a variable of text or task, it can also be considered a variable of self because students do not share similar exposure or experiences within a domain, making certain tasks more challenging for some than others. According to Bandura (1986), students' self-evaluations should be most accurate when the task is challenging yet attainable. Research findings suggest that students tend to be overconfident when approaching new and difficult tasks, while under confident when tackling easier ones (Bjorkman, 1992). Interestingly, the highest achieving students have been found to experience only slight overconfidence on difficult tasks, while for the same task, the lowest achieving students have been found to experience overconfidence. Similarly, on the easiest of tasks,

the highest achieving students have been found to report under confidence while the lowest achieving students report only slight under confidence (Ferrell, 1995, Hacker et al., 2000).

According to Bandura (1986), overconfidence is a normal reaction to the exposure of difficult material. This overconfidence benefits students by motivating them to persist through challenging tasks. Likewise, it seems logical that students do not require the same motivation in order to engage and persist on easier tasks. Still, these assumptions do not explain the proclivity of students to report perceptions of under confidence for the easiest of tasks. One possible explanation is that on easy tasks, students can generate better answers than the given choices by relying on their previously learned knowledge (Stone, 2000). If so, then students may feel conflicted by being able to generate better answers than the ones which were to be inferred from a passage or the ones offered on a multiple choice test. Such confusion can lead to feelings of self-doubt. Of course another possible conclusion is that students may fear the social repercussions of answering an easy problem incorrectly. Instead, they may want to protect their self-image by appearing humble or cautious by reporting under confidence for easy tasks while simultaneously appearing highly motivated to tackle the more difficult ones.

According to Kroll and Ford (1992) students have either ego-oriented or task-oriented motivational constructs. Kroll and Ford hypothesized that the orientation style of students is related to their calibration abilities. Ego-oriented students tend to place a heavy emphasis on demonstrating their abilities while exerting as little energy as possible on any given task. These students feel a sense of accomplishment by comparing their abilities to others. Success for ego-oriented students means having others notice how little effort is required of them to succeed. In contrast, students who are task-oriented tend to place less importance on managing their self-image in favor of achieving a mastery of task. Task-oriented students feel a sense of accomplishment when learning for learning's sake. In support of their hypothesis, Kroll and Ford found that ego-oriented students were less accurate at calibrating performance than were task-oriented students.

It is possible that ego-oriented students are less successful at evaluating their comprehension because of interfering goal priorities. By prioritizing control of their self-image, ego-oriented students may devalue the importance of comprehension goals. For example, Butler (1993) has noted that students pay greater attention to different sorts of information, such as comparing their performance to the performance of others rather than to the demands of the task, depending on their goal orientations. Another possibility is that goal orientation relates to students' use of strategies. In fact, according to Bouffard, Boisvert, Vezeau and Larouche (1995), students who posses a mastery of task orientation are more likely to engage in a variety of self-regulated learning strategies. Similarly Archer

(1994) found that goal orientation was related to the effective use of strategies, independent of perceived abilities.

The role of ego-involvement was further investigated by Lin and colleagues (2001), who examined students' self-image presentations and monitoring accuracy. The researchers used two scales to determine students' image orientations. The first, the Marlowe-Crowne Social Desirability Scale, designed by Crowne and Marlowe (1960), established how likely students were to deny their failures or inadequacies in order to preserve a socially desirable appearance. The second, the Self-Monitoring Scale, designed by Snyder (1987), established how likely students were to pay attention to the environmental cues around them and to adjust their behaviours, in order to maintain a favourable self-image presentation.

According to results, students who rated themselves high on either scale were also likely to report high levels of self-perceived calibration ability, although only the relationship between social desirability and self-perceived calibration ability was found to be significant. As for actual calibration ability, high self-monitors were able to accurately predict their performance calibration (post-diction), while no relationship was found between social desirability and performance calibration. This finding supports Snyder's (1987) claim that self-monitors are astute at picking up environmental cues or feedback. Feedback is important to these students because it assists them in making accurate comprehension judgments in order to preserve a favourable self-image. As further evidence of Snyder's claim, without the assistance of feedback, self-monitors were not able to make accurate calibration of comprehension predictions (pre-diction) nor were students who rated themselves high on a measure of social desirability. Thus, self-image orientation may be related to students' ability to use feedback. Overall, students' self-perceived calibration ability was related to performance but not to actual calibration ability. In other words, students who perceived themselves as being the most accurate calibrators were generally better performers although they were generally not better calibrators. The researchers suggested that perceived calibration ability may be related to judgments of comprehension competency rather than reflections of metacognitive skill.

In a later experiment, Lin-Agler and colleagues (2004) found that on the first test of a semester, students' metacognitive self-evaluations and reported study times were not related. However, those students who reported increased study times on subsequent tests also tended to increase their self-evaluation judgments. Thus, it appears that after receiving performance feedback on the first test, high self-monitoring students altered both the amount of time that they spent studying and their metacognitive self-evaluations. Presumably, these high self-monitors allocated more time on subsequent tasks in order to maintain their goal of appearing favourable to others. Thus, students who were the most concerned with keeping up their social appearances (i.e. high self-monitors) were also the most likely to

exert the greatest effort expenditure on task. Evidence also suggested that certain personality traits affect metacognitive self-evaluations. Specifically, Lin et al. found that competitive students rated their metacognitive abilities higher than non-competitive students. The researchers suggested that competitive students are more likely motivated to set achievement goals, which include stabilizing confidence across time. Also, the researchers suggested that highly competitive students may hold a more challenging orientation, which may motivate them to work harder towards meeting their goals. Interestingly, the researchers failed to find a relationship between students' cognitive abilities and self-perceived metacognitive skills when mediated by personality.

Inaccurate calibration judgments may stem from such factors as faulty task analysis, a lack of self-knowledge (Bandura & Schunk, 1981; Butler, 1996), a lack of strategy knowledge (Schraw & Graham, 1997), or from maintaining an ego-orientation (Kroll & Ford, 1992). Similarly, students with learning disabilities (LD) are typically less accurate calibrators than their non-disabled peers (Butler, 1996; Klassen, 2004). For instance, LD and non-disabled students have been reported to share similar performance judgments for writing, even though the LD students had documented writing disabilities (Graham, Schwartz, and MacArthur, 1993). One plausible explanation for these findings is that struggling students do not have the requisite cognitive abilities to make accurate comprehension judgments (Butler, 1996). Another explanation is that these students perceive more pressure to appear socially desirable due to a continual lack of academic success (Alvarez & Adelman, 1986). For example, students who feel threatened by their lack of success and perceive themselves as failures may sense an increased need for presenting an image of competency. These students may also be motivated to overstate their abilities due to anticipating behavioural consequences such as an intervention for acknowledging a weakness. Research examining the calibration skills of students with LD will be discussed briefly in order to further explore the relationships between calibration accuracy and ability, and calibration accuracy and goal orientation.

In a review of 22 empirical studies examining the calibration skills and self-efficacy beliefs of students with LD, Klassen (2002) found that although LD and non-LD students reported similar self-efficacy beliefs, LD students typically performed at lower skill levels. Klassen defined calibration as the degree of congruence between efficacy beliefs and actual performance. Overall, an analysis of the studies revealed that LD students were generally better at calibrating mathematical performance than writing or reading performance. In fact, in all five studies examining LD students' calibration accuracy for mathematical performance, students' performance predictions were generally accurate. Still, in the domains of reading and writing, calibration accuracy was low, with students with documented writing difficulties making the least accurate performance predictions. According to

Butler (1996), students with learning disabilities are less metacognitively aware, tending to be poor calibrators, because they place too much emphasis on the concrete demands of the task at hand rather than the more obscure tasks, such as self-monitoring.

In a study designed to examine the overstated self-evaluations of LD students, Alvarez and Adelman (1986) had students predict their performance for increasingly difficult math problems. Results indicated that 68% of the predictions were accurate and 30% of the predictions were overestimations. These results are similar to those generally reported in non-disabled populations. Interestingly, the researchers found that while LD students typically overestimated their performance predictions for tasks within their expected range of capabilities, they made accurate predictions for the easiest and most difficult tasks. In contrast, as mentioned, non-disabled students generally overestimate their performance predictions for the most difficult tasks, while underestimating their abilities for the easiest ones (Ferrell, 1995; Hacker et al., 2000). It has been suggested that students may need the extra confidence in order to engage in and to persist on more challenging tasks (Bandura, 1982). However, this does not explain why LD students reportedly overestimate their abilities on tasks which are within their range of capabilities. LD students may make overestimated performance predictions in order to protect their egos. In fact, Alvarez and Adelman suggest that it is because LD students are able to recognize which tasks are within their expected range that they feel the most threatened and, thus, feel the most compelled to overestimate their performance predictions. These findings suggest that students with LD may have the cognitive ability to accurately predict their comprehension, as demonstrated by their ability to accurately calibrate for the most demanding of tasks. Yet these students may be motivated to report overestimations for tasks which they are capable of answering correctly and, thus, feel the most threatened by.

Finally, Alvarez and Adelman (1986) had students fill out a measure of self-protectiveness in order to assess how threatening the overall task was. Although students typically were reluctant to admit that they perceived the task as threatening or that they predicted their performance with consideration of how best to protect their self-image, they tended to evaluate their peers differently. For instance, students were more apt to suggest that their peers were defensively motivated to overestimate their performance predictions.

*Social and cultural influences*

The definition of metacognition can be broadened from an awareness of one's cognitive processes to an awareness of others' cognitive processes as well (Jost, et al., 1998). In fact, thinking about other people's thinking has been found to influence one's own metacognitive beliefs. For example, in an experimental setting, Karabenick (1996) found that students' self-reports of

comprehension declined as the number of questions asked by co-learners increased. Similarly, it has been suggested that one's own thinking can be greatly influenced by the way in which one perceives what others' are thinking about one's thinking. Research has found that students' confidence judgments for novel tasks may be altered by manipulating the performance feedback they receive from others (Bouffard-Bouchard, 1991). Another way in which one's thinking is influenced by others is through the act of social comparison. According to Butler (1993), students seek either normative information, which they gain from their environment by comparing their performance to the performance of others, or objective information, which is gained by comparing their performance to the demands of the task. Thus, social influences appear to affect the manner in which one thinks about one's own thinking.

Students' susceptibility to social persuasion and its impact on performance judgments and achievement were studied by Bouffard-Bouchard (1991) using a verbal concept-formation task. Participants included students who shared similar domain experience and prerequisite knowledge for the novel task. In order to examine the scope of the influence of social persuasion, Bouffard-Bouchard arbitrarily divided students into one of two groups. Students received different feedback regarding their performance, after performing the verbal task, depending on which of the two groups they had been assigned to. Regardless of performance, students assigned to one group received positive feedback. This group was referred to as the high self-efficacy group. Students in another group received negative feedback, also regardless of performance. This group was referred to as the low self-efficacy group. Students in the high self-efficacy group were told how well they were performing in relation to their peers, while students in the low self-efficacy group were told how poorly they were performing. Following an initial task and feedback session, students continued to consecutively perform three similar tasks, each time making performance predictions.

Results indicated that students' self-efficacy judgments were susceptible to manipulation. In fact, students assigned to the high self-efficacy group were more accurate than those assigned to the low self-efficacy group in predicting performance, even though both groups performed similarly. This finding is particularly interesting since all participants were initially shown to have had equal knowledge within the domain and the self-efficacy group in which they were assigned was randomly chosen. Eighty-four percent of the students in the high self-efficacy group reported an objective to complete the four experimental tasks, while only 31% of the low self-efficacy group reported this same objective. This finding suggests that students who received positive feedback believed themselves to be more efficacious than those who received negative feedback. That the low self-efficacy group did not share the same ambitious

goals may suggest that students' persistence is partially mediated by their self-efficacy beliefs through the achievement goals they set.

At one time or another, most students have probably experienced feeling as though they understood the material being covered in class until their fellow classmates began raising questions. As mentioned earlier, research has found that students' self-reported comprehension levels go down as peers' questioning of class material goes up (Karabenick, 1996). Further, students who report having the highest awareness of their peers' presence also tend to be the most affected by their peers' questioning. Thinking about how other people think may be beneficial to one's learning. For example, a student may be overly confident in his or her own comprehension until a fellow student raises a question. Not only may the student benefit from thinking about the particular question raised but also by considering why he or she had not thought about the question or by considering how the classmate's thinking lead to the question. It is logical to assume that students who are better at monitoring their own comprehension may also be likely to pay closer attention to classmates' questions, since self-monitors generally question their comprehension throughout the learning process (Butler & Winne, 1995). Of course, as Karabenick points out, students are less likely to pay as close attention to peer questioning when the questions are asked by a peer or peers who generally ask a lot of questions anyway. Karabenick suggests that students' comprehension judgments are most affected when the peers doing the questioning are considered to be worthy or of similar abilities. In other words, one must believe that the way one thinks is similar to the way a peer thinks in order to have one's own confidence shaken by peer questioning.

In an exploratory study, Klassen (2004) investigated the effects of culture (immigrant Indo Canadian vs. non-immigrant Anglo Canadian) on students' self-efficacy beliefs for mathematics. According to his findings, both groups of students were capable of calibrating performance, with Indo Canadian students reporting slightly higher levels of efficacy, while also achieving slightly higher performance levels. As mentioned earlier, according to Bandura (1982), sources of self-efficacy beliefs include mastery experiences (past performance), vicarious experiences (watching others), social/verbal persuasion, and physiological or emotional states. It is through these experiences, Bandura suggests, that self-referent thoughts are gained and feelings of what one is capable of are established.

In Klassen's study, Indo Canadian students' math performance was predicted by their self-oriented experiences (mastery experiences and physiological events) and by other-oriented events (vicarious experiences and social persuasion), whereas the only significant predictor of Anglo Canadians' performance was self-oriented experiences (mastery experiences and physiological events). Regardless of culture, mastery experiences were reported as the most influential source of students' self-efficacy beliefs. However, immigrant Indo Canadian students also placed a heavy emphasis

on other-oriented experiences such as social comparison and external feedback. In fact, a significant difference was found between the vicarious experience source ratings of students, with Indo Canadian students reporting them as significantly more influential. Similarly, a modest effect was found in the higher source ratings of social persuasion among Indo Canadian students. Regardless of source magnitude differences, self-efficacy beliefs were found to predict math performance across cultures.

The degree to which physiological arousal affects students' self-efficacy beliefs also appears to be related to students' cultural backgrounds (Eaton & Dembo, 1997; Klassen, 2004; Steinberg, Dornbusch & Brown, 1992). In particular, fear of failure has been suggested as a highly motivating catalyst among non-Anglo populations. For example, in a study conducted by Eaton and Dembo (1997), fear of failure was indicated as the strongest predictor of Asian American students' academic behaviour. In contrast, fear of failure was the least successful predictor of academic behaviour among non-Asian American students. Also, the researchers found that although Asian American students reported less optimistic self-efficacy beliefs, they still outperformed their non-Asian American peers and were more accurately calibrated. According to research, non-Asian parents assume lower expectations while maintaining overestimations of their children's academic abilities, which works against high academic achievement for non-Asian students (Steinberg et al., 1992; Stevenson, Chen, & Uttal, 1990; Stigler, Smith, & Mao, 1985). Thus, Asian American students may strive harder to meet their parents' goals while evaluating themselves more critically. As mentioned, low self-efficacy beliefs have been suggested to generate motivational and affective deficits in students (Bandura, 1986).

In a large cross-cultural study examining the academic beliefs of 3,000 students from several cities (East Berlin, West Berlin, Los Angeles, Berne, Tokyo and Prague) researchers found that across cultures, students as young as seven years of age shared very similar beliefs regarding their abilities, and, likewise, their perceptions of what is needed to succeed in an academic setting (Stetsenko, Little, Gordeeva, Grasshof & Oettingen, 2000). In another large scale cross-cultural study, the confidence judgments of 551 post-secondary students from five countries (Taiwan, Palestine, Israel, the Netherlands and the United States) were examined (Lundeberg, Fox, Brown & Elbedour, 2000). All participants were instructed to immediately report their confidence judgments (performance calibration) for correctly answering each question on their respective final exams. Although there was a great deal of performance variation within each country, students performed similarly across countries, with students from Taiwan and Palestine scoring slightly below the mean. However, students' calibration skills were significantly different across countries. For example, Palestinian students reported the greatest overall confidence, while Taiwanese students reported the lowest. Additionally, Palestinian students were as likely to be overconfident in their performance predictions for both their correct and

incorrect responses, while Taiwanese students showed the greatest discrimination. Students from the United States made the most accurate predictions when reporting the greatest feelings of certainty, whereas, Palestinian students made the least accurate predictions when reporting the greatest feelings of certainty. Overall, performance accuracy was related to confidence judgments in the United States, Taiwan, Israel, and the Netherlands, but not in Palestine. The researchers suggest that Palestinian students' overconfidence may reflect a need to present a positive self-image since Arabic societies tend to focus on achievement in terms of what it means for the community as a whole rather than for the individual. Thus, Palestinian students may want to preserve their feelings of self-worth by adopting a system of overconfidence. Still, it is important to point out that many Asian societies are also considered collective societies. It has been suggested that students within these Asian societies tend to evaluate themselves against more stringent standards, often resulting in higher calibration accuracy, possibly due to an increased awareness of one's parents' and one's own academic goals (Steinberg et al., 1992; Stigler et al., 1985). Thus, it remains unclear what role different societal structures play on students' performance judgments and self-efficacy beliefs. Although there are still too few studies to understand the impact that culture has on students' calibration judgments it does appear that students from around the world tend to share similar academic beliefs and have fairly competent calibration skills (see Zabrucky et al., 2009, for a further discussion).

Although overconfidence may stimulate the necessary motivation required to tackle new and challenging tasks, little is known about the long-term effects of overconfident calibration judgments. In a related area of research, Robins and Beer (2001) studied students' self-enhancement bias, which was defined as the difference between students' self-perceived academic ability and their actual ability. In the study, students filled out six questionnaires regarding their self-perceived abilities over a four year college experience. The first questionnaire was completed during the first week of the students' freshmen year. Each questionnaire included measures of students' self-serving attributes, ego-involvement, self-esteem, subjective well-being and narcissism. In order to establish an initial objective measure of academic ability, the researchers combined students' SAT and high school GPA scores, creating a single composite score. Finally, graduation status and academic achievement (cumulative GPA) were used as the final objective measures.

Students who performed at lower achieving levels, while overestimating their abilities on self-evaluations, were referred to as self-enhancers. Self-enhancers typically attributed their success to their natural abilities and effort while simultaneously dismissing their abilities as a contributing factor when unsuccessful. Instead, self-enhancers were most likely to attribute their failures to situational variables, which they perceived as beyond their control. Interestingly, self-enhancers reported

feeling happier than usual after completing objective tasks for which they had overestimated their abilities. Thus, it appears that self-enhancing tendencies may generate beneficial feelings of affect, at least in the short-term. However, the researchers found that towards the end of their college careers, self-enhancers were more likely to disengage from their academic experiences. In particular, self-enhancers became less ego-involved with their academics, reporting that grades were less important to them. This detachment may reflect a growing sense of failure since self-enhancers continuously fall short of meeting their inflated self-perceptions. In comparison to their peers who held accurate perceptions and self-diminishing perceptions, self-enhancers reported lowered feelings of well being and self-esteem at the end of their educational experiences. Finally, although self-enhancers initially reported higher confidence in their abilities to succeed and to earn higher grades than their peers, their confidence did not translate into higher GPA's nor did it increase the likelihood of them completing college. In fact, self-enhancers were slightly more likely to drop out in comparison to students who held accurate and self-diminishing perceptions. Thus, although it appears that self-enhanced perceptions may be beneficial in the short-term, it is unclear what the long-term effects on students are. It is important to note that in this study researchers did not examine the calibration skills of students, but instead, examined what may be a closely related area of research, self-enhancing tendencies.

## Conclusions

Researchers studying metacognition would benefit from a more systematic examination of all aspects of how one thinks about thinking. By bridging the gap between cognitive and social cognitive theories and empirical data, researchers will be better able to understand the complex set of factors that affect students' metacognitive judgments. For example, evidence suggests that students' calibration skills are influenced by more than ability and prior performance. Instead, researchers have found that individual differences such as self-efficacy beliefs (Bandura, 1982; 1986; Finney & Schraw, 2003; Klassen, 2004; Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1995; Zimmerman & Bandura, 1994), level of expertise (Glenberg & Epstein, 1987; Glenberg et al., 1987; Weaver, 1990), goal-orientations (Butler, 1993; Kroll & Ford, 1992; Lin et al., 2001; Lin-Angler et al., 2004), susceptibility to social influences (Bandura, 1982; Bouffard-Bouchard, 1991; Karabenick 1996; Klassen, 2004) and cultural differences (Eaton & Dembo, 1997; Klassen 2004; Steinberg et al., 1992; Lundeberg et al., 2000; Zabrucky et al., 2009), also affect students' metacognitive judgments.

In the present paper we have emphasized the role that self-efficacy plays in influencing students' calibration of comprehension judgments. Research findings have shown that self-efficacy beliefs play an integral part in the calibration paradigm by influencing performance predictions (Finney & Schraw, 2003; Klassen, 2004; Pajares, 1996; Pajares & Kranzler, 1995;

Pajares & Miller, 1995) and by making direct and independent contributions on performance (Chen, 2002; Pajares & Kranzler, 1995; Zimmerman & Bandura, 1994; Zimmerman, et al., 1992). Thus, it is recommended that investigators continue to examine students' self-efficacy beliefs, as it may be all but impossible to disentangle them from the calibration paradigm. Additionally, by examining the sources of students' self-efficacy beliefs, researchers can explore how self-oriented (mastery experiences and physiological events) and other-oriented events (vicarious experiences and social persuasion) influence students' beliefs and why they affect individual students differently.

Although students' overconfident performance judgments or self-enhancing tendencies have been suggested to be beneficial in the short term (Bandura, 1982, 1986; Zimmerman, 1990, 1995), it still remains unclear what the long term effects are. For example, students may require the extra motivation gained from overconfidence in order to engage and to persevere on challenging tasks (Bandura, 1982; Schunk 1990). However, research indicates that students' performance judgments are influenced more by their prior judgments than by their prior performances (Hacker et al. 2000). Thus, students may need more than additional motivation in order to improve their metacognitive skills. Similarly, some students continually deny their failures and inadequacies in order to preserve a socially desirable appearance (Lin et al., 2001). Thus, even if students have the requisite monitoring abilities not all students will use them. According to Robins and Beer (2001) inflated self-perceptions may be beneficial in certain domains, such as in the area of health and sports, yet harmful in others, such as in an academic setting.

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# Children's metamemory: A review of the literature and implications for the classroom

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**Abstract**

In this paper we examine the development of children's metamemory and provide practical implications of research findings for the classroom. In the first part of the paper we define and discuss the global concept of metacognition, the component processes of metacognition and the importance of each component to children's learning. We then examine the development of children's knowledge about memory and ability to monitor memory (i.e., metamemory). We focus, in particular, on seven major research themes: children's metamemory develops with age and experience, younger children are less aware than older children of the benefits of categorization on recall, younger children use different strategies than older children, children's causal attributions may affect metamemory, instructional interventions must be appropriately timed, children will show more strategy transfer when explicit instructions are provided and children overestimate their memory ability. We discuss implications of these major themes for teachers of young children.

**Keywords**: Metamemory, Metacognition

## Introduction

Children come to school from a variety of backgrounds and with varying degrees of knowledge. Teachers are often faced with challenges involved in

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teaching children the information and skills they need to know to be successful. Although student learning is the main priority in every classroom, teachers are not always appropriately informed about how to facilitate student learning. It is common for teacher training programs to involve courses that emphasize content and delivery of information and skills that are required of students. However, there appears to be less emphasis on educating future teachers about the process of student *learning* (Borowski & Muthukrishna, 1992). Teachers who understand and apply principles involved in the cognitive processes of learning are more effective at instructing and more effective at teaching students how to learn than those who simply understand and deliver content (Schneider, 2008).

The ultimate goal in the education of children is to help students become self-sufficient learners. According to theorists and researchers, successful self-sufficient learners are self-regulating (Butler & Winne, 1995), motivated, possess a wide body of knowledge and skills, and demonstrate ownership in learning situations. Not only will such children find it edifying to ask questions and seek out information, they will also be able to monitor their own cognitive performance and be able to determine whether they have acquired new information sufficiently. This ability to monitor, control and assess one's own thinking is known as metacognition (Flavell, 1979). Sophisticated learners must be metacognitively mature in order to determine if learning is taking place, or if more work must be done to master a skill or understand a concept (Flavell, Miller & Miller, 2002). Attention is increasingly being paid to the importance of metacognitive skills in self-regulated learning (Eflkides, 2008; 2009).

One component of children's metacognition is their metacognitive knowledge (Flavell, 1979). Metacognitive knowledge includes the knowledge children have regarding the role of person, task, and strategy variables in cognition, is relatively stable in content and is a part of children's developing declarative knowledge (Efklides, 2008; 2009). Teachers can increase children's ability to learn, in part, by helping them become aware of person, task, and strategy variables that affect cognition. Indeed some investigators (e.g., Pintrich 2002) have called upon teachers to explicitly teach children metacognitive knowledge.

Another component of children's metacognition involves their metacognitive experiences, which include their ability to assess or evaluate their progress on cognitive tasks *as well as* their ability to use strategies to regulate progress in a systematic manner. Again, teachers can increase children's ability to learn by helping them become aware of the importance of assessing ongoing cognitive processes during tasks and teaching them strategies for improving their performance when evaluative processes indicate problems (see Bjorklund, Dukes, & Brown, 2009, for a further discussion). It is clear that metacognitive knowledge as well as metacognitive experiences are related to learning (Bjorklund, et.al, 2009; Dunlosky & Metcalf, 2009: Schneider, 2008).

In this paper we focus on the development of metamemory skills and provide some practical information regarding how current research findings can be applied in the classroom. First, we provide an explanation of metamemory. Second, we discuss the importance of metamemory skills. Finally, we review major research findings and themes in the field of metamemory, accompanied by practical applications and suggestions for teachers.

**Metamemory**

Metamemory, or knowledge of and control of one's memory, has been a topic of interest since the concept was first introduced and defined by Flavell (1971) in response to the question, "What is memory development the development of?" His response (and the introduction of the term, metamemory) to this question was "It seems in large part to be the development of intelligent structuring and storage of input, of intelligent search and retrieval operations, and of intelligent monitoring and knowledge of these storage and retrieval operations- a kind of 'metamemory', perhaps" (p. 277). Thus, the concept of metamemory was established for future researchers to investigate.

Weed, Ryan, and Day (1990) provide a more thorough and updated definition of metamemory, stating that "Metamemory has been operationally defined, alternatively, as (a) verbalizable knowledge of person, task, and strategy variables affecting recall; (b) as self-regulation; and (c) as the effects of instructions incorporating executive control components or metacognitive acquisition procedures (p. 849)." As Weed et al.'s (1990) definition indicates, metamemory is believed to incorporate two major components. First, metamemory concerns stable knowledge of the variables that affect one's memory. This stable knowledge includes knowing about person, task, and strategy variables. These variables constitute (1) an understanding that the size and/or quality of a person's memory is affected by individual ability (person variables), (2) the relative difficulty of a task (task variables) and (3) the relative effectiveness of different strategies (strategy variables). An example of person knowledge is knowledge that at one point in time, someone may remember one idea but be unable to remember something else. An example of task knowledge is the knowledge that a more difficult task (such as remembering a list of 15 words) will be harder to remember than a simpler task (remembering four words). Strategy knowledge is the knowledge that grouping related words together may be more effective than rehearsal (repeating the list over and over) when attempting to remember a long list of words.

Stable knowledge is typically assessed using questionnaires. Some researchers (Schneider, 1986; Short, Schatschneider & Friebert, 1993; Weed, Ryan & Day, 1990) have used questionnaires that have already been developed while others (Andreassen & Waters, 1989; Henry & Norman, 1996; O'Sullivan, 1996; Schneider & Sodian, 1988) have created their own to

fit the needs of a study. Both types of questionnaires are designed to glean information about a person's knowledge regarding memory. For example, O'Sullivan's (1996) study of children's metamemory about the influence of conceptual relations on recall sought to determine if children were aware of the impact of knowledge on memory. To learn about a child's metamemory, the researcher asked, "What did you do to try to remember the words?" and "What helped you most to remember, something you did, something about the words or something else?" (pp. 8-9).

Stable knowledge about memory affects, and is affected by, experiences with remembering (Cavanaugh & Perlmutter, 1982). As children encounter different experiences, they also learn *how* they learn. As they internalize these lessons, they are gaining stable knowledge. Yussen and Bird (1979) were among the early researchers interested in determining what sort of stable knowledge exists in young children. They examined whether four- and six- year old children were able to understand the impact of length and noise (task variables), age (person variable), and time on memory performance. Results of the study showed that children as young as four understood that these variables had an effect on the cognitive domains of memory, communication, and attention. In addition, six-year olds possessed more stable knowledge about the variables than four-year olds, suggesting that children gained stable knowledge through experience.

Chi (1987) contends that differences in stable knowledge due to age are attributable to the different ways that children use information (as opposed to differences in the amount of knowledge they possess). Chi provides an example regarding the way that children know how to categorize information. At first glance, it seems that children are unable to categorize groups of words as effectively as adults. However, they may, in fact, be categorizing such words differently. As youngsters learn new vocabulary, they may "file" the new word, temporarily, in an area that is not hierarchically logical to adults. However, over time, such vocabulary may work its way into a more common semantic structure. Thus, to an adult, stable knowledge regarding categorization may seem to be lacking, whereas really, it is just different and possibly evolving. Still, the evidence to date suggests that children's metacognitive knowledge systematically develops throughout childhood (Schnider, 2008).

The second component of metamemory involves the monitoring of one's memory. Memory monitoring involves an individual's ability to judge how well he/she is performing on a memory task *as well as* the ability to use strategies to improve performance. It is the ability to spontaneously check and test one's performance during and after such a task (Flavell, Miller, & Miller, 2002). This ability to monitor and regulate one's memory is also referred to procedural metamemory (see Efklides, 2008; 2009; Lockl & Schneider, 2002).

Memory monitoring is typically assessed using the following three research paradigms (Schneider, 2008; Schneider & Lockl, 2008): Ease of Learning Judgments (EOLs), Judgments of Learning (JOLs), and Feelings of Knowling (FOKs). EOL judgments are judgments made by a learner before a task (Lockl & Schneider, 2002) regarding how easy or difficult they believe a learning task will be. JOLs are judgments made during or after a task (Lockl & Schneder, 2002) regarding how well the learner believes he/she will perform or has performed. FOKs refer to one's ability to recognize an item even if he/she may not be able to recall it (Wellman, 1977). As discussed in more detail later, most investigators have found improvement in children's judgments as they proceed through elementary school.

*The Relationship between Metamemory and Memory*

Researchers (Flavell, 1971; Henry & Norman, 1996; Koriat, Goldsmith & Pansky, 2000; Pressley, Borowski, & O'Sullivan, 1980; Wellman, 1977) have investigated the notion that metamemory and memory are related. The idea that metamemory and memory are related stems from the very nature of metamemory itself. Metamemory involves both the knowledge that certain variables affect one's memory (stable declarative knowledge) and the ability to monitor and regulate one's memory (procedural memory). Theorists believe that a person who has these abilities will be better at remembering than a person who does not. Many researchers have explored metamemory-memory correlations. Correlations have been documented between both stable knowledge and memory (Henry & Norman, 1996; O'Sullivan, 1996; Schneider & Sodian, 1988; Short, Schatschneider, & Friebert, 1993) and monitoring ability and memory (Koriat, Goldsmith & Panshy, 2000; Schneider, 1998; Wellman, 1977).

An example of a study documenting metamemory/memory correlations is one conducted by Henry and Norman (1996). Henry and Norman examined the relationships between stable knowledge about memory and memory performance in young children. To determine children's knowledge about memory, the researchers administered a questionnaire pertaining to person, task, and strategy variables. Questions were asked to determine the extent of the children's stable knowledge. Results showed that stable knowledge was, indeed, related to free recall and memory span.

Schneider and Sodian (1988) also found correlations between children's metamemory and their memory performance. These researchers examined children at four-, five-, and six-years of age to determine if children could identify and use retrieval cues in a memory-for-location task. Children were shown ten toy houses, each affixed with a picture of a common item (police car, ball, flower, key, etc.). The children's task involved placing small pictures of people in each of the ten houses and later remembering which person was in each house. "People" consisted of a doctor, policeman, dancer, etc. Successful completion of the task involved remembering where each

"person" was. This could be accomplished by placing people in houses that contained items matching their role (e.g., the policeman would be placed in the house with the police car). Results showed that children's strategy knowledge was correlated with their memory performance. Children who chose to match the items were able to remember the location of the people better than those who did not.

Wellman (1977) investigated feeling-of-knowing in kindergarten, first-, and third-grade children and determined that children who were successful at monitoring were also successful at remembering. To test FOK, the researcher showed pictures to children and asked them if they knew the name of each picture. If a child could not think of the name of the picture, the researchers asked whether he/she would be able to recognize the name of the object from a list of possible names. Responses were compared to actual memory accuracy. Wellman found that monitoring accuracy was related to performance and that older children were better at predicting than younger children.

Studies of metamemory-memory correlations provide information that is useful to both teachers and students. It seems clear that improving children's metamemory knowledge and skills may improve memory. Unfortunately, there is limited information available for teachers regarding ways to foster and improve metamemory skills. Thus, the following information is provided as a guide for teachers who want to be aware of important research findings and apply them in the classroom. Seven major themes about the nature of metamemory have been identified. These findings include:

- Children's metamemory develops with age and experience
- Younger children are less aware than older children of the benefits of categorization on memory
- Younger children use different strategies than older children
- Children's causal attributions may affect metamemory
- Instructional interventions must be appropriately timed
- Children will show more strategy transfer when explicit instructions are provided
- Children overestimate their memory ability

*Children's metamemory developments with age and experience*

According to Schneider and colleagues (Schneider, 2008: Schneider & Pressley; 1997), as children age their metamemory improves. Several investigators (Bjorklund & Zeman, 1982; Lovett & Flavell, 1990; Moynahan, 1978; O'Sullivan, 1996; O'Sullivan, Howe, & Marche, 1996; Schneider, 1986; Wellman, 1977; and Yussen & Bird, 1979) have documented developmental changes in children's metamemory knowledge and monitoring. As previously described, Wellman (1977**)** examined the way kindergartners, first-graders, and third-graders monitor their own recognition ability. In

this study, the researcher asked children whether they recognized and could name certain pictures. For pictures that a child could not name, he or she was asked about the likelihood that he/she would be able to correctly recognize the name of the object if it was presented to them. Third-graders were significantly better at accurately assessing their feeling-of-knowing than were younger children and kindergartners were only slightly better than chance at correctly assessing their FOK.

Moynahan (1978) examined the development of other metamemory milestones, seeking to determine if developmental differences existed in first, third, and fifth grade children's ability to judge memory performance and select appropriate strategies for given situations. Children were given paired associate tasks (in which a child must remember which "response" word has been paired with a particular stimulus word in word pairs such as frog-purse or snowman-ring) and were instructed to use one of two strategies, either a simple repetition strategy or an interaction strategy which required children to imagine the two words interacting in some way. After the task, children were asked to reflect on the usefulness of the strategy they were instructed to use. Finally, the children were given a third paired associate task in which they could use any strategy or none at all. Results showed that the older children recognized the effects of strategy use, whereas the younger ones did not. In addition, the older children were more likely than the younger children to attribute success to a particular strategy. Thus, developmental differences were found in children's knowledge that strategies are useful and that some are more beneficial than others.

Yussen and Bird (1979) were among a handful of early researchers interested in understanding the developmental progression of certain aspects of metamemory. In a study of three-, four-, and five-year olds, these researchers looked at children's understanding of the effects of length, noise, time, and age on memory. The children were given a series of pictures and questions that provided scenarios of easy tasks or difficult tasks or situations. For instance, to determine if children had an understanding of "person" variables, they were asked to choose from two pictures that depicted individuals remembering a list of words, either a young girl or a grown woman. Children who could indicate that adults were more likely to remember more words were deemed to have an understanding of "person" variables. The researchers found that children were aware of stable variables and their effects on memory but that older children were considerably more accurate than younger children in regards to metacognition.

Bjorklund and Zeman (1982) also found evidence of developmental progression in metamemory. The researchers conducted a study to determine if remembering familiar information was more likely to elicit knowledge of strategy use than remembering unfamiliar information. First-, third-, and fifth- graders were given memory tasks. The researchers asked

the children a set of questions regarding strategy use either before or after they participated in a recall activity. Next, children were given the recall activity in which they attempted to remember either a list of classmates (familiar information) or a list of somewhat unfamiliar words. Recall for the familiar information was higher for all three groups of children. However, when given the unfamiliar information, fifth graders used a helpful strategy of clustering and performed best on the task. In a subsequent experiment, recall was the same for the first and third graders but was significantly improved for fifth graders who received a thirty-second wait time, indicating that these children used their time to reflect on and choose a strategy. These fifth graders also showed greater clustering ability and consistently claimed that they clustered in a way that the researchers documented. Thus, although all age groups may have used some rudimentary strategies to remember familiar and/or unfamiliar information, only the fifth graders could accurately identify their strategy use.

Lovett and Flavell (1990) were interested in learning if, and at what age, children differentiate between the strategies needed to be successful to memorize vs. comprehend information. The researchers set up tests of memorization (strictly rote memory), memory/comprehension combinations (word memorization), and comprehension (similar to a picture vocabulary test). First- and third-grade children were asked to choose which strategy would be better for either rote memorization or comprehension. Strategies included rehearsal, word definition, and a combination of rehearsal and word definition. They were also asked to identify lists of words that would be easier for comprehension (familiar words are easier than unfamiliar words, regardless of the length of the list of words). Both groups of children had difficulty distinguishing between strategies that would prove most helpful in given situations and both groups were better at identifying memorization than comprehension strategies. However, unlike first-graders, third-graders were beginning to be able to distinguish between comprehension and memory and what strategies would improve each. Thus, according to this study, at some point between the first- and third-grade, children begin to learn the difference between memorization and comprehension and how to focus strategies on each process exclusively.

Schneider (1986) examined the way that children and adults organize information in an attempt to understand if differences were due to changes in children's semantic memory or knowledge base or due to children's deliberate strategy use. He argued that as children grow older their use of deliberate memory strategies does not increase, but in fact, only changes. Schneider modified the traditional sort-recall task to determine if this was true. During a sort-recall task, a child is asked to sort a series of words or pictures to best help him/her remember them later. In this case, second- and fourth-grade children were first shown a video demonstration of four strategies that could be used to aid in memorization. The strategies included rehearsal (saying the words over and over), sorting according to categorical

grouping (animals, vehicles, etc.), naming (simply saying each word aloud), and looking (staring at each picture for some time).

Schnieder found that older children were more likely than younger children (second-graders) to spontaneously cluster or sort the test items. Further, fourth-graders seemed to be more adept at choosing an appropriate and helpful strategy than second-graders. However, younger children did show evidence of deliberate strategy use and metamemory skill. Thus, developmental differences may exist in the *way* that metamemory is applied, and not necessarily in the degree to which it is applied.

O'Sullivan (1996) conducted a study to determine what children of different ages know about conceptual relations and the effects of these relations on recall. The conceptually related terms used in this study included words that were all animals or parts of the body. A list of conceptually distinct words included words that had no obvious, conceptual relationships. O'Sullivan examined first-, third-, and fifth-grade children to determine what age differences existed regarding the influence of conceptual relations on recall. Although all age groups showed improved performance when recalling words from conceptually related lists, the youngest children did not report category use or the use of other deliberate strategies. Third- and fifth-graders, however, reported the use of, and demonstrated strategies such as, rehearsal and categorization. Thus, children develop more sophisticated methods of committing information to memory as they mature.

O'Sullivan, Howe, and Marche (1996) conducted an interesting study to examine what children believe about certain aspects of long term retention and how these beliefs change with age. They examined whether children believed that forgetting was more likely to happen with central or peripheral details, and whether newly learned information interferes with remembering previously learned information (a phenomenon known as retroactive interference). Developmental differences in knowledge were found in these children, who ranged in age from preschool to third-grade. As expected, older children were more likely to state that peripheral details were more easily forgotten than central details. They also believed that people are subject to suggestibility and that retroactive interference is possible.

Much of the stable knowledge and monitoring ability classified as components of metamemory improves as children grow older (see Schneider, 2008, for a further discussion). By third grade, children have become aware of influences on memory (Lovett & Flavell, 1990; O'Sulivan, 1996; O'Sullivan, Howe, & Marche, 1996; Schneider, 1986; Wellman, 1977), and can, by fifth grade, apply useful strategies in appropriate situations (Bjorklund & Zeman, 1982; Moynahan, 1978). Teachers should be aware of this progression and have an understanding of what is typical metamemory development for elementary school children. Second-, third-, and fourth-

grade teachers would be wise to point out potential times when strategy use would benefit their students, keeping in mind that children of this age will need guidance. Teachers of fifth graders should also be aware of how well their students are performing on memory-type assessments and identify whether they are using appropriate strategies.

Despite the many findings suggesting that metamemory improves with age, there are also studies that show that some aspects of metamemory may not consistently improve with age, include two memory-monitoring skills: judgements of learning (JOLs) and feelings of knowing (FOKs). Lockl and Schneider (2002) conducted a study to investigate the developmental progression of FOKs as previous research (Butterfield, Nelson, & Peck, 1988; Cultice, Somersville, & Wellman, 1983) had resulted in mixed and inconsistent findings. Lockl and Schneider looked at children's ability to judge their own performance on a recognition test. Children consisted of first-, second-, third-, and fourth-graders. The researchers began by using a vocabulary test to determine words that each child could correctly define. Next, children were asked to rate their confidence regarding the words they had not defined correctly. Confidence levels measured children's confidence that they would recognize the correct answer from a list of options. Findings showed that FOK accuracy was generally low to moderate for all age groups. Lockl and Schneider concluded that there was no evidence that FOK judgments significantly improve over the school-age years.

Schneider, Vise, Lockl, and Nelson (2000) conducted two experiments to examine possible developmental trends that may exist in children's monitoring skills. Kindergartners, second-graders, and fourth-graders were asked to make judgments regarding the likelihood of remembering newly acquired information (JOLs) on a memory test. Children were asked to recall information in one of two ways, either immediately after learning or after being given a two-minute "delay." Prior research (Nelson & Dunlosky, 1991) has demonstrated a clear advantage for adults' performance when they are provided with a delay. Schneider et al. found that, similar to adults, children benefited from a delay and were more likely to provide accurate answers when provided with this delay. In addition, the researchers concluded that there appears to be no evidence that JOLs are affected by a child's age. This research provides practical information to educators by suggesting that students may benefit from being given a delay before being asked to predict his/her readiness for a test.

*Younger children are less aware than older children of the benefits of categorization on recall*

The findings regarding the developmental progression of metamemory reveal that, unlike older elementary students, younger children are unaware of the beneficial effects of categorizing on remembering. The lack of ability to effectively categorize to aid recall may represent a lack of monitoring ability. A study by Salatas and Flavell (1976) was one of the first to look at the way

children respond to and use categorization as a strategy for remembering. In an experimental group, children were instructed to look at sixteen pictures that were placed into obvious categories in an array. The children were instructed to remember the words and to take notice of the categories. Children in a control group were simply instructed to look at the pictures. Both groups were given a recall test after a short amount of time. Results indicated that children in the experimental group performed significantly better on the recall task. However, children from the experimental group were no more likely than the control group to state that categorization aids recall. Further, knowledge of the beneficial effects of categorization did not necessarily transfer to behavior. In other words, children who claimed that categorization was beneficial were no more likely to categorize on subsequent tasks. Thus, despite the fact that some strategy knowledge regarding categorization existed, the children still did not apply it.

In a similar study (Bjorklund, 1980), kindergarteners, third graders, and sixth graders were instructed to learn lists of words that had been categorized in taxonomic ways and in complementary ways. Taxonomic categories contain groups of words that belong together by group (e.g., animals, tools) while complementary categories are groups of words that belong together due to function or location (e.g., things that go in the kitchen, things that a teacher uses). One group of children was made aware of the existence of categories before the test was given. A second group was not told about the categories but the test-words were presented in clusters, according to groups. A third group of children was not made aware of the categories and words were not presented in particular groups. Kindergarteners understood both taxonomic and complementary groupings but this understanding did not facilitate memorization. Instead, they tended to memorize each word on an "instance-by-instance" basis. Although the kindergarteners performed slightly better when they remembered taxonomically similar words, they were unable to identify the reason. Only the sixth graders were able to consistently identify the categories, regardless of the test condition.

In response to findings that young children are less likely than older children and adults to organize information to be remembered, Bjorklund and Zeman (1982) conducted a study to examine "spontaneous organization" in closer detail. They were interested in finding out more about when children may begin to organize for recall. To do so, the researchers set up an experiment that necessitated organizational strategy, yet created an activity simple enough for young children to complete successfully. Results showed that whereas older children (fifth graders) were able to identify a useful organizational strategy and use it consistently, first and third grade children were more likely to "happen upon" a strategy if they were to use one at all.

Schneider (1986) looked further at this phenomenon, investigating the mechanism(s) behind sorting and categorizing behaviours in children. Schneider studied the conceptual knowledge that second- and fourth-grade

children have and how it affects the way they apply strategies in sort/recall tasks. Results showed that second-graders are relatively unaware of the benefits of clustering and sorting for recall, and that fourth- graders are in the beginning stages of learning the benefits of deliberate memory strategies. Henry and Norman (1996) offer the hypothesis that young children seem to be unaware of the benefits of categorizing because of the way the sort-recall tasks are conducted. They argue that children may not actually have trouble with the task of categorizing (category items are usually obvious, even to young children) but that they may have simply not recognized its usefulness as a memory strategy yet. In other words, young children may be able to "do" the strategy but they may not yet make the connection that it will enhance memory.

In a study of preschoolers' classification styles, Bjorklund and Zaken-Greenberg (1981) found that four- and five-year old children do not necessarily benefit from the same methods of categorizing as older children. Specifically, sorting taxonomically did not benefit preschool children the way it did older children. In this study, preschool children who sorted in complementary ways outperformed those who sorted taxonomically, on certain recall tasks. Four- and five-year olds were given word lists and instructed as to how they should group the words prior to memorization. Half of the children sorted taxonomically and the other half sorted nontaxonomically. Half of each of these groups sorted the words once prior to testing and the other half sorted two times (the same way both times) prior to testing. Although children in the taxonomic group outperformed those in the nontaxonomic group on the one-sort activity, the opposite was true for the two-sort activity. The researchers attributed this to a novelty effect. When searching for ways to associate the words, the children were elaborating enough to commit the words to memory. These results point to what may be another qualitative difference between older and younger children's metamemory.

Teachers should be aware that during the elementary school years children become aware of organizational strategies, learn to apply them and will eventually use them spontaneously. Due to the fact that using organizational strategies becomes increasingly important as children mature and face more challenging academic classes in middle and high school (when more difficult memorization tasks will be required), the acquisition of strategies is an important accomplishment. It may be helpful for teachers to point out situations where organization is helpful and encourage students to use it. For instance, science and social studies are two subjects where memorization skills are necessary. If asked to memorize a group of animals from the animal kingdom, students may consider grouping them according to size or colour. Experimenting and practicing with grouping and categorization may be a helpful way to learn about strategy use.

*Younger children use different strategies than older children*

As noted earlier, young children (under the age of seven years) do not necessarily show a connection between the use of simple strategy use (categorization), memory performance, and metamemory (Henry and Norman, 1996). However, there is evidence that young children engage in and benefit from different strategies than older children. Henry and Norman (1996) examined the relationship between the use of simple strategies, memory performance, and metamemory in four- and five-year old children. The researchers used a nonverbal questionnaire to determine children's predictions about their own memory abilities. This questionnaire consisted of a series of pictures of people trying to remember different items. Children were asked to point to pictures that showed easy or hard remembering tasks. Children were also given tests of free recall and memory span.

Henry and Norman monitored the strategies that children used during the free recall and memory tasks. Children who used a verbal naming strategy during presentation in the recall task performed better than those who did not. The verbal naming strategy consisted of the child naming each object as it was presented to him/her. Of particular importance was the point at which the children verbalized, or named, the stimuli. Those who named the stimuli at recall but not presentation were less successful than those naming at presentation only. Henry and Norman hypothesized that this phenomenon may be a result of the way that children encode information to be remembered.

Baker-Ward, Ornstein, and Holden (1984) came to a similar conclusion in their study of four-, five-, and six-, year olds. These researchers were interested in learning about the existence of deliberate memory strategies in young children and how they differ from the more commonly known strategies of older children and adults (e. g., rehearsal and categorization). Children were provided with a group of toys. Children in the experimental group were told to do anything they wanted to with the toys in order to help remember them. Children in the control condition were only told to play with the toys. The children's behaviours were recorded for analysis. Children who were in the "remember" condition played with the toys considerably less than those who were not asked to remember. They also used their time to name the objects and visually examine them. Baker-Ward et al. concluded that naming and visual inspection are likely to be precursors to the more sophisticated strategies of older children. Further, the deliberation and "studiousness" of the children suggests that they made efforts to remember, perhaps helping them develop a respect for strategy use. Thus, the "naming" strategy found during the younger years may be practice for the more sophisticated strategies found in older children.

Naming objects or words to be remembered may be an important first step in developing other, more effective, memory strategies. One way that teachers may interpret and use this information is to encourage young children to reflect upon this practice (naming stimuli at presentation) and recognize that it is helpful. According to Schneider and Sodian (1988),

children who engage in metacognitive behaviours are more likely to use strategies and display successful memory behaviour. Thus, encouraging a child to reflect upon the use of this strategy, albeit a simple one, may be helpful in both encouraging metacognitive thinking and encouraging the use of the strategy itself.

*Children's causal attributions may affect metamemory*

Teachers who are interested in fostering strong metamemory skills in order to increase strategy use and recall in the classroom should be aware of children's causal attributions. Weed, Ryan, and Day (1990) conducted a study and proposed a model regarding the way that both metamemory and causal attributions relate to recall. In their study, the researchers examined the effects of various measures of metamemory and academic causal attributions on recall. Fourth-graders were given an IQ test, a general test of metamemory (questionnaire regarding knowledge about strategy use), a test of task-specific metamemory (children were asked how to study for a recall test), a questionnaire regarding academic causal attributions (children were asked about their motivational orientation), and a free recall test. Children who believed that effort and strategy play a more substantial role than luck in learning situations tended to be the most successful on the free recall task. Weed, Ryan and Day's results emphasize that students must be reminded that success in such situations is under their own control.

O'Sullivan (1996) found that causal attributions differed depending on the age of the child. In a study of the influence of conceptual relations on recall, O'Sullivan found that first-graders were more likely than third- and fifth- graders to attribute success to general, rather than specific, attributions. General attributions included "phonological or spelling characteristics of the words, trying or working hard, attributions focused on the subject's brain, mind, eyes, and ears" (p. 15). These general attributions were less apparent in the older children who displayed "attributions to the presence of categories in the word list" or "attributions to the subject's use of specific mnemonic strategies" (p. 15). These findings suggest that the general attributions of younger children may be eventually phased out by more specific, metamemorial knowledge and functioning.

Researchers have also studied the causal attributions that children have regarding how strategies work. Fabricius and Cavalier (1989) examined the influence of such beliefs on children between the ages of four and six. They found that as children mature, they develop more sophisticated or well-developed theories about the ways that organization and labelling work in remembering. Children who gave "mental" explanations regarding the helpfulness of labelling said that labelling helped them remember because they could repeat the word over and over or visualize it. Children who gave "perceptual/behavioural" explanations said that labelling allowed them more time to hold on to the information. Fabricius and Cavalier provide a possible interpretation of their findings, stating that the process of explaining the

usefulness of a strategy may help the child develop a stronger belief in that strategy, thus, increasing the likelihood of using it again. A similar explanation was given by O'Sullivan, March, and Howe (1996), who suggested that children may not be able to control their use of deliberate strategies until they are able to explain their beliefs about strategy use.

It is very important that teachers help students become aware of their attributions for success or failure in memory situations. Children who are aware of their attributions may be more likely to reflect upon and modify their own behaviours. Teachers can help children reflect by asking them questions about their memory and what they attribute their success to. Further, children must be reminded that success is under their own control and that using deliberate memory strategies can lead to success.

*Instructional intervention must be appropriately timed*

The findings of O'Sullivan (1996) and Weed, Ryan, and Day (1990) suggest that young children may be prone to relying on older causal attributions instead of their developing metamemory. These children may benefit from a teacher prompting them to rely on their developing metamemory skills. The findings of Weed, Ryan, and Day (1990) echo those of Andreassen and Waters (1989), who conducted a study to determine if and when children plan to organize information to be remembered in a free recall task. Metamemory assessments were given to first- and fourth-graders either before or after a free recall task was assigned. Results showed that older children planned to use deliberate memory strategies and could benefit from prompts prior to the activity. Younger children did not plan ahead of time. Andreassen and Waters concluded that the process of learning to intentionally plan to use strategies begins with the recognition of strategy use during the activity and that this process may be developmental in nature. These findings can be applied to the classroom by reminding teachers that children must be given prompts if they are to be expected to use certain strategies. Such prompts may be necessary for far longer than prompts given for other cognitive tasks. Young children should not be expected to retain strategies simply because they have previously been successful.

*Children will show more strategy transfer when explicit instructions are provided*

Studies have shown that children do not spontaneously use memory strategies that have proven to be successful in the past (Schneider, 1985). In early studies (Brown, Campion, & Barclay, 1979; Brown, Campione, & Murphy, 1977) researchers determined that children do not necessarily generalize learned strategies to new situations. Older children are better able than younger children to maintain strategies under some circumstances. Several researchers (Ghatala, 1986; Levin, Pressley, & Goodwin, 1986; Ghatala, Levin, Pressley & Locico, 1985) have investigated

the ways that strategy training must be conducted in order for children to benefit and effectively transfer strategy use.

It would appear that simply showing children how to use an appropriate strategy does not effectively lead to the transfer of the strategy in future situations (Borowski & Muthukrishna, 1992; Pressley, Levin, Ghatala, 1984; Pressley, Ross, Levin, Ghatala, 1984). Ghatala, Levin, Pressley, and Lodico's (1985) study of second-graders provides evidence that monitoring training must be included in strategy-transfer training for maintenance to occur. In their study, the researchers examined three groups of second- graders. One group was given strategy-monitoring training, which included a lesson in the importance of using useful strategies to improve memory performance. A second group was given the choice of using one of two strategies that were taught and encouraged to reflect on the affective qualities of the strategy instead of its effectiveness (e.g. how much fun it was). A third group was used as a control and was not given instructions about the strategies presented. Although all children chose a strategy to use on a final memory test, only the strategy-utility group indicated that the one they chose was the best because it was the most effective in the past. Further, this group maintained the strategy over a long period of time, as opposed to the other two groups. Strategy maintenance resulted in the highest recall levels after a nine-week interval. These findings point to the importance of teachers including thorough metacognitive/monitoring components in training sessions when training for strategy use, transfer, and maintenance. Teachers must specifically point out the way that a strategy is useful in order for children to understand the full benefit of that strategy.

Ghatala, Levin, Pressley, and Goodwin (1986) conducted a similar study to determine the best way to train second-graders to select and use strategies. The children were divided into either "training" conditions or "information" conditions. In the "information" conditions, children were provided with information regarding how well certain strategies worked, in addition to participating in a training session. In the "training" condition, three groups of children were given different combinations of training sessions. One group received the "three-component" training series. This consisted of assessment (children were encouraged to reflect on the usefulness of the strategy they practiced), attribution (children were encouraged to attribute success to the use of the strategy), and selection (children were encouraged to select the best strategies using what they learned from the experience). A second group received a "two- component" training series consisting of assessment and attribution only. A third group received only the assessment-training portion. A final group of children was used as a control and did not receive training. Ghatala et al. emphasized that the "information" group was provided with explicit information regarding strategy effectiveness whereas the children in the training group had to figure out the effectiveness of the strategies on their own.

Results showed that only the "three-component" training group performed better than the control group. However, this was only true when the researchers prompted the children to "think-back" to what they had previously learned during training. The researchers attribute this success to the importance of the "selection" component, in which children had to judge the effectiveness of a strategy. Ghatala et al. emphasized the importance of "think-back" prompts. Ghatala (1986) further emphasized that direct instruction in one or more strategies does not sufficiently teach a child to use that strategy. Instead, the training must include monitoring-training. This monitoring-training is essential for ensuring maintenance.

Teachers should be aware that children do not automatically benefit from specific types of prompts or instructions to use strategies. Training children to use a strategy may only benefit them during an immediate task. Simply teaching a strategy and requiring students to practice it may not have any long-term effect on the children's ability to use the strategy in the future. Instead, children must be taught monitoring skills, coupled with specific strategies. Borkowski & Muthukrishna (1992) advise that teachers use explicit instruction to make strategies, "overt, sensible, and purposeful" (p. 488).

*Children overestimate their memory ability*

Investigations of children's memory and metamemory have shown that a number of developmental differences exist. One such differences includes young children's tendency to overestimate their memory ability (Dunlosky & Metcalfe, 2009; Scheider, 1985; Scheider & Lockl, 2002). In an early metamemory study, Flavell, Friedrichs, and Hoyt (1970), determined that young children (preschoolers and kindergarteners) were likely to overestimate the number of pictures they would be able to remember. However, by the age of seven, children were much more able to accurately predict their memory span. In a similar study, Yussen and Levy (1975) examined prediction accuracy in preschoolers, third-graders, and college students. The researchers found that preschoolers would overestimate the number of pictures they could remember despite having recently been reminded of their tendency to overestimate. Third-graders were more realistic about the number of pictures they could remember and college students were the most accurate.

Kail (1990) attributes the tendency for young children to overestimate their memory ability to a lack of knowledge about task variables. Task variables can include the presence of (and lack of) semantic relations in word pairs to be remembered. Such relations may not be considered significant enough to influence memory predictions in young children (Kreutzer, Leonard, & Ravell 1975; Moynahan, 1973). Young children believe that semantically unrelated words are as easy to remember as lists of semantically related words. However, by ten years of age, children understand that semantic relations can play a more important role in

remembering than the number of words to be remembered. Thus, by the age of ten, children may have considerably better-developed stable knowledge and, therefore, may be less likely to overestimate memory ability. Investigators have suggested that children's overestimation of their memory abilities may actually serve an adaptive function (Dunlosky & Mecalf, 2009; Scheider & Lockl, 2002) by keeping them motivated to persist on difficult tasks.

It is important for teachers to understand that young children are likely to believe that they are able to remember more information than they actually can. Children may be unaware of the influence of task variables such as the amount of information to be remembered and the content of information to be remembered. They may be unaware of their limitations, even when directly faced with them. Teachers must realize that repeated practice and experience might not have the same influence on a child's expectation of his/her own memory as that of a child's age. Teachers should also realize that children's overestimation might serve a useful purpose in terms of motivation and persistence on difficult tasks.

## Conclusion

Although young children can be strategic and do possess some metamemory skills, they also tend to be somewhat less adept at understanding the many influences on memory and at monitoring their own memory. Research findings from the themes we discussed provide evidence that, with help, children can improve their metamemory skills and, thus, become better learners. Some investigators have stressed the need for more explicit instruction of metacognitive knowledge and skills (Pintrich, 2002) and others have found that effective teaching includes the consistent use of strategy instruction (Schnieder, 2008). It is hoped that the themes provided in the present paper will allow a greater understanding of children's knowledge of memory and memory monitoring skills and provide a greater context for teachers to help their students become more strategic learners.

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# Learner autonomy, self regulation and metacognition

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**Abstract**

Different theories try to explain why some students are more successful than the others. Phenomenologists (Mc Combs, 1989) study self concepts of the students and find such students prone to achieve more. Attributional Theorists (Dweck, 1986; Weiner, 2005) focus on personal outcome such as effort or ability. Metacognitive theorists (Pressley, 2000; Schunk, Pintrich & Meece, 2007) examine students' self regulated learning strategies whereas Constructivists (Maxim, 2009; Paris & Byrnes, 1989) believe supportive environments are important to be successful. In this study, the metacognitive theory will be given more importance and the purpose of the article is to find the correlation between self regulation, metacognition and autonomy.

**Keywords:** learner autonomy, self regulation, metacognition.

## Introduction

Different theories try to explain why some students are more successful than the others. Phenomenologists (McCombs, 1989) study self concepts of the students and find such students prone to achieve more. Attributional Theorists (Dweck, 1986; Weiner, 2005) focus on personal outcome such as effort or ability. Metacognitive theorists (Pressley, 2000; Schunk, Pintrich & Meece, 2007) examine students' self regulated learning strategies whereas Constructivists (Maxim, 2009; Paris & Byrnes, 1989) believe supportive

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environments are important to be successful. In this study, the metacognitive theory will be given more importance.

Self regulation refers to the degree individuals are metacognitively, motivationally and behaviorally active participants in their own learning process (Zimmerman, 1986). It is believed that the major cause of failure is the lack of self regulation. Underachievers are more impulsive, have lower academic goals, are less accurate in assessing their abilities, are more self critical and less efficacious about their performance and tend to give up easily than achievers (Borkowski & Thorpe, 1994). These students are more anxious, have a lower self esteem, have a higher need for approval, and are more easily influenced by extrinsic factors. On the other hand, self regulators are immediately identified in the classroom according to such criteria:

- they are self starters
- they are confident, strategic and resourceful
- they are self-reactive to task performance outcomes.

In this field, two different types of studies are held: this is either identifying self –regulated students and learning about their personal attributes or teaching the strategies that are believed to enhance self regulation and testing them.

According to the studies (Maxim, 2009; Zimmerman& Martinez-Pons,1988), students who use self regulated strategies and prove to be autonomous learners are more likely to volunteer for special projects, they are intrinsically self motivated, they rely on a planned learning and use more goal setting, planning, organizing, memorizing and self-monitoring strategies whereas the second type of studies are concerned with teaching the strategy training especially metacognitive components, providing feedback to increase efficacy.

*Motivation and Learner Autonomy*

Learning involves the active process of involving and high levels of effort, concentration and persistence. Meece (1994: 25) states that there are two types of achievement goals:

- learning oriented /task oriented: These learners seek to improve their level of competence. Feelings of pride, success are derived.
- performance oriented /ego oriented: Individuals who pursue ego oriented goals try to demonstrate high ability or gain favourable judgments of abilities. These individuals are likely to view their abilities as stable traits that can be judged in relation to others.

Achievement goals affect students' task persistence and problem solving efforts. Self regulated learning is the control over students' thinking, affect and behaviour. Such students are more likely to choose challenging

tasks. Performance oriented children prefer short term strategies and poor recall of information in the long run (Benware & Deci, 1984).

On the other hand, Borkowski and Thorpe (1994:45) deal with underachievers and the relation between self regulation and motivation proposing that an understanding of underachievement can be found in the failure to integrate self regulation and affect and is attributable to insensitivities, unresponsiveness placed by parents on children. Krouse and Krouse (1981) believe that there are three underlying reasons for underachievement:

- skill deficit
- personality dysfunction (impulsiveness, fear of failure, high need for approval)
- deficiencies in self-control.

They hold that it is the inadequate integration of self regulation with strong motivational beliefs about the power and importance of self efficacy. Those who know how to integrate cognitive, metacognitive, and motivational components are good at self regulation.

**Table 1.** Features of Self Regulation

| **Features of Self Regulated Learners** | **Achievers** | **Underachievers** |
|---|---|---|
| Know a large number of learning strategies | + | --- |
| Know how, when and where to use learning strategies | + | --- |
| Select, monitor strategies wisely | + | --- |
| Adhere to an incremental view regarding the growth of mind | + | --- |
| Believe in effort | + | --- |
| Are intrinsically motivated, task oriented | + | --- |
| Have concrete, multiple images of themselves | + | --- |
| Know a lot about many topics | + | --- |
| Have a history of being supported by parents, schools and society. | + | --- |
| Do not fear failure | + | --- |

This table which is based upon Borkowski and Thorpe's article (1994: 45–74) maintain that individuals who have high efficacy beliefs appear to have motivational patterns and self regulatory capacities.

*Self-efficacy and Self Regulation*

Self efficacy refers to personal beliefs about one's capabilities to learn or perform skills. Schunk (1994: 75) maintains that self regulation depends upon students feeling efficacious about performing well. He makes use of Bandura's social cognitive model of self regulation:

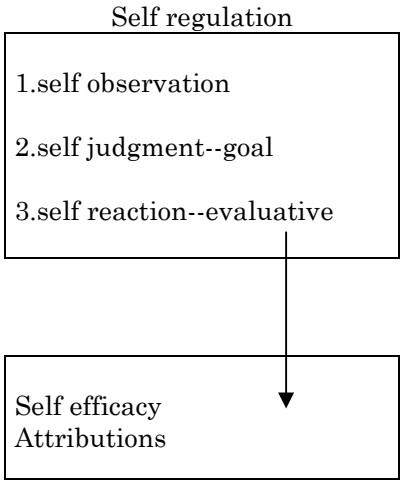


**Figure 1.** The Relation between Self regulation and Self efficacy

In this figure self observation is deliberate attention to aspects of one's behaviour. Learners cannot regulate their actions until they know what they do; self judgment refers to comparing present performance with one's goal. The belief that one is making progress enhances self efficacy. The third component in self regulation, self reaction is about evaluations one has about himself. Those with self regulatory processes have high self efficacy for accomplishing a task, participate more readily, work harder, and persist longer when they encounter difficulties.

*Self Regulated Learning /Autonomous Learning*

Self regulated learners are closely related to good thinkers who show the following four main characteristics (Brown & Pressley, 1994:158):

- good thinkers use cognitive strategies
- good thinkers employ metacognitive strategies. They monitor their progress closely.
- good thinkers have other knowledge (on the other topics)
- good thinkers possess motivational beliefs.

In another study held by Wyatt, Pressly, el Dinary, Stein, Evans and Brown in 1993 (Schunk& Zimmerman, 1994) the self regulated readers have other merits such as they are good at

- anticipating and predicting information

- looking for information relevant to their goals
- jumping forward to look for particular information
- jumping back to look for particular information
- rapidly move back and forth in texts
- backtrack
- attend to tables and figures and some other details
- construct paraphrases/explanations
- summarize effectively.

Such readers successfully make use of cognitive and metacognitive strategies and they are always engaged in self regulated learning as well, knowing what to do, how to do, when to do. These learners plan very well and know how, when and where to use the strategies. If students have not developed such habits and strategies, the best way is to train them regarding the use of the metacognitive strategies and establish an intrinsic motivation in them. For that purpose teachers should explain and model effective cognitive and metacognitive strategies and help students monitor their progress.

A semi-structured interview is given to students studying at the the third year in a Teacher Training department to see what they think of self regulation,whether they use metacognitive strategies that are essential for autonomous learning and what they expect teachers to accomplish in the class.

## Method

*Aim and Research Questions*

The aim of the study is to tackle the relation between self regulation, autonomy and metacognition and to discover whether there is a correlation between these three concepts.

*Participants*

The set of participants were 82 junior level students from the English teacher training program at a university in Turkey. Their ages ranged from 20-22. The subjects were informed verbally that their participation in the study was completely voluntary and would not influence their grades in the courses.

*Instruments*

The interview was designed with the help of the other methodology teachers and researches done by Chan (2001) and its split half reliability is found to be .92.

*Procedure*

All students (18 boys and 64 girls) were asked to respond honestly to the semi-structured interview which was about learner's thoughts on self regulation and how consciously they used metacognitive skills. All

interviews were transcribed verbatim as soon as possible after each interview and written texts were created. Creswell's (2002) strategy for the coding process was implemented in the present study. Codes were given for the segments of information.

## Results

The first question, which was related to what students thought of teachers' roles, was presented in Table 2. Students took the first, third and fourth options indicating that they wished to see their teachers acting as a resource, a model and a helper. Half of students preferred to see teachers who were very knowledgeable and who set a model for them.

**Table 2.** Teacher roles according to students

| **Teachers' roles** | **n** | **%** |
|---|---|---|
| A resource | 58 | 26.3 |
| An advisor | 42 | 19.0 |
| A hepler | 60 | 27.2 |
| A model | 50 | 22.7 |
| An authority | 10 | 4.5 |
| Total | 220 | 100 |

Question 2 sought to establish the subjects' predisposition to the notion what teachers' expected actions were. 32.7 % ticked 'motivating students', which denotes that students need some encouraging from teachers to accomplish their aims. They wished to see teachers correcting their mistakes (25.8 %) and explaining the things to them (25 %). This result might seem to be paradoxical in the way that students both need to be corrected by their teachers but at the same time they wish it to be done in an encouraging manner and they need to be motivated well, which shows they do not trust themselves. In a way, this response is again indicative of what would seem to be a totally negative predisposition to this particular concept of autonomy. Table 2 ostensibly seems to indicate a totally negative predisposition to this component of autonomy

**Table 3.**Teacher's expected actions

| **Actions** | **n** | **%** |
|---|---|---|
| Lecture | 32 | 13.7 |
| Explain | 58 | 25 |
| Help students pass the class | 4 | 1.7 |
| Motivate students | 76 | 32.7 |
| Follow the book | 2 | 0.8 |
| Correct students' mistakes | 60 | 25.8 |
| Total | 232 | 100 |

The third question asked whether students thought teachers should help them learn independently or not and the interesting answer was their desire to be independent learners. Most of them, 79.4% ticked 'yes'. It sounds odd that on one hand, they are in constant need to be motivated, encouraged and stimulated by teachers; on the other hand, they wish to be autonomous learners.

**Table 4.** The teacher should help students learn independently

| **Answers** | **n** | **%** |
|---|---|---|
| Yes | 62 | 79.4 |
| No | 16 | 20.5 |
| Total | 78 | 100 |

The fourth item converged with the third item and students (87.8%) indicated their teachers should help them become responsible learners. They thought it was teacher's job to teach them responsibility and being independent learners. There was a positive disposition towards their wish to be responsible. This implies that they do not think they have the sense of responsibility.

**Table 5.** The teacher should help students to become responsible

| **Answers** | **n** | **%** |
|---|---|---|
| Yes | 72 | 87.8 |
| No | 10 | 12.19 |
| Total | 82 | 100 |

Table 6 questions whether students thought knowledge was transmitted by teachers or not. More than half (52.6 %) refute the old notion that teachers should impart knowledge.

**Table 6.** Knowledge is transmitted by the teacher

| **Answers** | **n** | **%** |
|---|---|---|
| Yes | 36 | 47.36 |
| No | 40 | 52.63 |
| Total | 76 | 100 |

Table 7 corroborates Table 6. Students thought they should discover knowledge, which implied some positivity towards autonomy. 82% of the participants showed unflinching desire to be independent learners.

**Table 7.** Learners should discover knowledge

| **Answers** | **n** | **%** |
|---|---|---|
| Yes | 68 | 82.92 |
| No | 14 | 17.07 |
| Total | 82 | 100 |

Table 8 showed whether students liked it better when the teacher lectured, students shared the responsibility or the teacher let students teach. Most students loved it when they had a share in the class design.

**Table 8.** Students' expectations from their teachers

| **Students like it when** | **n** | **%** |
|---|---|---|
| the teacher lectures | 30 | 17.6 |
| the teacher corrects their mistakes | 50 | 29.4 |
| the teacher lets students teach | 22 | 12.9 |
| the teacher shares the responsibility with the class | 68 | 40 |
| the teacher does nothing | 0 | 0 |
| Total | 170 | 100 |

Table 9 indicated students' preferences in working alone (39.6 %) and cooperating with another friend (39.6 %) had the same rating.

**Table 9.** Students' preference regarding group or individual work

| **Preferences** | **n** | **%** |
|---|---|---|
| working alone | 42 | 39.6 |
| working in pairs | 42 | 39.6 |
| working with the class | 22 | 20.7 |
| Total | 106 | 100 |

Table 10 highlighted the students' beliefs on who should do the assessment; most preferred it to be teachers or accept the peer assessment when it was done with the supervision of the teachers.

**Table 10.** Assessment

| **Preferences** | **n** | **%** |
|---|---|---|
| teachers | 78 | 50 |
| students | 4 | 2.56 |
| both teachers and students | 74 | 47.43 |
| none | 0 | 0 |
| Total | 156 | 100 |

The last item was related to the readiness of students when it came to autonomous learning. They said they could help with the lesson plans and this was the area where they felt most ready but regarding the syllabus and assessment, they remained reluctant.

**Table 11.** Readiness in autonomous learning

| **Readiness** | **n** | **%** |
|---|---|---|
| Designing the syllabus | 6 | 3.2 |
| Choosing the course materials | 48 | 26 |
| Selecting the activities | 32 | 17.3 |
| Designing the lesson plans and implementing them | 76 | 41.3 |
| Assessing | 22 | 11.9 |
| Total | 184 | 100 |

Table 12 tried to see whether students were aware of the metacognitive strategies or not. They were asked to write whether they were aware of their own strengths and weaknesses in reading and list down what they would do consciously if they were given a text to study, to mention whether they make plans and if they do how they plans and whether they monitor their study or not. Students are aware of the strategies but making plans and monitoring seems to be not so popular with them.

**Table 12.** Metacognitive strategies

| **Metacognitive strategies** | **n (82 students)** | **%** |
|---|---|---|
| Highlighting | 34 | 41.4 |
| Underlining | 42 | 51.2 |
| Circling | 45 | 54.8 |
| Imaging | 25 | 30.4 |
| Visualizing | 35 | 42.6 |
| Rereading | 50 | 60.9 |
| Semantic mapping | 41 | 50 |
| Paraphrasing | 35 | 42.6 |
| Outlining | 25 | 30.4 |
| Self questioning | 15 | 18.2 |
| Thinking aloud | 12 | 14.6 |
| Monitoring progress | 14 | 17 |
| Making adaptations or changes if necessary | 20 | 24.3 |
| Defining goals | 18 | 21.9 |

## Discussions

The results show that students do not feel ready for the autonomous learning and they still believe the teaching activity should be designed and they should be evaluated by the teacher but they show enthusiasm to learning to undertake more responsibility and rejecting the idea that

knowledge should be transmitted by the teacher, however, they do not like to cooperate and collaborate with their classmates. It can be said that low autonomy is closely related to the low self regulation habits. Students who expect most from teachers in syllabus design and class activities prefer to be working individually with the guidance of teachers. Self-regulated learners feel autonomous. This does not mean they are self-sufficient and isolated from others. On the contrary, they feel comfortable working with others (Newman, 2002: 134) but the results show the Turkish students are not fully autonomous learners. When it comes to the metacognitive strategies, half of them use the cognitive strategies but the second aspect of the metacognition, planning and monitoring (18% and 17% respectively) are not employed by students who show not self regulatory habits. Students with the low self regulation and the low autonomous inclination employ less metacognitive strategies (Ertmer & Newby, 1996) In order to accelarate this process, teachers should help students in many ways: First, students can benefit from analyses and discussions of strategies for learning. Students might discuss how to use pictures as clues to text meaning, whereas college students might discuss alternative ways to take notes, but they are both metacognitive discussions about regulating learning. Teachers need to be able to describe appropriate strategies - what they are, how they operate, and when they should be applied - and be able to lead discussions so that students can explore their understanding about how they learn. Second, teachers can design open-ended instructional activities and scaffold assistance for student inquiry. Less emphasis should be placed on workbook exercises and routine tasks and more emphases should be placed on working together to guide students to more effective approaches to learning. Third, teachers can minimize objective tests (e.g., multiple-choice tests, true-false tests), competitive test scores, and public comparisons of performance which detract from students' sense of efficacy and mastery. Projects, portfolios, and performance assessments can motivate students, provide opportunities for self regulated learning, and enhance creative expression. Linking self-assessment with external standards may help students regulate their actions to desired outcomes. Fourthly, teachers should make students cognizant of the benefits of self regulated learning. More work is needed, however, on how best to implement and evaluate teacher training strategies for facilitating autonomous learning. The pursuit of this research direction can help put into practice—via effective teachers and teaching practices—what is known about skill, will, and socio-emotional support factors that foster positive student affect and promote motivation for lifelong autonomous learning.

## Limitations of the study

Though the results are based on 82 teacher trainees at a large western state university, they need to be treated with caution. If the other groups are taken as participants within the same university or from the other

universities and these students have high grades, the results might be different and this needs to be searched.

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# The role of self-regulated strategies and goal orientation in predicting achievement of elementary school children

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**Abstract**

The present study examined the predictiveness of self-regulated learning strategies and goal orientation of elementary students' academic achievement. Eighty one ($n$ = 81) fifth graders were asked to respond to two scales. It was hypothesized that student achievement would be predicted by prior achievement, use of self-regulation strategies, and goal orientation. Results showed that prior achievement and use of self-regulation strategies accounted for a significant amount of variance in students' academic achievement. Overall, goal orientation was not a significant predictor of students' outcomes measures across different subject areas. Areas for future research are explored and implications for school personnel are provided.

**Keywords:** Self Regulation, Motivation, Achievement, Elementary Students

## Introduction

From a general perspective, metacognitive and self-regulatory strategies can have a major influence on a students' achievement. In fact, the role of

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self-regulation and goal orientation on elementary student achievement has been identified recently within the research literature in various subject areas (Fuchs, Fuchs, Prentice, Burch, Hamlett, Owen, & Schroeter, 2003; Glaser, & Brunstein, 2007; Howse, Lange, Farron, & Barron, 2003; Patrick, Ryan, & Kaplan, 2007; Pintrich, 2000; Torrance, Fidalgo, & Garcia 2007). Self-regulation refers to the degree to which students are metacognitively, motivationally, and behaviourally active participants in their own learning process (Zimmerman, 1989). Students who are self-regulated learners are partially distinguished from non-self-regulated learners because they set mastery oriented goals rather than performance goals and utilize and differentiate effective versus ineffective self-regulated learning strategies to accomplish these goals. A mastery goal focuses on learning a task, improvement, and increased understanding whereas a performance goal focuses on competence or ability and how it compares to the ability of others (Middleton & Midgley, 1997; Midgley & Urdan, 2001).

Both self-regulation and motivation are highly influenced by prior achievement experiences (Zimmerman & Schunk, 2008). For example, a student who has consistently done well in mathematics will more likely have more adaptive goal oriented cognitions and self-regulatory behaviours in the future than a student who has previously not done well in mathematics. However, relatively few studies have examined how prior achievement influences self-regulation and motivation in elementary-aged children (DiPerna, Volpe, & Elliott, 2005). Therefore, the scope of this study is to examine the extent to which prior achievement, mastery and performance goal orientation, and self-regulated learning strategies can predict academic performance of elementary students in language arts, math, science, and social studies in both the classroom (e.g., grade point average) and on a federally mandated standardized test.

Research on prior achievement (e.g., previous grade point average), with primarily high school and college students, shows that it is positively linked to student self-regulated learning strategy use and achievement in the classroom (DeBerard, Spielmans & Julka, 2004; Garavalia & Gredler, 2002; Kitsantas, 2002). However, there is a study with elementary students Kindergarten through sixth grade that tested a model of how different academic enablers such as prior achievement, motivation, and study skills influenced elementary student reading and language arts achievement (DiPerna et al., 2005). Elementary students were split into two groups for analysis: primary (grades K-2, $n$ = 192) and intermediate (grades 3-6, $n$ = 202) and then rated by their homeroom teachers based on the different academic enablers examined. Findings showed that prior achievement influenced a string of variables including motivation and study skills, which in turn influenced academic achievement.

Additionally, other research suggests that prior academic performance and having a mastery goal orientation is positively related to self-regulated learning strategies for elementary (DiPerna, Volpe, & Elliott, 2005; Meece

& Miller, 2001) high school (Sungur, 2007) and college students (Howell & Watson, 2007; Somuncuoglu & Yildirim, 1999). However, there is little empirical evidence documenting the relationship between how prior academic performance, goal orientation, and self-regulated learning strategies may be related to the current achievement across multiple academic domains in elementary school students. We believe studying these concepts in younger populations is critical to promoting effective learning and teaching self-regulated learning strategies earlier on that may increase the chances for positive beliefs and study habits in the future.

In addition to prior achievement, research shows that goal orientation also influences a student's use of self-regulated learning strategies, their ability to self-regulate their learning, and academic achievement (Alao & Guthrie, 1999; Somuncuoglu & Yildirim, 1999). More specifically, mastery goal-oriented students strive to gain understanding of a concept, whereas performance oriented students aim to outperform their peers and display their competence (Ames, 1992). Mastery oriented students have been found to exhibit higher levels of effort and persistence, are more likely to engage in challenging tasks, and use more effective cognitive and self-regulated learning strategies while performance orientated students are found to engage in less achievement-supporting behaviours and strategies (Middleton & Midgley, 1997; Zimmerman & Schunk, 2008). Further, mastery-oriented students are more likely to have adaptive attributions for academic successes and failures while performance orientated students are more likely to have less adaptive attributions that result in less adaptive behaviours such as learned helplessness (Pintrich & Schunk, 2002) and academic self-handicapping (Leondari & Gonida, 2007). In fact, Alao and Guthrie (1999) found that mastery goals accounted for 37% of the variance in learning strategy use for a sample of elementary students. This pattern is expected since students who truly want to learn are more likely to use self-regulated learning strategies to help them actually master the material, whereas students who want to display competence would use superficial learning strategies to achieve good grades. Overall, students who are mastery oriented are able to engage in more effective self-regulated learning strategies than students who are performance oriented (Linnenbrink, 2005; Somuncuoglu & Yildirim, 1999).

Furthermore, mastery goal orientation has more adaptive outcomes in terms of achievement, self-regulation, and motivation, while performance goal orientation is more associated with negative outcomes (Broussard & Garrison, 2004; Kaplan & Midgley, 1997). For example, Meece and Miller (2003) sought to examine how the goals of elementary school students changed over the course of two years (3rd to 5th grade). Specifically, Meece and Miller (2003) attempted to understand how different goals changed or remained stable over time in the domain of reading and writing and how these changes influenced their use of self-regulated learning strategies. The researchers found that student adoption of mastery and performance

goals had decreased over time and that changes in mastery goals had explained a significant portion of the changes in self-regulated learning strategies. In other words, adoption of mastery goals were positively related to more effective self-regulatory strategies and were negatively related to the less effective surface level strategies. Other researchers have discovered a higher level of mastery goal orientation is related to greater academic achievement in both younger and older students (Broussard & Garrison, 2004). Therefore, it is critical that students approach learning with a mastery goal orientation to be effectively engage in self-regulated learning.

Student's goal orientation also influences the types of self-regulated learning strategies they use which in turn influences outcomes. To illustrate, Pintrich (2000) explored the association of achievement goals (mastery and performance), various motivation variables (e.g., self-efficacy, task value), affect, and various adaptive and maladaptive self-regulated learning strategies (cognitive and metacognitive) in 150 middle school students. Using a series of scales administered at the beginning and end of their eighth grade, and the beginning of their ninth grade it was discovered that students who assumed more mastery goal orientations had the highest likelihood of using adaptive self-regulated learning strategies and reported higher levels of self-efficacy than performance oriented students. Similarly, Kaplan and Midgley (1997) attempted to examine the extent to which perceived competence impacted the relationship between goal orientation and patterns of adaptive and maladaptive behaviour in middle school students. Their results revealed that mastery goals were positively related to adaptive self-regulated learning strategies while performance goals were positively related to maladaptive self-regulated learning strategies.

A number of research studies also show that a significant link exists between self-regulated learning strategies and performance in elementary school aged children, however, research has yet to thoroughly examine this relationship partially because experts have questioned whether younger children are capable of discussing concepts such as learning or reflecting and reporting different self-regulated strategies (Moschner, Anschuetz, Wernke, & Wagener, 2008). Nevertheless, some studies show that the use of strategies can facilitate learning of academic tasks such as composition and writing (Glaser & Brunstein, 2007; Klein, 2000). For example, Klein (2000) sought to understand the different self-regulated learning strategies that children used when writing and which were most effective at helping students not only learn the material, but also to recall, critically analyze, and evaluate ideas. One conclusion drawn from this study was that the self-regulated learning strategies children use when writing to learn are most effective when they are diverse, moderately sophisticated, and domain-specific (Klein, 2000).

Overall, research evidence suggests that students' academic achievement is indeed related to goal orientation and strategy use

(Anderman, Anderman, & Griesinger, 1999; Broussard & Garrison, 2004; Patrick et al., 2007; Stipek & Gralinski, 1996) and self-regulated learning strategies (Fuchs et al, 2003; Glaser & Brunstein, 2007; Patrick et al., 2007; Pintrich, 2000; Torrance, Fidalgo, & Garcia 2007). In particular, mastery oriented students tend to achieve at higher levels academically than performance oriented students (Broussard & Garrison, 2004; Kaplan & Midgley, 1997) in both high school and elementary school settings (Broussard & Garrison, 2004). More research is needed however to: (a) examine the predictiveness of prior achievement, self-regulated learning strategies, and goal orientation across multiple subject domains in young elementary aged children; and to (b) examine these domains collectively instead of independently to gain a better understanding how socio-cognitive processes and achievement can differ across subjects.

The purpose of the current study is to examine how prior achievement and self-regulation processes contribute to fifth and third grade students' GPA and standardized test scores. It is hypothesized that student achievement would be significantly predicted by prior achievement, use of self-regulated strategies, and a mastery goal orientation. It is also expected that prior achievement, followed by use of self-regulatory strategies, and mastery goal orientation would explain a significant amount of variance in students' academic achievement in language arts, math, social studies, and science as well as a mandated standardized test. On the other hand, a performance goal orientation is not expected to significantly predict future achievement in any of the four subject areas or the standardize test.

## Methods

### *Participants*

Eighty-one ($n$ = 81) fifth graders in a public elementary school participated in the study. The ethnic compositions of the participants were: 74% White, 8% African American, 8% Latino, 8% Asian, and 2% percent other. The students' ages ranged from nine to 11 years with a mean age of 10 years. There were 41 males and 40 females. The percentage of students who received free and reduced lunch was approximately 10%. The fifth graders were selected because SOL tests are a major focus in the curriculum (see definition below). All the fifth grade students enrolled in one elementary school were selected to participate.

### *Measures*

*Personal data questionnaire.* This brief questionnaire was developed to obtain information regarding the participants' age, gender, grade in school and teachers' name.

*The Motivated Strategies for Learning Questionnaire (MSLQ).* The MSLQ is an 81-item, self-report measure that utilizes a 7-point Likert scale (1 "not at all true of me", and 7 "very true of me") to evaluate student motivation and application of self-regulated learning strategies by college students.

The MSLQ is comprised of two scales: the Motivation Scale and the Learning Strategy Scale. This study only utilized the second Learning Strategy Scale to examine the different learning strategies that students engaged in. The Learning Strategy Scale is comprised of 50 items. The subscale regarding students' use of cognitive and metacognitive strategies was used in this study. Sample items include: "I ask myself questions to make sure I understand the material, I have been studying in this class", and "During class time I often miss important points because I think of other things". The MSLQ is a reliable, valid, efficient, and convenient measure for various types of research (Duncan & McKeachie, 2005). Strong and significant coefficient alphas range from .62 to .93 for the first motivational scale and from .52 to .80 for the second learning strategy scale (Duncan & McKeachie, 2005). For the purposes of this study, we modified the language slightly on the MSLQ to be more appropriate for fifth graders. For instance, we substituted the word *class* for the word *course*. The reliability of the data for this specific sample indicated strong internal consistency with an $\alpha$ =.81.

*The Patterns for Adaptive Learning Scale (PALS).*The Patterns for Adaptive Learning Scale, developed by Midgley, Kaplan, Middleton, Maehr, Urdan, Anderman, Anderman, and Roeser (1998), assesses motivation by using achievement goal theory as a theoretical framework. The PALS scale includes both teacher and student measures and uses a five point Likert scale (1 "Not at all true," and 5 "Very true") to assess levels of mastery and performance goal orientations (Midgley et al., 1998). This study used the revised student scales that measure mastery and performance approach goal orientation. The mastery goal orientation measure is composed of five items (e.g. "It is important to me that I improve my skills this year") and the performance approach goal orientation measure is also composed of five items (e.g., "One of my goals is to show others that class work is easy for me.").

Various studies indicate that the PALS scale demonstrates high concurrent, construct, and discriminant validity (Midgley et al., 1998). Additionally, this scale is an effective tool for measuring across populations with different genders and ethnicities as well as a wide range of grade levels (Midgley et al., 1998). The significant coefficient alphas from this current sample are as follows: mastery goal orientation ($k$ = 5, $\alpha$ = .79); performance-approach goal orientation ($k$ = 5, $\alpha$ = .87); performance-avoidance goal orientation ($k$ = 4, $\alpha$ = .70); academic self-efficacy ($k$ = 5, $\alpha$ = .75); and academic self-handicapping ($k$ = 6, $\alpha$ = .86).

*Achievement.* Achievement was assessed in three different ways. First, student grade point averages (GPA) in Language Arts, Math, Science, and Social Studies were extracted from their records. Second, student scores on the SOLs at the third grade level were collected to examine achievement. Finally, SOL scores were collected again at the student's fifth grade level to examine any changes or influences on longitudinal achievement.

The Standards of Learning (SOLs) for Virginia Public Schools were formed by the Virginia Department of Education (VDOE) to meet the mandate of the No Child Left Behind Act (NCLB). These standards describe the commonwealth's expectations for student learning and achievement in grades K-12 and represent a broad consensus of what parents, classroom teachers, school administrators, academics, business, and community leaders believe students should have mastered by their respective grade levels. A curriculum framework is provided to schools that details the specific knowledge and skills students must possess in order to meet the standards for these subjects. Then the SOLs are administered to all students across the state at grades three, five, and eight, and eleven to assess if schools have met the standards in the four core areas of language arts, mathematics, science, and history/social science (VDOE, n.d.). The school in the current study was above average in academic selectivity for all categories: the previous year's mandated standardized test scores SOL scores for fifth graders were: Language Arts 87.9%, Math 79.3%, Social Studies 91%, Science 91.2%, and Writing 100%.

*Procedures*

Four fifth grade classes from a public elementary school were asked to participate in the study. Eighty five (85%) of the students returned parental consents and therefore were permitted to take the surveys that assessed their goal orientation and learning strategies. All surveys were administered during class in two different sessions. One of the researchers collected the SOL scores from the participants' records across all the core subject areas at grade three and then later at grades five for analysis.

## Results

Preliminary analyses using independent t-tests in regards to gender differences revealed that no significant differences in any of the variables included in this present study. The means and the standard deviations for all variables are presented in Table 1. Correlations are also presented in Table 2. Significant relationships emerged between the self-regulation and motivation variables and achievement measures. Specifically, self-regulated learning strategies and a mastery goal orientation were found to be moderately related to all the GPA measures ($r$ = .29 - .43, $p$ < .05), but not to prior or future SOL performance. In terms of fifth grade performance on the SOLs, self-regulated learning strategies and a mastery goal orientation were related to mathematics performance ($r$ = .22 and .23 respectively, $p$ < .05) and only self-regulated learning strategies were related to language arts ($r$ = .22, $p$ < .05) and science ($r$ = .26, p < .05) performance. Third grade SOL scores were not related to the use of self-regulated learning strategies or mastery goal orientation. The only significant relationship that emerged was between performance goal orientation and third grade science SOL achievement ($r$ = .37, $p$ < .05).

**Table 1.** Descriptive statistics of all variables examined in this study

| Variable | Mean | Standard Deviation |
|---|---|---|
| Age | 10.5 | .52 |
| Self-Regulated Strategies | 3.75 | .74 |
| Mastery Goal Orientation | 4.23 | .93 |
| Performance Goal Orientation | 2.82 | 1.12 |
| GPA | | |
| Language Arts | 3.77 | .42 |
| Math | 3.49 | .62 |
| Science | 3.48 | .65 |
| Social Studies | 3.70 | .48 |
| 5th Grade SOL | | |
| Math | 482.67 | 58.79 |
| Science | 487.53 | 49.96 |
| Social Studies | 458.74 | 42.42 |
| 3rd Grade SOL | | |
| Language Arts | 458.70 | 47.75 |
| Math | 520.73 | 48.68 |
| Science | 481.32 | 55.13 |
| Social Studies | 467.70 | 51.18 |

**Table 2.** Correlations among MSLQ subscales, PALs subscales, GPA and SOLs

| Variables | Self-Regulated Learning Strategies | Mastery goal Orientation | Performance Goal Orientation |
|---|---|---|---|
| GPA | | | |
| Language arts | .33** | .43*** | .06 |
| Math | .33** | .36*** | -.09 |
| Science | .31* | .40*** | .04 |
| Social Studies | .29* | .40*** | -.04 |
| 5th Grade SOL | | | |
| Language Arts | .22* | .20 | .15 |
| Math | .22* | .23* | .15 |
| Science | .26* | .10 | .21 |
| Social Studies | .11 | .10 | .16 |
| 3rd Grade SOL | | | |
| Language Arts | .21 | .21 | -.04 |
| Math | .20 | .06 | -.01 |
| Science | .11 | .14 | .37* |
| Social Studies | .01 | .04 | .19 |

* $p < .05$; ** $p < .01$; *** $p < .001$

In order to determine the effectiveness of the various measures in predicting academic performance, linear hierarchical regressions were employed to estimate how much of the students' GPA and SOL variance was accounted for by each of the clusters of variables separately and together. Four regression models were formulated predicting GPA and performance on state mandated tests for each of the four subject areas: language arts, math, science, and social studies. In the first model, students' third grade scores on a language arts state achievement test were entered first, followed by their goal orientations, then use of self-regulatory learning strategies to predict their fifth grade achievement in language arts, see Table 3.

The results revealed that students' prior academic performance accounted for 21% variance of student's GPA in language arts, $R^2 = .21$, $F(1, 35) = 9.23$, $p < .01$. When the mastery and performance-approach orientations were added to the model, a significant change was detected in the accounted variance $R^2 = .27$, $F(3, 33) = 4.06$, $p < .05$. The self-regulated learning strategies variable also significantly contributed to the accounted variance in students' GPA, $R^2 = .45$, $F(4, 32) = 6.40$, $p < .01$. Altogether, these variables explained 45% of the variance in students' GPA in language arts. Similar results were shown for students' achievement in math. Specifically, students' prior academic performance accounted for 27% ($R^2 = .27$, $F(1, 35) = 12.67$, $p < .001$) variance of student's GPA in math whereas goal orientations added an additional four percent ($R^2 = .31$, $F(3, 33) = 4.96$, $p < .01$) and self-regulated learning strategies added an additional 14% ($R^2 = .45$, $F(4, 32) = 6.63$, $p < .01$). In regards to social studies and science the results showed that the only significant predictor of students' performance in these areas was the use of self-regulated learning strategies which explained 43% and 36% of the variance in student's GPA, ($R^2 = .43$, $F(4, 32) = 6.06$, $p < .01$, $R^2 = .36$, $F(4, 32) = 4.53$, $p < .01$), respectively.

In terms of predicting student performance on the Standards of Learning (SOL) state mandated tests, regression models were assessed. Specifically, prior achievement was entered as the first step while goal orientation and self-regulated learning strategies were entered as the second and third step, respectively. This was done to take into account the theoretical notion that motivation and self-regulation are related in a cyclical manner, in that prior achievement experiences influence the type of goal orientation that students adopt which is turn is related to the type of self-regulated strategies that students engage in while learning.

The results revealed that students' prior academic performance as measured by third grade SOLs accounted for 27% variance of student's SOL scores in language arts, $R^2 = .27$, $F(1, 35) = 12.59$, $p < .001$. When the mastery and performance-approach variables were added to the model, a significant change was detected in the accounted variance $R^2 = .41$, $F(3, 33) = 7.73$, $p < .001$. The use of self-regulated learning strategies also

significantly contributed to the accounted variance by 5% ($R^2$ = .46, $F$ = .68, $p$ < .01).

**Table 3.** Hierarchical regression analyses predicting GPA in across subject areas

| Variable | *SC* | *t* | *p* | $R^2$ |
|---|---|---|---|---|
| Language Arts GPA | | | | |
| A. 3rd Grade Language Arts SOL | .46 | 3.04 | .004 | .21** |
| B. Goal Orientation | | | | .27* |
| Mastery Goal Orientation | .24 | .155 | .13 | |
| Performance Goal Orientation | .09 | .60 | .55 | |
| C. Self-Regulated Strategies | .46 | 3.18 | .003 | .45** |
| Math GPA | | | | |
| A. 3rd Grade Math SOL | .51 | 3.56 | .001 | .27*** |
| B. Goal Orientation | | | | .31 |
| Mastery Goal Orientation | .19 | 1.31 | .20 | |
| Performance Goal Orientation | -.09 | -.64 | .53 | |
| C. Self-Regulated Strategies | .42 | 2.89 | .007 | .45** |
| Social Studies GPA | | | | |
| A. 3rd Grade Social Studies SOL | .19 | 1.15 | .26 | .04 |
| B. Goal Orientation | | | | .20 |
| Mastery Goal Orientation | .39 | 2.52 | .02 | |
| Performance Goal Orientation | -.10 | -.63 | .54 | |
| C. Self-Regulated Strategies | .52 | 3.59 | .001 | .43*** |
| Science GPA | | | | |
| A. 3rd Grade Science SOL | .24 | 1.46 | .15 | .06 |
| B. Goal Orientation | | | | .21 |
| Mastery Goal Orientation | .38 | 2.43 | .02 | |
| Performance Goal Orientation | .10 | .61 | .55 | |
| C. Self-Regulated Strategies | .43 | 2.80 | .009 | .36** |

* p < .05; ** p < .01; *** p < .001

Together, 46% of the variance in students' academic achievement was accounted for by the prior experience, goal orientations, and use of learning strategies variables. Similar results were shown for students' achievement on standardized testing in math and science. Specifically, students' prior academic performance accounted for 35% ($R^2$ = .35, $F$(1, 35) = 18.48, $p$ < .001) variance of student's GPA in math whereas performance-approach and mastery goal orientations added an additional two percent ($R^2$ = .37, $F$(3, 33) = 6.39 $p$ < .01) and use of self-regulated learning strategies added an additional five percent ($R^2$ = .42, $F$(4, 32) = 6.39 $p$ < .01). For social studies the results showed that the only significant predictor of students' performance in these areas was students' prior performance, ($R^2$ = .29, $F$(1, 28) = 11.23, $p$ < .01). Finally, with regards to science 36% ($R^2$ = .36, $F$(1, 35)

= 20.05, $p$ <.001) of the variance of student's GPA was explained by prior performance on SOLs. A significance change was detected in the accounted variance when the performance-approach and mastery goal orientations variable was added to the model, $R^2$ = .40, $F(3, 33) = 7.46$ $p < .01$. Self-regulatory strategy use significantly added an additional nine percent, ($R^2$ = .49, $F(4, 32) = 7.54$ $p < .001$), see Table 4.

**Table 4.** Hierarchical regression analyses predicting standards of learning scores across subject areas

| Variable | *SC*□ | *t* | *p* | $R^2$ |
|---|---|---|---|---|
| Language Arts SOL | | | | |
| A. 3rd Grade Language Arts SOL | .51 | 3.55 | .001 | .27*** |
| B. Goal Orientation | | | | .41*** |
| Mastery Goal Orientation | .23 | 1.61 | .12 | |
| Performance Goal Orientation | .32 | 2.42 | .02 | |
| C. Self-Regulated Strategies | .23 | 1.57 | .13 | .46 |
| Math SOL | | | | |
| A. 3rd Grade Math SOL | .59 | 4.30 | .001 | .35*** |
| B. Goal Orientation | | | | .37** |
| Mastery Goal Orientation | .10 | .70 | .49 | |
| Performance Goal Orientation | .11 | .82 | .42 | |
| C. Self-Regulated Strategies | .26 | 1.74 | .09 | .42 |
| Social Studies SOL | | | | |
| A. 3rd Grade Social Studies SOL | .54 | 3.35 | .002 | .29** |
| B. Goal Orientation | | | | .30 |
| Mastery Goal Orientation | .13 | .79 | .44 | |
| Performance Goal Orientation | -.04 | -.22 | .83 | |
| C. Self-Regulated Strategies | -.07 | -.38 | .71 | .31 |
| Science SOL | | | | |
| A. 3rd Grade Science SOL | .60 | 4.48 | .001 | .36*** |
| B. Goal Orientation | | | | .40** |
| Mastery Goal Orientation | .17 | 1.23 | .23 | |
| Performance Goal Orientation | .13 | .90 | .37 | |
| C. Self-Regulated Strategies | .31 | 2.25 | .03 | .49* |

* p < .05; ** p < .01; *** p < .001

## Discussion

In the present study it was expected that prior achievement, followed by use of self-regulatory strategies, and mastery goal orientation would explain a significant amount of variance in students' GPA and Standards of Learning in language arts, math, social studies, and science. To examine these hypotheses, hierarchical regressions were performed to identify how

prior performance (e.g., 3rd grade SOL performance), goal orientation (e.g., mastery and performance goal orientation), and self-regulation (e.g., learning strategies) could predict both student GPA and fifth grade SOL performance in the four main subject areas (e.g. language arts, mathematics, social studies, and science).

Overall, the results in this study revealed that prior achievement on the standardized tests along with self-regulatory strategies accounted for most of the variance in student GPA and current SOL scores in math, science, and language arts (with the exception of social studies). However, contrary to our hypotheses, mastery goal orientation did not significantly predict student achievement. In terms of GPA, goal orientation did not predict GPA in either language arts or mathematics, but it significantly predicted GPA in social studies and science. However, prior performance predicted GPA in language arts and mathematics, but not for social studies or science. The only variable that consistently predicted GPA across all subject areas was self-regulated strategies. This finding is consistent with previous research which has also found a similar relationship (Fuchs et al., 2003; Glaser & Brunstein, 2007; Torrence et al., 2007). This finding suggests that developing effective self-regulated strategies is important for students to be successful across all academic domains. However, the relationship is different when SOL test scores are examined. Specifically, strategies significantly predicted science and mathematics test scores, but not language arts and social studies. This may be due to the developmental nature of mathematics and language arts, where prior performance may significantly impact present and future performance. For example, reading requires a set of skills (e.g., pronunciation, word knowledge) that are developed from the previous level. However, knowledge of the American Indians learned in the third grade does not necessarily need to be used to learn about the Civil War in fifth grade.

Surprisingly, mastery goal orientation was not a significant predictor of SOL scores in any of the four subjects. In fact, contrary to hypotheses, performance goal orientation significantly predicted SOL performance in language arts. This may be a result of standardized testing, where the focus is more on the outcomes and performance rather than mastering the content. In terms of GPA, however, mastery goal orientation was significantly correlated to student GPA across all subject areas, but not with SOL scores with the exception of fifth grade math SOL scores. Additionally, the use of self-regulated strategies only significantly predicted student performance in the areas of mathematics and science. These results suggest that goal orientation and self-regulated strategies are better predictors for student GPA than SOL scores.

Prior achievement plays different roles across different subject areas when predicting student GPA. However, when predicting SOL test scores, prior performance becomes a more consistent predictor of achievement across different subject areas. This is an expected pattern because of the

identical instruments used to measure and predict achievement (e.g., past SOL test scores used to predict current SOL test scores). However, it is interesting that prior performance only contributes a significant amount of variance to language arts and mathematics, but not to social studies or science. This indicates that prior performance may be an important aspect for teachers to consider for particular subject areas. However, this may also be as a result of the No Child Left Behind Act, where there are serious consequences for schools if students do not reach a proficient level in the specific areas of language and mathematics. We suspect therefore, that the math and language arts curriculum may be more strictly aligned with the state mandated benchmarks, whereas the social studies and science curriculum are given more flexibility in terms of classroom teaching methods and the curriculum.

Research evidence in the current study did not support the hypothesis that mastery goal orientation would significantly predict student GPA and SOL performance. Specifically, in terms of GPA, mastery goal orientation did significantly predict both achievement in social studies and science, but not for language arts or mathematics. In fact, contrary to hypotheses, performance goal orientation significantly predicted SOL performance in language arts. Surprisingly, mastery goal orientation was not found to contribute a significant amount of variance to achievement in any of the SOL subject areas. This pattern is not very surprising considering the nature of the state mandated SOL test, which has been argued that it unintentionally promotes competition among schools and states to outperform each other (Hunter & Bartee, 2003). Furthermore, other researchers, Stipek and Gralinski (1996) have discovered that mastery goal orientation was not as influential in achievement outcomes such as GPA and standardized test scores as children's beliefs about intelligence and performance. We found similar results with Stipek and Gralinski's study. Mastery goal orientation did not predict achievement whereas prior achievement along with self-regulation predicted achievement over and above mastery goal orientation. The research linking mastery goal orientation with achievement is inconsistent (i.e. in some cases being associated with adaptive behaviours and in other cases correlating with maladaptive behaviours) (Kaplan & Midgley, 1997; Linnenbrink, 2005).

Overall, the findings of the present study compliment previous findings revealing the positive impact of self-regulation and goal orientation on elementary students' achievement (Fuchs et al., 2003; Glaser & Brunstein, 2007; Howse et al., 2003; Patrick et al., 2007; Pintrich, 2000; Torrance, Fidalgo, & Garcia 2007). In particular, research shows mastery goal orientations are related to more adaptive patterns of learning than are performance goal orientations (Anderman & Anderman, 1999; Ames, 1992; Kaplan & Midgley, 1997; Midgley & Urdan, 2001). Prior research with high school and college students indicates that when teachers focus on improvement, effort, and learning for intrinsic reasons,

students focus on mastery oriented goals. On the other hand, when teachers focus on grades, ability differences, and outperforming others, students are likely to focus on performance oriented goals. One of the unique characteristics of this study is that prior achievement, goal orientation, and self-regulated learning strategies were examined across the four main domains of school.

The limitations in the current study include the fact that all of the data were self reported. Additionally, the sample size was small and not ethnically or socio-economically diverse in that there was not much variation in the participant pool, with 74% of the students being White and less than 10% of the total participant pool receiving free and/or reduced lunch. Also, the school was above average in academic selectivity and the assumption is that these students overall are typically more academically inclined, despite the learning expectations. Therefore, based on the limited research with elementary students and self-regulation and goal orientation, future research could include more studies that examine the relationship between motivational and self-regulatory factors and elementary-aged student achievement. Furthermore, future inquiry could be conducted to explore and develop other more reliable measures of motivation and self-regulation.

**Implications for School Personnel**

There are important implications for teachers, school psychologists and administrators despite the mixed results in the current study. First, we suggest teachers make a concerted effort to lessen the competition of individuals in the classroom and provide more opportunities for students to approach their learning based on their individual skills. Achieving academic success through high GPA and standardized test scores is now as important in elementary school as it is in secondary and post secondary school. Recognizing the contribution that self regulation strategies and prior achievement have on both GPA and standardized test scores, it is beneficial for elementary school teachers to examine both of these variables either through journal publications or professional development workshops and then to include best practices in their pedagogy. For example, teachers can encourage elementary students to be meta-cognizant of their learning strategies and actively involved in identifying and improving their academic behaviour (Zimmerman, 1989) in the classroom.

Additionally, school psychologists can contribute to this mission by including concepts (e.g., self regulation) in psycho-educational interventions they provide for students in small or large group settings. For example, school psychologist often run small group counselling interventions consisting of six to eight students at a time. These group intervention topics vary, but provide adequate opportunity for students to discuss goal settings and successful learning behaviours that contribute to academic achievement. The students can be taught the differences between

mastery and performance goal orientations and encouraged to strive for goal mastery. Focusing these efforts on phenomenon that has been linked to increase overall academic achievement in school may prove to be beneficial.

In a similar vein, school administrators can build on these findings and help faculty and staff (e.g., teachers, school psychologists, teacher assistants) improve their direct instructional methods in the classroom as well as indirect interactions that occur in school by creating and supporting policies that establish a school wide (e.g., systemic) environment that is less focused on competition and more focused on mastery of learning material. In other words, school administrators can promote a learning environment that encourages students to be all that they can be with high expectations for each individual student based on where they are currently functioning.

In summary, the findings of the present study are useful in identifying areas to consider for future research. Furthermore, this line of inquiry may lead to more robust evidence that can be used to influence learning environments for elementary students. Although mastery goal orientation was not found to be predictive of standardized test scores, it was found to be significantly related to GPA. Therefore, teaching elementary students to adapt a mastery goal orientation and engage in self-regulation practice may be important because maladaptive learning strategies can be targeted as early as possible in order to establish a positive foundation for future academic development.

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# Mathematics and metacognition in adolescents and adults with learning disabilities

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**Abstract**

A majority of studies on learning disabilities have focused on elementary grades. Although problems with learning disabilities are life-affecting only a few studies focus on deficits in adults. In this study adults with isolated mathematical disabilities ($n$=101) and adults with combined mathematical and reading disabilities ($n$=130) solved tests on procedural calculation and number knowledge, numerical facility and visuospatial skills. Metacognitive skilfulness was assessed through calibration measures, a questionnaire, stimulated recall, and thematic analyses after a qualitative interactive interview with a flexible agenda to discover the interviewee's own framework of meanings and to avoid imposing the researcher's structures and assumptions. In our dataset the isolated group (MD) did worse than the comorbid group (M+RD) on mental representation, dealing with contextual information and number knowledge. However the comorbid group did worse on the number sense tasks. No significant differences were found between the MD and M+RD adults for fact retrieval, procedural calculation and visuo spatial tasks. In addition adults with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results in the calibration task. Moreover, adults with M+RD thought that they were worse on the evaluation of the own results, the evaluation of the own capacities and on monitoring when things went wrong compared with adults in the M+RD group. Thematic analyses revealed that many adults had problems with planning and keeping track of steps and that supporting surroundings were important protective factors towards the chances of success. Consequences for the assessment of metacognition in adults and for the support of adults with mathematical disabilities are discussed.

**Keywords:** metacognition, mathematical learning disabilities, assessment, comorbidity

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## Introduction

*Mathematics and mathematical learning disabilities*

It is hard not to overemphasize the importance of mathematical literacy in our society (Swanson, Jerman, & Zheng, 2008). In everyday life situations we need to be in time, pay bills, follow directions or use maps, look at bus or train timetables or comprehend instruction leaflets and expiry dates. A lack of mathematical literacy was found to affect people's ability to gain full-time employment and often restricted employment options to manual and often low paying jobs (Desoete, 2007a; Dowker, 2005).

Most practitioners and researchers currently report a prevalence of mathematical disabilities between 3-14% (Barbaresi, Katuskic, Colligan, Weaver, & Jacobsen, 2005; Desoete, 2007a; Dowker, 2005; Shalev, Manor, & Gross-Tsur, 2005).

*Comorbidity*

Reading disabilities and mathematical disabilities co-occur more frequently than would be expected by chance, sampling bias, population stratification, definitional overlap and rater biases (Desoete, 2008). The comorbidity rate of combined mathematical and reading disabilities (M+RD) varies from 17% to 43% (Fuchs & Fuchs, 2002; Light & DeFries, 1995). In a recent meta-analysis Swanson et al. (2009) found no support for the notion that the differentiation between M+RD and isolated RD was related to variations in reading across the reviewed studies.

Also in adults comorbidity remains an important topic (Clark, Watson, & Reynolds, 1995; Pennington, 2006). Nevertheless only a limited number of studies focus on comorbidity in adolescents and adults. Martinez and colleagues revealed that adolescents with M+RD had more problems at schools and were more often depressive than adolescents without learning disabilities. However, on the one hand, in contrast with the 'severity hypotheses, they found no difference between M+RD and adolescents with an isolated learning disability (Martinez & Semrud-Clikeman, 2004). On the other hand they revealed, in line with the 'severity hypotheses', that the M+RD group had a more negative perception than peers with an isolated learning disability about the social support they encountered (Martinez, 2006). In sum, there are inconsistent results in adolescents and adults on whether comorbidity can be explained through the 'severity hypotheses' or not.

In literature several models evolved out of an attempt to understand comorbidity within an individual (Neale & Kendler, 1995; Pennington, 2006; Rhee, Hewitt, Corley, Willcutt, & Pennington, 2005). Some of them are: the cognitive subtype hypothesis, the severity hypothesis and the three independent disorders model. The 'cognitive subtype hypothesis' expects the group with comorbid disabilities to have more severe deficits (both quantitative and qualitative) than the group with isolated disabilities (e.g.,

Kibby, Marks, Morgan, & Long, 2004). The severity hypothesis predicts that the problems of the comorbid group are more severe than the problems of the isolated groups (e.g., Pennington, 2006). The three independent disorders model (e.g., van der Sluis et al., 2004) predicts that problems of the comorbid group are an additive combination of the problems of the isolated groups.

To conclude, the debate on comorbidity remains unsolved. In the case of the 'cognitive subtype hypothesis' the difficulties of the group with mathematical and reading disabilities would be more severe (both quantitative and qualitative) compared with the group of adults with isolated disabilities. According to the severity hypothesis a quantitative but no qualitative difference is predicted between both groups. Another possible explanation is the three independent disorders model whereby the mathematical problems of the group with mathematical and reading disabilities are considered to be the same as those of the group with isolated mathematical disabilities. The reading problems of the comorbid group are considered to be the same as those of the group with isolated reading disabilities.

*Metacognition*

It is nowadays widely accepted that metacognitive knowledge and skills influence mathematical problem solving (e.g., Borkowski, Chan, & Muthukrishna, 2000). Metacognition refers to the ability of individuals to be aware of and monitor their learning processes. Metacognition has traditionally been differentiated into two central components, namely metacognitive knowledge and metacognitive skills. In young children a combination of prediction and evaluation skills was successful to differentiate children with mathematical learning disabilities from below-average performing peers and average performers from expert problem solvers (Desoete, Roeyers, & Buysse, 2001).

There are different methods to assess metacognition (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Self-report questionnaires, hypothetical interviews and stimulated recall, think-aloud protocols and systematical observations are fruitfully being used (e.g., Desoete, Roeyers, & Huylebroeck, 2006; Efklides, 2001; Elshout-Mohr et al., 2003; Pressley, 2000; Pugalee, 2001; Veenman, 2005). In addition in the performance calibration and post-diction paradigm participants are asked after the solution of a mathematics task, to assess the correctness of the solution (e.g., Lin & Zabrucky, 1998). A comparison is made of whether evaluation after a task corresponds with the actual performance on the task.

To conclude, research on individual differences in metacognition has mainly used quantitative and interviewer structured research techniques. However, on the basis of such data, it is often very difficult to discover the interviewee's own framework of meanings and to avoid imposing the researcher's structures and assumptions (e.g., Coffey, Atkinson, 1996;

Frank, 2004; Seale, Gogo, Gubrium, & Silverman, 2004; Tesch, 1991). It has been suggested that researchers have to remain open to the possibility that the concepts and variables that emerge may be very different from those that might have been predicted at the outset (e.g., Creswell, 2003; Flick, 1998; Holliday, 2002; Ritchie & Lewis, 2003). Therefore a thematic analysis including a less intrusive qualitative interactive interview with a flexible agenda combined with a semi structured interview on core questions not covered the first part might be advised. The present study aims to add such data to enhance the existing body of research and to look for emergent themes and meanings of metacognition in adults with mathematical learning disabilities.

*Aims of the study*

In this study we aim to investigate whether adults with mathematical and reading disabilities (M+RD) show a similar profile of mathematics deficits compared with adults with isolated mathematical disabilities (MD) and if eventual differences can be explained through the severity or cognitive subtype hypothesis (M+RD>MD). The second aim of this study is to investigate whether MD adults differ in metacognitive skills and performance calibrations from M+RD adults and if qualitative research can add to our understanding of metacognition.

## Method

*Participants*

Only at least average adults with a previous diagnosis of learning disability, learning problems across at least two successive grades and remediation not leading to improvements were accepted in the cohort of adults with learning disabilities.

Our sample included 101 adults with isolated mathematical disabilities (MD) and 130 adults with combined mathematical and reading disabilities (M+RD).

*Measures*

*Mathematics measures.* Mathematical performances of all participants were tested. Since in mathematical disabilities often procedural deficits, number knowledge deficits, semantic memory deficits and visuospatial deficits are described (Cornoldi, Venneri, Marconato, Molin, & Montinaro, 2003; Geary, 2004; Stock, Desoete, & Roeyers, 2006), we included the CDR with the P- and K-tasks for procedural and number knowledge deficits, a test on retrieval of arithmetic number facts from semantic memory (see TTR), and the DyscalculiUM with the comprehension of graphical information for visuospatial deficits.

The Cognitive Developmental skills in aRithmetics (CDR, Desoete & Roeyers, 2006) is a test on number-naming or reading (NR), dealing with operation symbols (S), knowledge (K) of the base-ten structural

relationships, procedural (P) skills to solve mathematical tasks in a number problem format (e.g., 47-9 = ___), linguistic skills (L) enabling children to understand and to solve one-sentence mathematical problems in a word-problem format, (e.g., 9 less than 47 is ___), mental representation (M) skills, contextual skills (C) enabling the mathematical problem solving in a more than one-sentence word-problem, skills to select relevant information (R) and number sense skills (N). The psychometric value has been demonstrated on a sample of 871 Dutch-speaking adults in Flanders. Cronbach's α's were .80 for NR-tasks, .70 for S-tasks, .82 for K-tasks, .81 for P-tasks, .66 for L-tasks, .88 for M-tasks, .83 for C-tasks, .81 for R-tasks, .88 for N-tasks. Gutmann's split-half and Spearman-Brown's coefficients were .70 and .72 respectively.

The Arithmetic Number Fact Test (Tempo Test Rekenen, TTR) (de Vos, 1992) is a test on 200 arithmetic number-fact problems (e.g. 5x9=…). Children have to solve as many number-fact problems as possible out of 200 in 5 minutes. The test has been normed for Flanders on 872 adults. Cronbach's alpha was .90, the Guttman Split-Half Coefficient was .93, the Spearman-Brown coefficient was .95.

The DyscalculIUM (version 2.4.0) (Trott & Beacham, 2006) measures six facets of adult arithmetical problem solving: number knowledge (e.g., what number is represented here?), comparison of numbers (words, operations symbols and positions on the number line), comprehension of graphical information (bar charts and tables), abstraction skills, the knowledge to deal with spatial and temporal information and conceptual or operational skills in adults. The test has been normed for Flanders on 872 adults. Cronbach's alpha was .76, the Guttman Split-Half Coefficient was .83, the Spearman-Brown coefficient was .84. Cronbach's α's for the subtests varied from .94 to .98.

*Metacognitive measures.* In the Cognitive Developmental skills in aRithmetics (CDR, Desoete & Roeyers, 2006) the number of correct answers is the performance score (e.g., 30/45 on the test). In addition, persons have to gauge confidence in the correctness of the given answers (e.g., 'I think I will obtain 40/45 on this test'). The difference between the performance and evaluation score is the calibration score (e.g., here –10). The psychometric value has been demonstrated on a sample of 871 Dutch-speaking adults in Flanders.

The adult questionnaire (see Appendix A), which was created for this study, is a rating scale (10-item) questionnaire on metacognitive skills (e.g. I never (1) / always (4) knows in advance whether an exercise will be easy or difficult). The questionnaire was adapted from studies (Desoete & Roeyers, 2006). Test–retest correlations of .83 ($p < .01$) and interrater reliabilities varying between .99 and 1.00 ($p < .01$) were found. In this study Cronbach's α of .92 was found for the test score (10 items).

An in depth interview took place lasting l to 2 hours. First adults were asked to tell their whole story, from when they first noted problems at school. In a second part a semi-structured interview with stimulated recall took place on core metacognitive topics of the adult questionnaire. Thematic analyses on metacognition were conducted on the transcripts of both interviews.

*Procedure*

All subjects were first interviewed and then assessed individually, where they completed the TTR (de Vos, 1992), CDR (Desoete & Roeyers, 2006) and the DyscalculIUM (Trott & Beacham, 2006).

With informed consent, the interviews took mainly place in respondent's homes and lasted one to three hours and were audio taped and fully transcribed. If people preferred, they were interviewed and tested somewhere else. In the first part of the interview people are asked to tell the story of what happened to them, from when they first began to suspect there were problems. When the story was finished the researcher asked additional semi-structured questions, identified from previous literature review. Transcribed transcripts were returned to each adult for revision if necessary. From the transcripts categories or themes were developed. Sections of text were marked and linked to sections of text from other interviews that covered similar issues or experiences by using NVivo8. Themes were considered in the context of all the interviews. The different psychologists regularly discussed the coding and interpretation of the data.

The examiners, psychologists skilled in learning disabilities, received practical and theoretical training in the assessment and interpretation of mathematics and calibration. They also received a training in conducting non-directive in depth narrative interviews and in gathering data from semi structured interviews with open ended questions as well as in analyzing and writing up narratives. In order to guarantee reliability of the assessment, each examiner had to interview and test one adult and score the protocol in advance. This interview, transcription and protocol were analyzed by the author of this study. All examiners were provided with feedback. The test-protocols were not included in the analyses of this study. In addition, systematic, ongoing supervision and training was provided during the assessment of the first 10 adults.

## Results

*Procedural skills and number knowledge*

In order to look for differences between adults with MD and M+RD a Multivariate Analysis of Variance (MANOVA) was conducted with procedural skills, number knowledge but also number-naming or reading, dealing with operation symbols, linguistic skills, mental representation skills, contextual skills, skills to select relevant information and number

sense skills as dependent variables and belonging to the group of MD and M+RD as a factor. With an effect size of .21, we found a power of 1.00.

The MANOVA revealed a significant main effect for the performance group on the multivariate level ($F$ (10, 217) = 5.03, $p \leq .0005$).

In the total model, performance group was predicted for 22% (1-Wilk's Lambda) by the performance groups. Univariate significant between-subject effects were found for M, C and N and calibration tasks (see Table 1). Means and Standard Deviations of the performance groups are presented in Table 1.

**Table 1.** Mean typical scores on CDR

| | MD<br>*M*<br>(*SD*) | M+RD<br>*M*<br>(*SD*) | *F* (1,227)<br>(*SD*) |
|---|---|---|---|
| NR-tasks | 3.27<br>(1.18) | 3.19<br>(1.17) | 0.25 |
| S-tasks | 3.30<br>(1.46) | 3.50<br>(1.46) | 1.13 |
| P-tasks | 2.12<br>(1.47) | 2.02<br>(1.46) | 0.28 |
| L-tasks | 2.01<br>(1.58) | 2.21<br>(1.48) | 0.99 |
| K-tasks | 3.60<br>(1.36) | 3.78<br>(1.24) | 1.04 |
| M-tasks | 1.64<br>(1.90) | 2.12<br>(1.34) | 4.88* |
| R-tasks | 2.53<br>(1.21) | 2.57<br>(1.31) | 0.06 |
| C-tasks | 1.68<br>(1.12) | 2.17<br>(1.23) | 9.31* |
| N-tasks | 3.54<br>(1.30) | 3.17<br>(1.39) | 4.26* |
| Calibration tasks | 1.56<br>(6.76) | -1.17<br>(8.54) | 6.88* |

* $p \leq .05$

As can be concluded from Table 1 adults with M+RD were better than MD performers on the mental representation and dealing with contextual information, whereas MD performers were better than M+RD adults on number sense tasks and both groups also differed on calibration.

*Retrieval of number facts*

In order to look for differences on fact retrieval between adults with MD and M+RD a Multivariate Analysis of Variance (MANOVA) was conducted with the number correct additions, subtractions, multiplications, divisions and mixed exercises as dependent variables and belonging to the group of MD, M+RD as a factor. With an effect size of .03, we found a power of .49.

The MANOVA revealed a no significant main effect for the performance group on the multivariate level ($F$ (5, 222) = 1.42, $p$ = .22). In the total model, performance group was predicted for 3% (1-Wilk's Lambda) by the performance group. Means and Standard Deviations of the performance groups are presented in Table 2.

**Table 2.** Mean typical scores on TTR

| | MD<br>*M*<br>(*SD*) | M+RD<br>*M*<br>(*SD*) | *F* (1,226) |
|---|---|---|---|
| Additions | 29.35<br>(5.68) | 27.97<br>(5.89) | 3.18* |
| Subtractions | 25.34<br>(6.10) | 24.27<br>(6.39) | 1.64 |
| Multiplications | 23.06<br>(7.52) | 23.72<br>(8.03) | 0.39 |
| Divisions | 20.87<br>(9.83) | 19.69<br>(8.78) | 0.91 |
| Mixed exercises | 23.52<br>(6.99) | 23.21<br>(6.99) | 0.11 |

* $p \leq .07$

A trend of difference was found between the fast retrieval of additions between MD and M+RD individuals. M+RD individuals solved less exercises correctly than MD adults.

*Visuospatial skills*

In order to look for differences on visuospatial skills between adults with MD and M+RD, a Multivariate Analysis of Variance (MANOVA) was conducted with the subtests of the DyscalculiUM as dependent variables and belonging to the group of MD or M+RD as a factor. With an effect size of .09, we found a power of 0.96. The MANOVA revealed a significant main effect for the performance group on the multivariate level ($F$ (6, 224) =3.78; $p$ =.001). In the total model, performance group was predicted for 9% (1-Wilk's Lambda) by the performance groups. Means and Standard Deviations of the performance groups are presented in Table 3. Univariate significant between-subject effects were found for number knowledge but not for the visuospatial tasks (see Table 3).

As can be concluded from Table 3, adults with M+RD had better scores on number knowledge than adults with MD. No significant differences were found between both groups on visuospatial tasks.

**Table 3.** Mean typical scores on DyscalculiUM

| | MD *M* (*SD*) | M+RD *M* (*SD*) | *F* (1,229) |
|---|---|---|---|
| Number knowledge | 9.26 (1.89) | 9.72 (1.76) | 3.60* |
| Comparison of numbers | 16.60 (3.21) | 17.20 (4.29) | 1.36 |
| Graphical comprehension | 12.02 (2.91) | 12.21 (3.04) | 0.23 |
| Abstraction | 5.83 (1.95) | 6.19 (1.62) | 2.35 |
| Orientation | 12.66 (2.14) | 12.12 (2.90) | 2.53 |
| Procedural skills | 11.74 (2.69) | 11.95 (2.62) | 0.33 |

* p <.05

*In depth and semi structured thematic analyses*

Thematic analyses revealed that almost all adults with MD or M+RD were better at mathematical reasoning and written calculation than in mental calculation. They had low accuracy in mental calculation. If they could write down steps or perform written calculations, the problems disappeared. However, some subjects were highly erratic at mental calculation and written calculation tasks. The mechanical process of subtraction and division, especially the long division multi-step process, remained confusing for most adults. Calculators helped to master these difficulties. In addition, a lot of adults still had problems with the tables of multiplication and division. About 60% of the MD adults and 75% of the M+RD adults thought multiplication tables whereas 66% of the MD adults and 81% of the M+RD adults considered division tables to be hard. Some of them thought that multiplication went better than division.

> TR4 "*I still don't know my tables by hard. This was a big problem in elementary school. In secondary education this was less of a problem since we could use a calculator then. … I also did not remember definitions in mathematics. If I could say it with my own words it went better, but if you wanted literal definitions I could not do them*"

About 83% of the MD adults and only about 9% of the M+RD adults spontaneously talked about problems with percentages, decimal numbers, fractions, proportions and measuring counts during the interview. Of this group 25% of the MD group and about 18% of the M+RD group still had problems working with percentages in adulthood. Moreover about 23% of the MD group and 18% of the M+RD group had problems interpreting decimal numbers. During the interview 74% of the MD group and 94% of the M+RD group discussed problems with fractions, 84% of the MD group and 94% of the M+RD group still had problems with proportion and 77% of the MD group and 71% of the M+RD group talked about problems with

measurements whereas 86% of the MD group and 82% of the M+RD group failed in situations with content and surface related tasks.

> TR8 "*10 or 50%, I know, but the rest is a problem"*
> TR 61 *"50% is an easy one when no one is around. But 30% is more difficult. I always have trouble to calculate how much discount I get"*
> TR 85.. *" I have a problem with the placement of the comma to decimal numbers"*
> TR 91…*"I manage in daily life for example km is no problem, but the formula's are difficult … From a cookbook converting the amounts of 4 to2 people is very difficult. My friend has typed all the recipes with the right quantities for me."*
> TR 102…*"I manage, but it takes a long time. I also still have a problem with fractions, proportions and measuring count of mathematics. Also content and calculate surface is difficult for me."*

Other stumbling blocks in almost all adults were naming mathematical concepts, terms or operations. Especially abstract concepts of time and direction in mathematical contexts lead to incorrect interpretation, as did use of numerical symbols and/of arithmetic signs. Many of the adults also lacked accurate estimation skills. Moreover, some adults described problems with visual-spatial tasks. They rotated numbers en failed in spatial placement of numbers on a number line and in geometric tasks where they have to rely on algebraic notations or graphical plots. About 21% of the MD adults and 56% of the M+RD adults mentioned during the interview that they often twisted numbers and 47% of he MD group and 48% of the M+RD group described it takes them a considerable amount of time to know the right from the left. About 36% of the MD group and 71% of the M+RD group described problems explaining tables and 39% of the MD group and 41% of the M+RD group described chart interpretation errors during the interview. Moreover, 19% of the adults talked about problems clock reading during the interviews. Adults often they used digital clocks because they still had problems to understand the analogical clocks. They also failed to represent of draw a plan of the surrounding streets, and to locate lands, oceans on a map.

> TR 5 "*I always pay with big money because I can not pay appropriate in the store. I never check my change*"
> TR 14 "*I often twist numbers, especially on large numbers"*
> TR 21 "*I twist numbers, when I am tired"*
> TR 44 "*I twist numbers in digital clocks and telephone numbers"*
> TR 64: "*I remember the left and right with a trick. If I am concentrated I do not confuse them*"
> TR 73 "*I always look in the living room for the time on the video recorder, since this is a digital clock. In the kitchen there is a large analogical clock, but I never use that one.*
> TR 85 "*I was often punished because I was too late at school when I went with friends to the town centre at noon and remained too long there*
> TR 89 "*If someone says to me you have 5 minutes I think I can still take a shower, read a news paper and so on, but this is mostly not the case. So I am mostly too late or very much too early on an appointment*"

*Metacognition*

*Calibration.* As can be concluded from Table 1 adults with MD differed from M+RD performers on calibration ($F$ (1, 226) = 6.88, $p$<.01). Individuals with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results in the calibration task.

*Metacognitive skilfulness.* In order to look for differences on the metacognitive questionnaire between adults with MD and M+RD, a Multivariate Analysis of Variance (MANOVA) was conducted with the 10 metacognitive questions as dependent variables and belonging to the group of MD or M+RD as a factor. With an effect size of .21, we found a power of 1.00. The MANOVA revealed a significant main effect for the performance group on the multivariate level ($F$ (10, 184) = 4.97; $p$ <.0005). In the total model, performance group was predicted for 22% (1-Wilk's Lambda) by the performance groups. Means and Standard Deviations of the performance groups are presented in Table 4.

**Table 4.** Mean typical scores on Metacognitive Questionnaire

| | MD<br>*M*<br>(*SD*) | M+RD<br>*M*<br>(*SD*) | *F* (1, 187) |
|---|---|---|---|
| Task difficulty estimating | 2.06<br>(0.92) | 1.82<br>(0.84) | 3.70* |
| Correctness of the solution estimating | 3.08<br>(0.95) | 2.76<br>(1.09) | 4.78* |
| Planning and working according to plan | 2.49<br>(0.98) | 2.42<br>(1.12) | 0.21 |
| Working precise on difficult exercises | 2.50<br>(0.76) | 2.68<br>(1.09) | 1.58 |
| Knowing when one will be correct or not | 2.15<br>(0.73) | 2.00<br>(0.89) | 1.53 |
| Panicking instead of adapting the plan | 2.10<br>(0.76) | 2.66<br>(1.21) | 13.45* |
| Telling in advance how one will work | 2.55<br>(0.94) | 2.53<br>(1.14) | 0.02 |
| Finding mistakes and correcting them | 3.00<br>(0.81) | 3.11<br>(1.03) | 0.67 |
| Knowing when to start to finish in time | 2.50<br>(0.95) | 2.49<br>(1.22) | 0.01 |
| Knowing how to study and learn | 2.36<br>(1.06) | 2.50<br>(1.09) | 0.81 |

* p <.05

Adults with M+RD were better on task difficulty (prediction) and correctness of solution (evaluation) estimation. The M+RD group did significantly panic less than adults in the MD group. Instead they adapting the plan when things went wrong (monitoring).

*Thematic analyses on the in depth interview and stimulated recall data.* About 42% of the adults (46% of the MD group and 38% of the M+RD group)

described during the in depth interview problems with planning and monitoring. None of them spontaneously referred to a lack of prediction skills and only ten adults talked about insufficiencies in evaluation skills. Thematic analyses revealed that many MD and M+RD adults had problems with planning and keeping track of steps. Some adults described how they studied for the wrong exam, did not work further on an assignment if they could not solve the previous question, forgot things and could not plan efficiently. Their working place was not very well organized, they often could not select main ideas from less important topics or they had problems to act according to appointments.

Most adults attributed the problems with planning and monitoring to a lack of concentration or sustained divided task related attention. The impact of poor metacognitive skills on school results and employment prospects was according to the respondents even bigger then the influence of poor mathematical or reading skills. They often also had more problems accepting these metacognitive limitations, than to deal with the mathematics or reading related limitations. They also told that the environment did not understand the metacognitive problems and attributed them to of bad faith or a lack of commitment placing them substantial disadvantage compared to non-disabled peers without those problems.

> TR 3: *I often am mad at my self, because I think it is a lack of character or perseverance not to be able to concentrate during exams or homework*
> TR 5 *My teacher had no patience with me forgetting my book or being to late with an assignment. He said that all other students were in time and that there was always something with me ….*

In the stimulated recall interview 29% of the MD respondents and 60% of the M+RD group also described to have prediction difficulties and 41% of the MD respondents and 43% of the M+RD group also described to have evaluation difficulties, whereas they did not describe such problems during the in depth interview. When the interviewer asked them why they did not talk about this in the in depth interview, they told that 'they did not know that we were researching those kind of things' or 'they did not know we these aspects were important to talk about'. These differences illustrate that adults make subjective estimations about the aim of the interview and the questionnaire and act according to them. This makes it unclear whether tests and questionnaires really reflect the ongoing thoughts and metacognitive skills.

All most all adults told that their performance was very much dependent on the task condition and on the person demanding this task. Often they described how they had no problem during a whole year and all troubles started again with a new teacher, school or job. For almost all adults with MD and M+RD supporting surroundings were important protective factors towards the chances of success. They also told that tests not always detected there problems, because it was often not a question of not being able, but rather a matter of not succeeding in time-limited

conditions, requiring unreasonable effort, being less certain or needing more time for tasks.

> TR3 "*Some math teachers allowed us to use an individualized mathematics glossary of concepts and formulae. They let me use this glossary during exams. This made the difference. Not all teachers allowed this, what made it difficult".*
> TR23 *"My wife checks all my papers for mistakes and manages my agenda… I listen very carefully to what my colleagues tell me about conferences they went to"*
> TR32 *"I always am too early or too late for an appointment. Sometimes I am 2 hours to early."*

## Discussion

This study revealed that a lot of adults with mathematical disabilities still have problems to solve mathematical tasks in dual-task or limited-time conditions. In addition, adults with isolated mathematical disabilities (MD) were better than adults with mathematical and reading disabilities (M+RD) on the number sense tasks and on fast retrieval of additions. Adults with combined disabilities (M+RD) solved more mental representation tasks correctly, had better number knowledge and had less problems to deal with contextual information compared with adults with MD.

Thematic analyses revealed that almost all adults with MD or M+RD were better at mathematical reasoning and written calculation than in mental calculation. Moreover, a lot of adults still had problems with the tables of multiplication and division. Most MD adults and a few M+RD adults described problems with percentages, decimal numbers, fractions, proportions and measurements during the interview. Other stumbling blocks in almost all adults were naming mathematical concepts, terms or operations. Many of the adults also lacked accurate estimation skills. Finally, some MD and M+RD adults described problems with visual-spatial tasks and clock reading.

Overall, the results clearly confirm the importance of metacognition even in adulthood. On calibration measure and the questionnaire our dataset revealed that individuals with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results. Moreover, adults with M+RD were better on task difficulty (prediction) and correctness of solution (evaluation) estimation. The M+RD group did significantly panic less than adults in the MD group. Instead they adapting the plan when things went wrong (monitoring).

In addition, results show the value of in depth interviews and semi structured stimulated recall interviews as non intrusive and actual measures of the metacognition. Thematic analyses on the in depth interviews revealed problems with planning and monitoring in adulthood on

most MD and M+RD participants. However, only very few of the adults with MD or M+RD spontaneously referred to a lack of prediction or evaluation skills during these in depth interviews, although they described problems on those aspects in the stimulated recall interview. These results reveal, in line with previous research (Desoete, 2007b), that the choice of diagnostic instruments highly determines the study outcome. Even in in depth interviews with a researcher remaining open to the possibility of unpredicted outcome, participants still have a picture of the research questions and tend to give socially desirable answers bringing or not bringing information according to this picture. It is not because a person does not describe certain problems spontaneously in the in depth interview that this person does not experience these problems. However also the opposite phenomenon was present. Some respondents answered to have problems on the metacognitive questionnaire. They however described a low impact of these problems in the stimulated response condition. Based only on the answer on the questionnaires one could have an imprecise or even incorrect picture of the degree or impact of problems. A stimulated recall after finishing the questionnaire showed a better picture of the interviewee's own framework of meanings and avoided incorrect assumptions.

Thematic analyses also revealed that metacognitive problems are often attributed to a lack of persistence or effort by the environment and to a lack of sustained attention or automated self regulation by the persons them selves. This means that including metacognition as an aspect of 'psychoeducation' is important. The goal of this psychoeducation is for the adult, his family and environment to understand and to be better able to deal with the obvious problems on mathematical problem solving but also with the more discrete comorbid metacognitive problems and erase false beliefs about it. The theory is, the better knowledge the persons haves of their problems but also about their own strengths, resources and coping skills, the better they can live with their condition.

Adults with mathematical disabilities often had more problems accepting the metacognitive limitations, than to deal with the mathematics or reading related limitations. They also told that the environment underestimated their metacognitive problems and attributed them to of bad faith or a lack of commitment. The thematic analyses made it clear that metacognition can not be studied overlooking the beliefs and emotions of individuals. One cannot engage in planning without believing in the ability to plan and worrying about the own skills. One can only understand metacognition if not only skills are assessed but also metacognitive knowledge, beliefs, attribution style, motivation and self-esteem are taken into account. We suggest that the use of multiple-method designs, including the evaluation of metacognition, cognition, motivation and emotion to discover the adults own framework of meanings and to avoid imposing the researcher's structures and assumptions

All most all adults told that their performance was very much dependent on the task condition and on the person demanding this task. These results are in line with Veenmans 'production deficiency' where subjects have a certain level of metacognitive knowledge and skills at their disposition but fail to use their metacognition due to task difficulty, test anxiety, lack of motivation or their inability to see the appropriateness of metacognition in a particular situation (Veenman, Van Hout-Wolters & Afflerbach, 2006). For almost all adults with MD and M+RD supporting surroundings were important protective factors towards the chances of success. They considered themselves as having planning and monitoring skills at their disposition, but not being able to keep investing the effort and conscious regulation to use these 'good' habits. In addition the results were in line with Sternberg's experiential subtheory (Sternberg, 1985) on intelligence and his definition of automated processes. According to hem, a process that has been automated has been performed multiple times and can now be done with little or no extra thought. Once a process is automated, it can be run in parallel with the same or other processes (Sternberg, 1997). Adults with MD and M+RD describe situations were metacognitive skills never became automated self instructions and always remained activities consciously decided upon and requiring supervising attention no longer available for other things on that moment.

Reflecting on the results of the present study there is evidence that how you test is what you get. In depth and semi structured interviews seem to give additional valuable information on the metacognitive skills and beliefs of adults with mathematical learning disabilities. We suggest that researchers who are interested in metacognition in adults use multiple-method designs, including quantitative and qualitative techniques.

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**Appendix**

**Metacognitive questionnaire**

*What typifies you during the last 3 months compared with peers? How often does this behaviour occur?* **1 = always**

**4 = never**

Note the corresponding number in □

- Reflecting in advance on how difficult this exercise will be □

P 1

- Controlling the work and estimating the correctness of the solution □

E 1

- Planning and working according the plan □

Pl1

- Working slower and more precise on difficult exercises □

Mo

1

- Knowing in advance where one will be correct or not □

P2

- Panicking if something goes wrong without adapting the plan □

Mo

2

- Able in advance to tell how one will work on a task □

Pl2

- Finding mistakes in a last control and being able to estimate the results of the task □

E2

- Knowing when to start to finish in time □

P3

- Knowing how to study and approach a learning task □

M3

*How would you situate you compared with peers?* **1 = very low - 4 = very good**

Note the corresponding number in □

- Mathematics □
- Reading □
- Social skills □
- Other remarks :

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# Self-regulated learning using multimedia programs in dentistry postgraduate students: A multimethod approach

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**Abstract**

The purpose of this study was to study the effect of a multimedia computing program on the production of activities and self-regulated learning processes in 18 students of the Dentistry postdegree (Celaya, Mexico). A multi-method design (quasi-experimental, pretest-post-test and qualitative: Think aloud protocol) was used. Self-regulated activities were identified with the MSLQ questionnaire. Results of the MSLQ pretest/post-test questionnaire didn't show an intervention effect. In contrast, the qualitative methodology allowed the registration of a high frequency of self-regulated dimensions on the metacognitive area, on the making of inferences (cognitive area), and on the planning time and effort (behavioural area). Our data revealed the usefulness of a qualitative methodology for the understanding of the complex nature of the self-regulatory processes on learning environments based on computers.

**Keywords:** self-regulated learning, multimedia, multi-method design, metacognition, post-degree students.

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## Introduction

The last decades, increased attention has been given to the Information and Communication Technologies (Its) and the influence on all aspects of our economic, social, political and cultural contexts. The implementation of the Its at the University required a careful follow up by all those who wish to go deeper on the characteristics of this new social and technological environment according to Saenz (2004).

As stated by Bartolomé (2004) or Kirkup and Kirkwood (2005), on Higher Education we are late assumers or simply reticent ones. Enormous technological potential must be ordered, systematized and applied on the new reality that we are living. Starting with the psycho-educational paradigms of learning based on the transmition of information and the generation of knowledge as the socio-cognitive theory and the information processing theory, a multimedia computing program was studied on students of the Dentistry Postdegree Program. The study was conducted under a multi-method perspective with a quantitative and qualitative boarding, procedure suggested by different authors (Desoete 2008, Van Hout Wolters 2000; Veenman, 2007).

*New information and communication technologies in Education*

On this century, facing the new circumstances and paradigms arose on the education field and ranging from the use of the ITs, its application and usefulness constitute a central theme for research since its reach and dimensions aren't well determined.

The virtual learning environment (VLV) was defined as the physical space where the new technologies such as satellite systems, the internet, and the multimedia and interactive television take place. The virtual learning environments are important because the human mediator is not available physically, although a human component is highly necessary in the learning process. Regian and Shebilske (1992) considered the virtual reality to be a superior environment to increase spatial abilities because the interface preserved the spatial characteristics of the simulated world and the motor actions of the student. The characteristics of virtual reality as an ideal learning environment had the following qualities:

- Great flexibility for the creation o virtual o artificial situations.
- The ability to offer a feeling of sense.
- The possibility of giving the user the control of the media and to be able to interact with objects and people.
- The possibility to obtain feedback from objects and people (Middleton, 1992).

Aguaded and Cabero (2004), stated that to the success of VLV depended on factors such as the instruction process and didactic strategies and attitudes that student's and teacher's have.. Otherwise, the same author (Cabero,2003) referred that the ITs located in the educational field is not

feasible to supply the didactic media known nor be the solution to all the problems that the relationship raised by the relationship teaching-learning phenomenon.

Nevgi et al. (2006) addressed the issue of motivational strategies for learning in students of the virtual university. The IQ form is a project of the University of Finland that involved the disciplines of information technology, computer sciences and education. The theoretical support of the project extended from the mediated learning theories, the distribution of cognition and theories of multiple intelligences by Gardner and the work of Pintrich.

*Social cognitive theory of learning and self-regulation*

The social cognitive learning theory is based the work of Miller and Dollard in 1941 who proposed a theory of social learning and imitation that rejected behaviourist theory prevailing in the psychological discourse at that time. Later the work of Bandura (2001), stated a series of considerations on three main components of the theory, equally, that interacted with each other and formed a triad of reciprocity:

- Staff with cognitive, affective and biological factors playing an important role.
- the behaviour and
- the so called environmental.

The theory mentioned contrasted sharply with the approaches of the theories of human functioning that overemphasized the environmental factors on behaviour and learning. At the core of social cognitive theory was the concept of self-efficiency defined as the personal judgments made by the subject about his capabilities to organize and execute actions required for different kinds of operations. This concept has been relevant in education studies involving constructs such as academic performance, success and failure attributes, determining goals, memory, and problem solving and teaching.

Another concept that underlies Bandura's theory (2001) is the one that refers to the capabilities available to man and that define him as such; being these symbolizing, planning alternative strategies, learning through watching someone else's experiences, self-regulated mechanisms, and the most distinctive capacity of human beings: self-reflection, with which the individual gives meaning to his experiences, explores his own knowledge and beliefs, engages in self-evaluation and as a result of the above changes his thinking and behaviour (Pajares, 2002).

*Self-regulated learning model*

Some self-learning models emphasized the integration of motivational and cognitive components of the learning process (Pintrich et al., 1993). Self-regulated learning requires awareness of reflection processes so that students are capable of evaluating their own actions and accomplishments. According to these authors, there are three broad categories of self-regulated learning:

- Cognitive strategies of learning. Weinstein and Mayer (1986) first mentioned the strategies of preparation, elaboration and organizational as important to the development of learning in the classroom.
- Preparation strategy referring to a technique where the items you wish to learn are mentioned aloud. Another one concerns the fact of emphasizing the lines of text on a passive and lacking in thought way. These strategies select important information for the student, enabling the working memory, but not necessarily cause a deep knowledge.
- Elaboration strategy includes the paraphrase of the text where the studied material is summarized creating analogies and making a connection and reorganization of ideas, explaining them in such a way that questions and answers about the topic are arose.
- Organizational strategies refer to the taking of notes or maps of the important ideas where the prose and structure of the text are identified, where as a result a deeper understanding than on the preparation techniques described above.

*Metacognition*

Flavell (1979) initially referred to metacognition as the knowledge that an individual has about his own cognition and to monitor and control that he has of the same knowledge (e.g., the student knows that is capable of reading fast, or that he has little capability of writing, etc). However Veenman et al. (2006) differentiated various aspects of metacognition, such metacognitive beliefs, metacognitive knowledge, feeling of knowing, learning judgment, metacognitive skills, higher order skills etc., revealing a lack of consistency and suggesting the need for further theoretical work to achieve a unified definition of metacognition. Metacognitive monitoring focuses on the progress of the cognitive process in which the person is engaged. One of this monitoring judgment is judgment of learning (JOL), which evaluate one's memory. However, there is a consensus on two general aspects of metacognition: knowledge about cognition and the self-regulation of cognition (Veenman, Kok, & Blot, 2005). Anderson and Krathwohl (2001) mentioned four categories of knowledge: factual, procedural, conceptual and metacognitive.

Moreover Suárez (2004) detailed the proximal development zones Vygotsky with respect to its implementation among subjects who were in

the process of learning and the benefited of using educational technology in network. He noted that, when learning the subject developed internal evolutionary processes that operated only in interaction and cooperation with other subjects. The zone of proximal development was defined as a category of analysis of the cooperative interaction among peers, which forced us to think that there was a theoretical basis of a significant interaction between peers (students), that was, based on social interaction by using the technologies as means of effective learning.

Since the use of instruments might influence the results, Van Hout (2000), Veenman (2006) and Desoete (2008) suggested using mixed methods to study metacognition.

*Metacognitive and self-regulatory strategies of learning*

Most models of metacognitive control or self-regulation strategies refer to the planning, monitoring and control of the students over their own cognitive and behavioural activities (Tobias, 2009; Serra & Metcalfe, 2009; Zimmerman, 2008). Of course not all academic learning follows these phases, since in many cases; students learn the academic material tacitly, implicitly or unintentionally, as suggested by the model (Pintrich et al, 1993)

Although it seems highly correlated empirically, can be discussed independently. The phases have been suggested in a heuristic to guide our thinking and may be considered as:

Phase 1. Planning of activities and formulation of goals. It has been investigated among students and it refers to the formulation of goals of study, skimming the text before reading, generating questions and doing an analysis of the problem. With these strategies, the understanding of the material is easier and the task is more efficient.

Phase 2. Monitoring processes of thought in terms of academic performance is a key activity in the regulatory activity. This activity takes place when students check their understanding on the previously self formulated purposes. An exercise that is often done is carefully monitor the reading of a text, making a series of questions through the reading and verifying if the material is really understood.

Phase 3. Resource management strategies, monitoring and control. Focuses on the strategies used by students to control, monitor and manage their studying environment. This item will include factors such as time and effort required to study; the environment that is achieved with other people including classmates and teachers through strategies of seeking assistance (Zimmerman, 2008). Such strategies help students to adapt and to change their way of studying making it correspond to their objectives and needs.

Phase 4. Reactions and reflections. This phase represents several kinds of reactions and reflections of him in relation to the activity or context.

There are publications where the various elements that make up our investigation such as the use of hypermedia and multimedia materials, intentionally designed for educational purposes. The use of structured questionnaires for the recording before and after educational interventions, using quasi-experimental study designs or multi-method, like those of Igo (Igo et al., 2008).

Boekaerts et al. (2000) used the term metacognitive knowledge presented to the student about the task, person and strategies. According to the work of Pintrich (1999) which refers to a scheme that relates motivation to self-regulated learning, this is defined as the strategies used by students to control and regulate their cognition (e.g., by using several strategies cognitive and metacognitive). A self-regulated student is aware of when he knows a fact or has a skill or when he doesn't. He views his achievements on a systematic manner and through the controlled process, so that he accepts as a big responsibility his goals. He, himself is the initiator of his learning process.

The self-learning has taken part in various learning theories in the behavioural theory regulation is through the external reinforcement. On cognitive theory self-regulation is handled as equivalent of metacognition and on social cognitive theory, self-regulation is a combination of self-observation, and self-reaction.

Teaching students to become more active learners, self-motivated is an issue that is continually mentioned in education. Authentic and meaningful classroom activities that are relevant and in real life generate knowledge processes on the student and conceptual changes. Although the motivational components are important it is equally important to include cognitive components on the learning models of universities (Pintrich, 2000).

Azevedo (2005) examined the relationship between epistemological beliefs, metacognition and student achievement in an hypermedia learning environment. Epistemological beliefs refer to beliefs about the nature of knowledge and of wisdom. Metacognition refers to the ability to reflect, understand and control the learning itself. This author recognizes that the dimensions of metacognition and epistemological beliefs have been little studied in relation to learning in a hypermedia context, and leaves the door open for further study where the kind of processes of deep knowledge are developed when there is a learning multimedia environment. Bendixen and Hartley (2003), examined the relationship between epistemological beliefs, metacognition and student achievement in a hypermedia learning environment. Stoney and Oliver (1999), described how the use of multimedia, taking into account the study of self-regulated learning, can achieve deep levels of thinking in the adult population. Refer also to the use of multimedia micro-world to explore and promote the use of self-regulated earning and in particular examines the degree to which elevated levels of

thought are achieved concluding suggestive ways in which these students could achieve these levels.

From another perspective, the work of Viniegra and Aguilar (1999), indicate that self-introspection is necessary, being aware of what happens in the process of developing the knowledge that, in the sense that we have been discussing has to do with student's self-conscious learning which they call, independent learning.

*Macromedia Flash ® version 2004 education*

Area (2002b) gives an example often given by teachers that apply multimedia materials such as Macromedia Flash ®. This program has a format of vector and interactive multimedia animations. There is a report based on constructivist theory that refers to two learning theories developed on the twentieth century: behaviourism and cognitivism. His methodological approach seeks to demonstrate that students in rebuilding a web site using author tools such as Macromedia Flash ® are able to develop a learner-centred learning, meaningful and cooperative-type (Neo & Neo, 2001). The Macromedia Flash ® was chosen because the environment multimedia has features that help students to make a more effective management of information and to make mental models that facilitate learning (Mayer, 2003). Multimedia programs and multimedia learning environments have the potential to increase the amount and kind of information that are accessible to students, allowing an active participation and facilitating the use of higher mental processes. The learning environment based on the use of computers with multimedia programs can be compared within complex systems, which are composed of interconnected or interwoven parts whose links contain additional information and the hidden observer. As a result of interactions between elements, new properties emerge that can not be explained from the properties of the isolated elements. Thus, the process of making products in the learning environments based on technology is supported by the use of higher mental abilities (Mayer, 2001).

*Present Study*

We intended to study the use of information and communication technology (ITs) in particular the use of Macromedia ® Flash, in the development of strategies and self-regulated learning behaviours and their implications for the conceptual understanding of the thematic units of Epidemiology in the field of Dentistry Postgraduate students.

We stated the following research questions:

a) Can postgraduate students of dentistry based on the use of a multimedia program and creating educational material, from the perspective of psycho educational paradigms of the transmission of knowledge (social cognitive theory and information processing theory), develop strategies and behaviours in self-regulated learning on the phases

described as: 1. anticipation/ planning/activation 2. monitoring, 3. using strategies, 4. difficulty of the activity and demand?

b) Can Dentistry postgraduate students improve their academic performance on the subject of Epidemiology using a multimedia program?

## Method

*Design*

A multi-method design was used combining a quantitative methodology (quasi-experimental pre-test / post-test, single group) with a qualitative approach (Protocol analysis using the coding system of self-regulation behaviours of Azevedo and Guthrie (2004, See Table 1). Graduate Dentistry students made use of the use of the educational software: Macromedia Flash®, on the Epidemiology class, taken as independent variable was the educational intervention with ITs, defined as the educational modality that uses electronic media to promote self-regulated learning on students: use of Macromedia Flash ®. As dependent variable self-regulated learning was taken, defined as the aware recognition of the student of the processes (cognitive) and cognitive strategies, metacognitive of resource management and motivational processes.

*Participants*

The participants were 18 graduate students (12 females and 6 males) of the Dentistry Specialty on Orthodontics and Maxilar Orthopedy at the Universidad Latina de Mexico (Celaya, Guanajuato) in the 4th semester (August-December 2008 period). The mean age was 29.9 years (varying from 26-40 year). Participating students had not previously taken the Epidemiology course during their academic education.

*Instruments*

In line with Jöreskog, Sörbom & Valentine (2006), Ruohotie and Nokelainen (2000), and Nevgi (2003) the MSLQ (Pintrich et al., 1993) was used to assess motivational scales (expectations, task value and affection). The original questionnaire consisted of 81 items was reduced to 44 items based on the fact of Confirmatory factor analysis revealed the semantic meanings of items and helped to validate factorial structure of motivational strategies in learning. Kuder Richardson's 21 consistency test was performed (number of items =44) to yield acceptable values of .81.

The MSLQ tested two types of factors:

1. motivational factors that included components such as interest and value of the learning task (items 1, 4, 5, 10 and 17), components of usefulness of the studies (items 7, 14, 15, 21), components of self-efficiency (items 2, 8, 11 and 13), components of expectations of success (items 6, 9, 16, 18, 19, 22) and anxiety and nervousness due to the exam components (items 3, 12 and 20).

2. Cognitive-Factor was composed of the components: effort regulation (item 43), self-regulation learning components (items 32, 40, 42), components of persistence in the studies (items 27 and 33), metacognitive components of rehearse strategy (items 23, 31 and 35), metacognitive components of critical thinking (items 30 and 37), metacognitive components that focus to learning the essentials (items 24 and 34), metacognitive components of constructive learning (items 28 , 36, 44), metacognitive components of the use of keywords (item 41), metacognitive component of theory application (item 39) and metacognitive components on reflection on what was learned (items 25, 26, 29 and 38).

The total score was 44 (minimum 0 maximum 44), considering values of 1 (always), 0.75 (most times), 0.5 (sometimes), 0.25 (almost never or rarely), 0 (never) for each of the items, resulting in the sum the final score obtained by each student. Subsequently, for statistical purposes was taken to a ratio of 100%. On our questionnaire a Cronbach's reliability analysis was done of the cognitive and motivational factors obtaining values of .85 and .87 respectively.

*Epidemiological Knowledge Test.* Consisted of 41 items and basic concepts necessary for the understanding of the epidemiological studies as rates, proportions, prevalence, incidence, mortality rates, relative risk, odds ratios, as well as different kinds of experimental studies, of cases and controls, cohort studies, meta-analysis. Cronbach's value was .78.

Self regulation was coded according to the following coding system (see Appendix)

*Procedure*

The procedure was divided into 2 parts:

*Part One.* A course of 14 hours (2 hours a week) on the basic handling of the use of Macromedia's Flash ® software led by a faculty expert in the management of the program and was conducted during October and November 2008.

Participants received 12 weeks of simultaneous instruction during the Epidemiology course of the processes and cognitive strategies, metacognitive, resource management and motivational processes, as reported by Pintrich et al. (1993), Winne (2008) and Azevedo (2009):

1. Anticipation / planning / activation: implies a conditioned conduct to the state of the problem as well as hierarchization of goals and sub-goals that can be identified by the student who when become aware of relevant prior knowledge before conducting its activity and during it.

2. Monitoring. The student becomes aware that he does not known or understands everything deciding on alternatives to improve their understanding and he monitors it in relation to his targets, assessing the usefulness and / or appropriateness of what he is doing.

3. Using the strategy. The selection and use of various cognitive strategies for memory, learning, reasoning, problem solving and thinking, can include the selection of a new representation, coordination of multiple representations, search on the multimedia environment, summarizes what he has read, inspects or listens, makes inferences, asks questions, and elaborates what he just read, see or hear.

4. Difficulty on the activity and demand. The student seeks assistance from someone with experience concerning the recent knowledge on the subject or of the instructions received, indicates whether the activity is easy or difficult and if using the media environment is more difficult than using the book, chooses aspects of the multimedia environment to expand reading and viewing of information and has expectations that a certain kind of representation proves to be an appropriate for a given goal.

The students were told that they could use the strategies mentioned earlier in the educational intervention with Macromedia Flash ® version of education.

A pre- and post-test design was used with 24 hours before and 24 hours after the educational intervention an exam on “Concepts of Epidemiology" took place. The time required to prepare the test was decided by the students themselves (40 to 60 minutes). This instrument was considered to evaluate the academic performance. In addition the MSLQ was also used as pre- and post-test.

*Part Two: Educational intervention.* The educational intervention consisted on a 20 minutes activity, in line with Bannert and Mengelkamp (2007), where the activities of speech and the "Think aloud protocol (Ericsson & Simon, 1993) took place, on which students were asked to develop a multimedia material on their computers, called "Current Aspects of the Epidemiology of Oral Diseases in Mexico” and used as sources for the search documents that were available on the hard disk of computers from the computer room of Universidad Latina de México in Celaya called:

1. "Formulas of Epidemiology," which is in the PowerPoint ® format;

2. "Ph.D. Intervention material" (which has the summaries of articles "Sociobehavioural risk factors in dental caries-international perspectives." Petersen, P. and "Dental cavities and associated Factors in Mexican school children aged 6-13 years”. A. Casanova-Rosado et al, both in Word format ®.

3. Epidemiology images "as a document in jpg format.

In the same way, portable recorders with cassettes were installed at each location for the sound recording of the student's verbalizations during the educational intervention. The teacher-researcher stayed with the students to answer doubts about the location of the equipment installed on the hard disk in order to streamline the process and the teacher who taught the course on Macromedia Flash ® tutored all of the time during the intervention the consultations on the use of the program. Students were

asked not to remain silent for more than thirty seconds during the activity. According to the methodology of the "Protocol analysis: verbal report as data (Ericsson & Simon, 1993). Students' verbalizations were registered using recorders Stern brand, made in China, and Sony made in Japan. For the analysis of recordings of the students' verbalization a transcription of each was done and then a comparison was made between the accuracy of the transcript of records with each recording register.

The analysis was made using the coding system of self-regulated behaviour proposed by Azevedo and Guthrie (2004; see Appendix). The coding was done before reading and re-reading by the author of various segments of the transcripts deciding on each case if each of the segments were selected in general, to each of the four self-regulation dimensions and in particular to each of the indicators identified. In total 360 minutes of recordings we analyzed. The transcript of the recordings of the material led to a document of 20,991 words in 45 pages with lines of one space (an average of 2.5 leaves per participant). The recordings obtained during the intervention with the Macromedia Flash ® multimedia material were transcribed and coded according to that described by Guthrie and Azevedo (2004; see Appendix).

*Statistical analysis*

On the quasi-experimental approach to manage data and perform the paired t test the statistical program Graph Pad Prism ® 5, was used, with which basic biostatistics and scientific charts can be performed. For the quantitative approach the frequency of emission of the students' verbalization was used.

## Results

The average pre-test result on the Test of Epidemiology Concepts was 41.18 ($SD$ = 10.59), whereas the post-test result was average 47.04 ($SD$ =14.09). The data were normally distributed. The paired t test revealed a significant difference between pre- and post-test results ($t$ = -2.36; $p < .05$).

The outcome of knowledge of concepts on Epidemiology showed a significant difference between the pre-test and post-test, demonstrating positive changes in terms of academic performance, which could be attributed to the effect of the intervention.

Also the data from the questionnaire on self-regulated learning strategies were normally distributed. The score obtained in the questionnaire of self-regulated learning strategies was lower in the post-test (69.88; $SD$ = 3.94) versus 60.13 ($SD$ = 6.61). The t-test revealed a significant difference ($t$ = 4.80, $p < .0005$)

In addition, the results showed that using the multimedia program was not beneficial to develop self-regulatory strategies, since no much self-regulatory strategies were used by the students during the use of Macromedia ® Flash.

*Qualitative methodology results*

Here we report the results of the frequency with which they were used self-regulated learning strategies on each of the 4 dimensions described above (Table 1).

On the dimension Anticipation/Planning/Activation the indicator "sub-goals" was the most frequent. Here, possible operations, proposed or planned are offered on a exploratory manner in the documents provided, as well as the 'Activation of previous knowledge" dimension with which the process of selecting information is begun The students conducted a series of proposals intended to be made, which could be considered as part of the self-regulatory processes, which were verified on a new way in their academic life and had no reference to pre-existing states. The dimension of prior knowledge activation was the second most used strategy.

As long as processing of information advanced, we found that during the "monitoring" stage the most frequently used indicator is that of "content evaluation" where the student monitored the content of his reading and was made aware of what he did not know. It might be that this situation is related to the thematic depth and variety of texts offered, coupled with the difficulty of the task (management of multimedia) as well as the use of computers for purposes other than those used by students such as transcription of texts or internet use. This involved mental concentration activities in specific stimuli as in the case of the activity with the multimedia program and the texts offered in PDF and jpg images, it was selective and changeable. The use of several readings offered a challenge for students, since it contained a greater density and complexity of the ideas that if it had only been a source of information. Supporting what was said before; the indicator "assessment of learning" was also frequently used.

The 'use of strategy' dimension, under its various indicators provided a general overview of the use of epistemic resources which operate on a higher level, such as making inferences. This mental activity involved the use of mental functions such as abstraction where concepts involved in a defined problem are covered in a manner that allows drawing a logical cause and effect line. At this point it was demonstrated that the activities suggested in the multimedia program Flash, can be taken as the origin of the use of complex mental activities and that students were able to make and of which they give evidence, despite the difficulty and complexity of the proposed task. We must also consider that some of the students proved to be suitable subjects for such interventions to have certain language skills and practical conceptual domain of the expression being analyzed. The promotion of inferences during the use of the program and requested product was transformed into a creative process of high value in education.

**Table 1.** Frequency of indicators of verbalized self-regulated learning during the intervention with the Macromedia Flash ®

| **DIMENSION** | | **DIMENSION** | | **DIMENSION** | | **DIMENSION** | |
|---|---|---|---|---|---|---|---|
| **Forethought / Planning / Activation** | | **Monitoring** | | **Strategy use** | | **Size and difficulty of the activity and demands** | |
| **INDICATOR** | ***f*** | **INDICATOR** | ***f*** | **INDICATOR** | ***f*** | **INDICATOR** | ***f*** |
| Planning | 17 | Judgment of learning (JOL) | 33 | Selection a new informational source | 1 | Time and effort planning | 35 |
| Sub goals | 50 | Feeling of knowing (FOK) | 2 | Goal free search | 10 | Help-seeking behavior | 21 |
| Prior knowledge activation | 25 | Self-questioning | 3 | Summarization | 6 | Task difficulty | 29 |
| Recycle goal in working memory | 7 | Content evaluation | 84 | Copying information | 5 | Control of context | 0 |
| | | Identify adequacy of information | 12 | Re-reading | 2 | Expectation of adequacy of information | 3 |
| | | | | Inferences | 20 | | |
| | | | | Hypothesizing | 2 | | |
| | | | | Knowledge elaboration | 1 | | |

The fact that generating higher mental processes required high levels of attention, selection of information, memory and integration of knowledge, so this must be subject for further research in our educational environment. It should also be mentioned that the high frequency of conducting inference highly contrasted with the quantitative results reported by questionnaire self-regulated learning strategies discussed above, especially in the exploration of the items in the cognitive and metacognitive kind.

The dimension of "difficulty of the activity and demands" involved activities where the student related all the circumstances during the task performance, being mostly an intentional attempt to control his behaviour under factors such as time and difficulty of the task; that is, the learning environment in the use of technology led to a behavioural change in student. We must recognize that to fulfil the task assigned to the group, specific technical skills were required to handle the Flash program and in this sense not all students could be compared, some used it easily while other showed

that the activity represented an extreme difficulty or expressed their opposition to the assignment.

## Discussion

The aim of this study was to look if an multimedia intervention on students in the Postgraduate Dentistry Program could improve their use of self-regulatory learning processes. Qualitative methodology, although challenging and complex in practice, carried in a manner appropriate allowed us to extract existing meaning in the contents of the material analyzed. Recent literature related to our work and study (Desoete, 2008; Igo et al., 2008) referred to the need and usefulness of combining mixed method designs, because only one quantitative approach are insufficient to explain the experimental conditions proposed and required the complementary of qualitative perspectives. Other authors such as Dresel and Haugwitz (2008), Graesser et al. (2008) and Manlove et al. (2008) have used computer programs including instructions for self-regulation, applied in populations of different educational levels, although none of the graduate like that of this work or in a population belonging to the health area. Their quantitative methodology provided different results and different conclusions, although the common denominator is the promotion of self-regulated learning, action sometimes achieved only partially. In our work, the computer program did not have a specific design for self-regulation and of common use on disciplinary areas different from educational activity, such as Graphic Design (Syllabus Acatlan FES, UNAM, 2009) in spite of this; we note the production of self-regulation on learners. This constituted an undeniable strength of this work and was consistent with the state of the art of research on self-regulation, particularly on the metacognitive processes that indicated the discrepancy that exists in the ways of conceptualizing the constructs, ways of operationalization and assessment methods (whether quantitative or qualitative) (Azevedo, 2007, 2009).

Supporting the above, let's only mention the different names found in the literature for the metacognition construct: metacognitive beliefs, metacognitive awareness, metacognitive experiences, feeling of knowing, learning judgment, theory of mind, metamemory, metacognitive skills, executive skills, higher order skills, metacomponents, monitoring understanding, heuristic strategies, (Veenman et al. 2006). Likewise, the proposal of this work has been based on cognitive acquisition (the development of processes and self-regulatory behaviours) and the review of practical behavioural elements from a reasoned and targeted use of information technology. It is also necessary to mention in order to have an objective overview of the results, the students refer to the difficulty of the task, because, being self-critical, not all had a positive experience with the use of the program. Until recently, in the field of education in dentistry when attempts are being made to integrate some of the theoretical elements of constructivism and meaningful learning such as concept maps, with

software such as PowerPoint ®, to improve the academic performance (Kinchin & Cabot, 2007).

## Conclusion

Postgraduate students of dentistry based on the use of a multimedia program and creating educational material, developed strategies and behaviours in self-regulated learning on the phases described as: 1. anticipation/ planning/activation 2. monitoring, 3. using strategies, 4. difficulty of the activity and demand, that could be registered by qualitative method. However, the results showed that using the multimedia program was not beneficial to spontaneously use self-regulatory strategies, since no much self-regulatory strategies were used by the students during the use of Macromedia ® Flash.

An attempt to approach possible alternative assumptions that caused this outcome includes:

*Abilities of students.* Pieschl (2009) mentioned that it is necessary to identify the perceptions that students have about the skills they recognized on themselves. This is represented as metacognitive monitoring and the author identifies it as a necessary precondition for successful learning that is a relationship between an estimate of their capabilities and performance. Underestimate their self-efficiency could have a direct effect on motivation. In the corresponding items to the metacognitive components of constructive learning scores fell between the pre-test and post-test.

*High degree of difficulty of the task.* It should be noted that the completion of the task was the collection and use of various learning objects (in the form of text files, forms and images) based on Macromedia Flash ®, making this activity a high degree of complexity because required the use of various higher mental activities such as attention, memory, and organization of knowledge (Mayer 2003). This process of multimedia learning could not be registered using questionnaire forms.

Another possible issue is that the questionnaire would, despite its effectiveness, the necessary adjustments to be used in learning environments based on computers, although the theoretical design which is robust and it is undeniably interesting and important in educational research (Duncan & McKeachie, 2005).

Dentistry postgraduate students improved their academic performance on the subject of Epidemiology using a multimedia program. In Test of Epidemiology Concepts  significant difference between pre- and post-test results was found which could be attributed to the effect of the intervention. In line with Desoete (2008) however this difference might also be the result of the teacher's participation (clarification of concepts and questions about the topics) and learning styles that students have used all along their academic life.

Based on the theoretical work we had the opportunity to study the phenomenon in two different ways, and in our case complementary: using the questionnaire of self-regulatory learning strategies of Pintrich et al., and the encodings of the records recorded for self-regulatory learning strategies proposed by Azevedo et al. Our proposal began a study on how to assess the production activities and self-regulatory processes.

However, we recognize that there are some limitations to the present study. First, one of the limitations is the small size of the sample. In addition the fact of trying to identify constructs of higher order cognition about cognition is methodologically a difficult task. Finally although a pre-test/post-test design with one single group has a high internal validity and is suitable for this sample, we could recommend a quasi-experimental design (non equivalent design group) for future research.

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## Appendix

Classes, Descriptions and Examples of the Variables Used to Code Learners' Self-Regulatory Behavior (Azevedo, Guhtrie, & Seibert, 2004).

| Variable | Description |
|---|---|
| **Forethought/Planning/Activation** | |
| Planning | A plan involves coordinating the selection of operators. Its execution involves making behaviour conditional on the state of the problem and a hierarchy of goals and sub-goals |
| Sub-Goals | Consist either of operations that are possible, postponed, or intended, or of states that are expected to be obtained. Goals can be identified because they have no reference to already existing states. |
| Prior Knowledge activation | Learner searches memory for relevant prior knowledge either before they actually begin performing task or during task performance. |
| Recycle Goal in | Learner restates the goal in working memory (WM) Working Memory |
| **Monitoring** | |
| Judgment of Learning (JOL) | Learner becomes aware that they don't know or understand everything they read. |
| Feeling of Knowing (FOK) | Learner is aware of having read something in the past and having some understanding of it, but not being able to recall it on demand. |
| Self –Questioning | Learner re-reads to improve his/her understanding of the content. |
| Content evaluation | Learner monitors content relative to goals. |
| Identify Adequacy of Information | Learner assesses the usefulness and/or adequacy of the content they're reading, watching, etc |
| **Strategy use** | |
| Selecting a New informational source | The selection and use of various cognitive strategies for memory, learning, reasoning, problem solving, and thinking. May include selecting a new representation, coordinating multiple representation, etc. |
| Goal-free search | Learner searches hypermedia environment without specifying a specific plan or goal |

| | |
|---|---|
| Summarization | Learner summarizes what he/she has just read, inspected, or heard in the hypermedia environment. |
| Copying information | Copying an informational source such as text and/or diagram from the hypermedia environment |
| Re-reading | Learner re-reads or revisits a section of the hypermedia environment |
| Inferences | Learner makes inferences based on what he/she read, saw or heard in the hypermedia environment |
| Hypothesizing | Learner asks questions that go beyond what they have read, seen or heard |
| Knowledge elaboration | Learner elaborates what he/she has just read, seen, or heard with prior knowledge |
| **Task Difficulty and Demands** | |
| Time and Effort Planning | Learner attempts to intentionally control his/her behaviour |
| Help-seeking Behaviour | Learner seeks assistance from experimenter regarding either their emerging understanding of the topic or their instructional behaviour. |
| Task Difficulty | Learner indicates one of the following:<br>1) the task is either easy or difficult,<br>2) using the hypermedia environment is more difficult than using a book. |
| Control of context | Learner uses features of the hypermedia environment to enhance the reading and viewing of information. |
| Expectation of Adequacy of Information | Learner expects a certain type of representation to prove adequate given the current goal. |

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# A metacognitive visuospatial working memory training for children

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**Abstract**

The paper studies whether visuospatial working memory (VSWM) and, specifically, recall of sequential-spatial information, can be improved by metacognitive training. Twenty-two fourth-grade children were involved in seven sessions of sequential-spatial memory training, while twenty-four children attended lessons given by their teacher. The post-training evaluation demonstrated a specific improvement of performances in the Corsi blocks task, considered a sequential-spatial working memory task. However, no benefits of training were observed in either a verbal working memory task or a simultaneous-spatial working memory task. The results have important theoretical implications, in the study of VSWM components, and educational implications, in catering for children with specific VSWM impairments.

**Keywords:** visuospatial working memory, metacognitive treatment, sequential-spatial

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## Metacognition

Metacognition refers to higher order thinking that involves active control over the thinking processes involved in learning. The term metacognition is attributed to Flavell (1971) who defined metacognition as thinking about one's own thinking. He described metacognition from a developmental perspective, with reference to learn how monitoring our cognitive processes, setting goals for understanding and activating strategies. Thus, metacognitive *knowledge* involved knowledge people have about their cognitive abilities (i.e., I have a bad memory), about cognitive strategies (i.e., to remember a number I should rehearse it) and about tasks (i.e., categorized items are easier to recall) (Flavell, 1979). Metacognitive *regulation* refers to processes that coordinate cognition. These include both bottom-up processes called cognitive *monitoring* (e.g., error detection, source monitoring in memory retrieval) and top-down processes called cognitive *control* (e.g., conflict resolution, error correction, inhibitory control, planning, resource allocation) (Nelson & Narens, 1990; Reder & Schunn, 1996).

Metacognitive knowledge and skills are essential components of successful learning since they can guide choice of strategies and, where necessary, provide for their adjustment (Sternberg, 1997).

Many researchers have dealt with metacognition as Brown (1975; 1987), Flavell and Wellman (1977), Borkowski, Milstead and Hale (1988), Vadhan and Stander (1994). In particular, Flavell and Wellman (1977; see also Cornoldi, 1998) proposed a distinction between *metacognitive attitude* and *specific metacognitive knowledge*. On the one hand, the metacognitive attitude regards general inclination to reflect about the nature of own cognitive activity and to recognize the possibility to use and extend them (Borkowski et al., 1988). On the other hand, the specific metacognitive knowledge regards the set of knowledge about the mental functioning and includes also the metacognitive control processes. Several studies have shown as metacognitive knowledge is involved in cognitive processes and influences, with other variables, not only memory but also learning performance of children (Cornoldi, 1990). Ericsson and Kintsch (1995) suggested that strategy use is the result of practice and experience, and a better use of strategies should make the task less attention-demanding, thus increasing the performance, e.g., in a working memory task. Finally, another important factor of strategy use is whether the individual is aware of the benefits of using a certain strategy at a young age.

Kluwe (1987) refined the concept of metacognition by noting two characteristics: the thinker knows something about his or her own and others' thought processes, and the thinker can pay attention to and change his or her thinking. This latter type of metacognition was called by Kluwe as *executive process*. Many other researchers also make the point that metacognition is best defined by acknowledging that it is both knowledge

about, and control over thinking processes (Allen & Armour-Thomas 1993). Hacker (1998) divided metacognition into three types of thinking focused on the participants' cognitive activities:

- Metacognitive knowledge: What one knows about knowledge;
- Metacognitive skill: What one is currently doing;
- Metacognitive experience: One's current cognitive or affective state.

**Visuospatial Working memory and Metacognitive Trainings**

Working memory (Baddeley, 1986) is a theoretical construct referred to the mechanism underlying the maintenance and processing of information during performance on cognitive tasks. The Baddeley's multi-component original model contains a central executive system, responsible for controlling the overall model, and two slave systems, the phonological loop dealing with verbal information and the visuospatial sketchpad dealing with visual and spatial information. The visuospatial sketchpad, also known as the visuospatial working memory (VSWM), has been explored in recent years, but to date there is no consensus on its architecture. For example, according to Logie (1995), the VSWM consists of a visual store, known as the *visual cache*, and a rehearsal mechanism, known as the *inner scribe*. The visual cache provides a temporary store for visual information (colour and shape), while the inner scribe handles information about movement sequences and provides a mechanism through which visual information can be rehearsed in the working memory system. In contrast, Pickering, Gathercole, Hall and Lloyd (2001) believe it is possible to distinguish between a static format, in which series of locations are presented simultaneously, and a dynamic format, in which the reproduction of moving paths is required. They found a developmental fractionation for static and dynamic conditions, suggesting that a critical distinction may concern not the visual and spatial properties of the tests, but the static and dynamic nature of the tasks, which tap different subcomponents of VSWM.

Regarding memory for object location, a further distinction was made by Postma and De Haan (1996). The authors subdivided object location memory into three separate processes. The first process requires encoding metric information and the coordinates of a particular object located in the environment. The second process, the *object-location binding,* requires the object's identity to be linked to its position. The final process integrates the first two mechanisms and combines metric information with object identity and location (Kessels, De Haan, Kappelle, & Postma, 2002a; Kessels, Kappelle, De Haan & Postma, 2002b). Recently, Lecerf and de Ribaupierre (2005) distinguished between an extra-figural encoding responsible for anchoring objects with respect to an external frame of reference, and an intra-figural encoding based on the relations that each item presents within a pattern. Within the intra-figural encoding, the authors further distinguished between pattern encoding, leading to a global visual image, and path encoding, leading to sequential-spatial positions. Mammarella,

Pazzaglia and Cornoldi (2008; see also Pazzaglia & Cornoldi, 1999) in a recent study tested various VSWM models in primary-school children, using confirmatory factor analyses. The best model fitting the data differentiated among visual working memory tasks, which require memorisation of shapes and colours, and two kinds of spatial tasks sharing the requirement to memorise patterns of spatial locations, but differing in presentation format and therefore in type of spatial processes involved: simultaneous in one case, sequential in the other. Evidence collected with different groups of children also gives support to differentiation between visual and spatial processes (Mammarella, Cornoldi, & Donadello, 2003) and between simultaneous-spatial and sequential-spatial processes (Mammarella, Cornoldi, Pazzaglia, Toso, Grimoldi, & Vio, 2006).

Research on working memory training can address a series of important issues. In particular, whether working memory capacity – despite being connected with neurological basic structures and generally held to be a fixed property of an individual – can be improved, and whether improvement reflects the well-established differentiations within the system.

Very little research has investigated whether working memory can be improved by practice and/or training. One example is Klingberg and colleagues (Klingberg, Forssberg, & Westerberg, 2002; Klingberg et al., 2005), who used an adaptive working memory training with ADHD children. The training consisted of performing visuospatial and verbal working memory tasks implemented through a computer program. Their results showed that not only did ADHD children improved performance on verbal and VSWM tasks, but also the training benefits could be generalised to others domains such as response inhibition, complex reasoning (Klingberg et al., 2002), and fluid intelligence (Klingberg et al., 2005). Moreover, Olesen, Westerberg, and Klingberg (2004) demonstrated that the benefit of working memory training could also be seen in changes in cortical activity. Specifically, after five-weeks' training, an increase in prefrontal and parietal cortical activity was found. It is worth noting that changes occurred in the multimodal association cortices that are active in a wide range of cognitive functions involving working memory. The same research group also tested if working memory training could help stroke sufferers (Westerberg et al., 2007). In this case, the results demonstrated an improvement in both working memory and attention. The common aspect of these studies is that they aim to clarify whether working memory training could be generalised to other cognitive functions. Other research, instead, is focused on understanding whether use of strategies or metacognitive knowledge could improve working memory performance.

In the research of McNamara and Scott (2001), participants had to learn word lists and were trained in use of a strategy, based on creation of a story, using the given words. Two experiments demonstrated that the strategic training improved working memory. In another study, Cavallini, Pagnin, and Vecchi (2003) trained young, young-old and old-old individuals

in two memory strategies, i.e. loci mnemonic (imagine a well-known route and then associate the objects to be remembered) and strategic training (use of different imagery strategies depending on the task requirement). However, the benefits of the training were relevant for tasks involving activities specifically trained, while working memory performances showed only modest training effects. Finally, Carretti, Borella, and De Beni (2007) examined the effect of strategic training, based on the creation of integrated images, with young and old adults. The authors found that the improvement of younger and older adults was comparable in both recall of word lists and a working memory task.

Recently, few case studies have been worked out about the effectiveness of metacognitive working memory trainings, in particular Mammarella, Coltri, Lucangeli & Cornoldi (in press) test the efficacy of a visuospatial memory treatment for a child with nonverbal learning disabilities (NLD) and results demonstrated that the metacognitive training was successful and improvements were maintained after six months.

In general, then, these studies showed that working memory performance can be improved by training, but did not take into consideration evidence concerning working memory subcomponents, nor examine the specific effects of training on different working memory subcomponents.

**Goals of the present study**

The present study is in line with research designed to understand whether working memory performance can be improved, but is focused on specific changes within VSWM. Specifically, we investigated whether sequential-spatial working memory could be improved by training of fourth-grade children using metacognitive strategies. To our knowledge, in the literature there is either general working memory training involving both verbal and visuospatial tasks (Klingberg et al., 2002; Klingberg et al., 2005; Cavallini et al., 2003), or else training involving only verbal materials (McNamara & Scott, 2001; Carretti et al., 2007). Specific VSWM trainings have recently been studied only in a single case with specific impairment of visuospatial working memory (Mammarella et al., in press). Our training involved not only VSWM tasks, but also a hypothesised subcomponent of VSWM (i.e. sequential-spatial working memory) that will be improved specifically using metacognitive strategies.

In sequential-spatial tasks, participants are usually presented with locations of items shown one at a time, and have to either recognise or remember them; the presentation order (or reverse order) is therefore paramount. The most typical test tapping sequential-spatial processes is the Corsi blocks task (Corsi, 1972), which consists of nine blocks irregularly arranged on a board. The blocks are tapped by an examiner following random sequences of increasing length, which participants must reproduce

immediately following the presentation order (forward recall) or the reverse presentation order (backward recall).

According to Cornoldi and Vecchi (2003; see also Mammarella et al., 2006), sequential-spatial and simultaneous-spatial tasks differ in the presentation format of the stimuli, which are presented sequentially in one case and all together (simultaneously) in the other. A widely used VSWM task that does not involve sequential items presentation, and which has been interpreted as visual (Della Sala, Gray, Baddeley, & Wilson, 1997; Logie & Pearson, 1997) and as simultaneous-spatial (Mammarella et al., 2006), is the visual pattern test (VPT: Della Sala, Gray, Baddeley, & Wilson, 1997). The VPT involves irregular matrices of increasing complexity in which half of the cells are filled in, and participants have to recall the locations of the filled-in cells. Both the Corsi blocks task and the VPT were used in the present study as pre- and post-training evaluation, together with the digit span task, a measure of verbal working memory, as control. We expected to find a specific increase in sequential-spatial memory due to a specific sequential training, and thus specifically in the Corsi blocks task, but no improvement in the VPT and digit span task.

As regards the training, the difficulty was adjusted considering the type of processing involved. Three sessions required recognition of locations and identity of the stimuli sequentially presented, three sessions required them to be remembered, while a last session was introduced to generalise the sequential-spatial memory in everyday life. This training started with simple tasks in order to allow children to experience success, and thus gain motivation. The training was given to a whole classroom by an expert trainer assisted by a teacher. The trainer suggested one or more possible strategies for recalling visuospatial information depending on the type of task and/or materials involved and, at the end of each session, strategy efficacy was discussed. The children were regular fourth-graders, with no learning disabilities or other cognitive impairments.

## Method

### *Participants*

A total sample of 46 fourth-grade children was divided according to their classroom into two groups: 22 (12M, 10F) children were assigned to the experimental training group, while the remaining 24 (14M, 10F) children were assigned to the control group. The classrooms were located in two different parts of the town and both teachers and children were unaware of the objectives of the research. Before the pre-training evaluation, teachers were presented with the SVS Questionnaire (Cornoldi, Venneri, Marconato, Molin, & Montinari, 2003) and were asked to rate a series of children's characteristics on a four-point scale. Ten items on the questionnaire (used to obtain a visuospatial score) refer to some of the deficits that, according to the literature, represent critical features of non-verbal learning disability children (Rourke, 1995). Two items gather information about a child's verbal

abilities (verbal score), and one item estimates socio-cultural level. The questionnaire was administered in order to ensure that no child had symptoms of non-verbal learning disabilities, and to match the groups on the basis of these scores. The two groups did not differ in visuospatial score $t(44) = -1.46$ $p = .15$ (experimental training group: $M = 36.40$; $SD = 6.13$; control group: $M = 33.67$; $SD = 6.59$), verbal score $t(44) = -.55$ $p = .58$ (experimental training group: $M = 6.90$; $SD = 1.59$; control group: $M = 6.09$; $SD = 1.52$), or socio-cultural level $U$ Mann-Whitney = 246, $p = .59$.

*Materials and Procedure*

*Pre- and post-training evaluation.* In pre- and post-training evaluation, the children of both groups were presented with one verbal (forward and backward digit span, see Wechsler's procedure, 1974) and two visuospatial working memory tasks: *the Corsi blocks test* (adapted from Corsi, 1972), tapping sequential-spatial working memory and *the visual pattern test (VPT),* (Della Sala et al., 1997) tapping a simultaneous-spatial component of VSWM. The tests were administered in a quiet room of the child's school during a single individual session. In order to avoid specific performance on a test being biased by effects of either practice or fatigue, test presentation order was balanced. Tests were administered four days before the first session of the training, and before the administration of each task two practice trials with feedback were given to the participants.

The Corsi blocks test consists of a series of nine blocks irregularly arranged on a board. On the tester's side of the board, the blocks are numbered to facilitate administration; the blocks are tapped by the examiner in random order, and the participant has to reproduce the same sequence of increasing length following either forward or backward recall direction according to the tester's instructions. In our study, items were presented at a rate of one cube per second, and sequence length varied from 3 to 8 in the forward direction and 2 to 7 in the backward direction. Children were presented with three trials at each difficulty level: when they correctly performed two trials, the third was not administered. Also, the procedure stopped when the participant was unable to solve two items of the same level of difficulty. The spatial span was taken to be the longest sequence in which at least two of the three trials presented were correctly reproduced.

In the VPT, children were presented with random square matrices created by filling in half the number of squares in the grid, for 3 seconds. The grids increased in size from smallest (4 squares at the first level, with two filled-in cells) to largest (22 squares at the last level, with 11 filled-in cells). After the presentation phase, in which participants memorised the filled-in squares, the initial stimulus was removed and children were presented with a blank test matrix in which they had to indicate the filled-in squares previously occupied by the targets. The level of complexity was defined as the number of filled-in cells in the matrix (from 1 to 10). The span

was taken to be the longest sequence in which at least two of the three trials presented were correctly reproduced.

*Training phase.* The entire experimental training group attended seven training sessions, which were completed within one month with a fixed interval between sessions. Specifically, the trainer, assisted by the class teacher, gave the training on Monday and Thursday each week. Each session took about 40 minutes, plus ten final minutes for discussing strategies used and giving a metacognitive debriefing to the children. The training was presented as a game in which the protagonist, Alex, had to undertake various activities. The same sequence of events characterised each session: explanation of objectives, stimuli presentation, demonstration of the task, questions, feedbacks, and finally, discussion about the strategies employed to perform the tasks. For each task, the trainer suggested a number of strategies, depending on the task requirements, and at the end of the activity, the children and trainer discussed the usefulness of them in a particular task. Some suggested strategies used to carrying out the tasks were: coding the stimuli in different ways, and then analyze information (for example, looking well at the figures, naming, rehearsing the labels following a path); creating chunks of visuospatial stimuli; using mental images to execute a task; verbalizing mental images. Finally, discussions were improved on the importance of recognizing the best strategy and on the children awareness.

The main goal was to train children in tasks involving sequential-spatial memory processes. The difficulty was increased both within each session (changing the number of stimuli to be remembered) and over the whole training (distinguishing among the cognitive task requests). For this latter, the training was divided into three sub-objectives: *memory recognition*, *memory recall* and *everyday memory*. In the *memory recognition* sessions, the children had to recognise pathways or positions and order of items; in the *memory recall* sessions, their task was to reproduce pathways or positions and order of items and, finally, in the everyday memory sessions, the children were presented with maps and had to reproduce some pathways. The specific organisation of the individual sessions is presented in the Appendix.

The control group was involved at the corresponding times in general cognitive activities administered by their teachers, without any focus on working memory.

## Results

*Pre-training evaluation*

The two groups did not differ in the pre-training evaluation. Specifically, they performed similarly in the forward digit span task $F(1, 44) = .05$ $MSE = .80$ $p = .82$ $\eta_p^2 = .001$, the backward digit span task $F(1, 44) = .05$ $MSE = .81$ $p = .82$ $\eta_p^2 = .001$, the forward Corsi blocks task $F(1, 44) = 1.09$ $MSE = .47$ $p = .30$ $\eta_p^2 = .02$, the backward Corsi blocks task $F(1, 44) = .49$ $MSE =$

.99 $p$ = .48 $\eta_p^2$ = .01, and, finally, the VPT $F(1, 44)$ = .08 $MSE$ = 2.10 $p$ = .77 $\eta_p^2$ = .002. The mean values of both pre- and post-training evaluations are given in Table 1.

**Table 1.** Mean values (standard deviations in brackets) obtained from control and experimental training groups, in both pre- and post-training evaluation.

| | Pre-training | | | | Post-training | | | |
|---|---|---|---|---|---|---|---|---|
| | Control | 95%CI | Treatment | 95%CI | Control | 95%CI | Treatment | 95%CI |
| Forward digit span | 5.17 (.92) | 4.78-5.55 | 5.23 (.87) | 4.84-5.61 | 5.54 (1.10) | 5.01-6.01 | 5.50 (1.01) | 5.05-5.95 |
| Backward digit span | 3.33 (.82) | 2.99-3.68 | 3.27 (.99) | 2.84-3.71 | 3.42 (.78) | 3.09-3.74 | 3.55 (.80) | 3.19-3.90 |
| Forward Corsi | 4.33 (.70) | 4.04-4.63 | 4.55 (.67) | 4.25-4.84 | 4.17 (.64) | 3.90-4.44 | 4.68 (.84) | 4.31-5.05 |
| Backward Corsi | 3.79 (1.02) | 3.36-4.22 | 4.00 (.97) | 3.57-4.43 | 3.71 (.99) | 3.29-4.13 | 4.27 (.88) | 3.88-4.66 |
| VPT | 3.12 (1.45) | 2.51-3.74 | 3.00 (1.45) | 2.36-3.64 | 3.17 (1.40) | 2.57-3.76 | 3.22 (1.51) | 2.56-3.90 |

*Post-training evaluation*

Pre- vs post-training changes in experimental and control groups were compared using mixed ANOVAs. For verbal working memory, a 2x2x2 mixed ANOVA was run, with group (experimental vs control) as between-subject factor and recall direction (forward vs backward) and treatment (present vs absent) as within-subject factors. The main effect of recall direction was significant $F(1,44)$ = 207.33 $MSE$ = .857 $p$ = .001 $\eta_p^2$ = .83, indicating that children had better recall of digits following a forward direction rather than working backwards. Also, the main effect of treatment was significant $F(1,44)$ = 26.21 $MSE$ = .11 $p$ = .001 $\eta_p^2$ = .37, showing that both groups improved performance over one month. A similar 2x2x2 mixed ANOVA was run for the Corsi blocks task. A main effect of group was observed $F(1,44)$ = 4.52 $MSE$ = 1.43 $p$ = .04 $\eta_p^2$ = .09. Also the main effect of recall direction was significant $F(1,44)$ = 10.21 $MSE$ = 1.07 $p$ = .003 $\eta_p^2$ = .19, showing that forward recall was higher than backward recall. Moreover, the interaction treatment by group was significant $F(1,44)$ = 6.89 $MSE$ = .18 $p$ = .01 $\eta_p^2$ = .14. Post-hoc comparisons with Tukey's test showed that the experimental group improved performance after training ($p < .05$). Finally, a 2 (group) x 2 (treatment) mixed ANOVA on the VPT span did not show either significant variations due to the training or main effect of group.

*Benefit due to training*

To gain a better understanding of the training effect, we calculated a score expressing the benefit resulting from the treatment. The formula used was: [(post-training scores–pre-training scores)/ pre-training scores] (see Carretti, et al., 2007).

Separate one-way ANOVAs were run using benefit indices for all working memory measures. No benefit was found in either forward digit span test $F(1,44) = .013$ $MSE = 1.43$ $p = .62$ $\eta_p^2 = .006$, or backward digit span $F(1,44) = 2.81$ $MSE = .03$ $p = .10$ $\eta_p^2 = .06$. For the Corsi blocks task, the variation in forward recall was in the positive direction, in contrast with the observation for the control group (see Figure 1), but not significant, $F(1,44) = 2.33$ $MSE = .019$ $p = .13$ $\eta_p^2 = .05$. However, a clear benefit was observed in backward recall $F(1,44) = 5.08$ $MSE = .029$ $p = .03$ $\eta_p^2 = .10$ (see Figure 1). Finally, no benefit due to the training was observed in the VPT $F(1,44) = 1.17$ $MSE = .063$ $p = .27$ $\eta_p^2 = .03$.

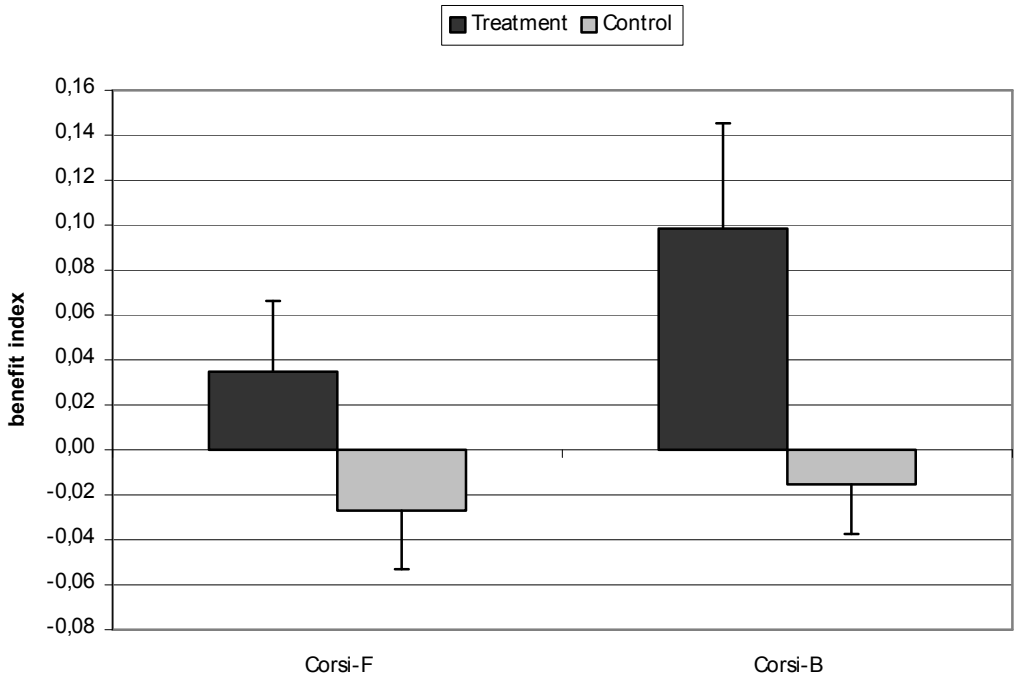


**Figure 1.** Variation of performance in the treatment and control groups in the forward Corsi (Corsi-F) and backward Corsi (Corsi-B) blocks task. Errors bars represent standard errors.

Moreover, in order to demonstrate the magnitude of the training-related gains in the Corsi blocks task, participant were classified into two groups: 1) a gain of one or more span-scores, 2) an absence of gain or a loss of one or more span-scores (for a similar procedure see Singer, Lidenberger, & Baltes, 2003). The numbers of cases were thus compared with a chi-squared. For the forward recall of the Corsi blocks task, we found only a tendency, the percentage of children who improved performance after training being 18% of the experimental training group and 4% of the control group, $\chi^2(1,N = 46) = 2.33$ $p = .13$. In the backward recall, on the other hand, the percentage was significantly different $\chi^2(1, N = 46) = 7.56$ $p = .006$:

specifically 36% of the experimental training group and 4% of the control group improved performance.

## Discussion

The present study shows that sequential-spatial working memory training can increase the amount of sequentially presented information that children can keep in VSWM. The improvement due to training was present, in general, for the Corsi blocks task and, specifically, gains were evident for the backward Corsi. Performances also improved in verbal working memory (i.e. the digit span task), but the spans increased to the same extent in both the experimental and the control groups, demonstrating that there was an effect due to external factors (probably a combination of maturation, practice and cognitive verbal stimulation) but not a specific training effect. In contrast, in the simultaneous-spatial task (i.e. the VPT) no improvement was observed. It should be noted that training was not presented to children with memory or learning impairments, and the specific increase of sequential-spatial spans proved that an initial deficit in VSWM or in spatial abilities is not necessary for improvement to occur. The presence of specific rather than generalised improvement is in agreement with our distinction within VSWM of visual, simultaneous-spatial and sequential-spatial processes. The result we obtained - i.e. the specific effect of a sequential-spatial training on the Corsi blocks task - could be interpreted as further support for the distinction between different VSWM processes (Pazzaglia & Cornoldi, 1999; Mammarella et al., in press). Moreover, our results confirm the positive effect of metacognitive training, in particular teaching new strategies, on sequential-spatial tasks performance. A meta-analysis of memory training in aging (Verhaeghen, Marcoen, & Grossen, 1992) demonstrated that the benefits of training are closely linked to metacognitive aspects – such as thinking about one's own memory – and to opportunities to share experiences. Children could also benefit from these aspects. Moely, Hart, Leal, Santulli, Rao, Johnson & Hamilton (1992) found that children who were trained and encouraged to use strategies were more likely to use the strategies in the specified learning situation, and were more likely to generalise the strategies they learnt to other pertinent situations. This result demonstrated that whether an individual employs strategies depends to some extent on whether they where trained to use strategies as children.

However, some limitations of this study should be borne in mind. First, the improvements in the control group were not particularly dramatic partly because the span measures employed could have underestimated improvement and consequently the benefits of the training. In fact, the scores have a limited range - from 3 to 5 or 6 - since the children attended primary school. Second, although in the training we avoided presenting situations similar to those found in the criterion tests, children could have

benefited from general similarities between the training situations and the Corsi task. Further evidence is therefore needed in order to know the generality of the effects of training of sequential-spatial working memory.

Finally, the results of the present study have important educational implications: recognizing the crucial role of metacognition, meaning that education could affect directly cognitive skills, but also, indirectly, on the possibility of using similar or different strategies during cognitive tasks. Moreover, training benefits may be transferred to other areas; thus, metacognitive treatment may be involved in other cognitive domains and may offer interesting implications in the fields of both education and rehabilitation.

In conclusion, our data suggest that not only children without VSWM impairments could benefit from training, but, in addition, children with specific sequential-spatial working memory impairments might gain from domain-specific intervention.

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# Appendix

The training was divided into three sub-goals: *memory recognition*, *memory recall* and *everyday memory*. The training was presented as a game in which the protagonist, Alex, had to undertake different activities. Each child had a booklet in which s/he could follow the activities and give her/his response.

1) *Memory recognition*
   - Session 1: The aim of the session was to recognise a series of maze pathways (of increasing complexity) selecting among three of four alternatives. The trainer showed the pathway sequentially in front of the children, who had to choose in their booklet the pathway shown by the trainer. For each maze a short story about Alex was presented in order to gain the children's interest.
   - Session 2: In this session, the concept of presentation order was introduced, and the children had to recognise the location and order of some patterns (e.g. the places where Alex's friends sit in the classroom following the order given by the trainer) or answer simple questions about the relationship between order and locations (e.g. Is Mary sitting near Robert? Who sat down before Robert? Where is Robert's desk?). The level of complexity increased in each trial, with increasing number of items to be recognised.
   - Session 3: In this session the children were introduced to the concept of reverse order. Simple stories about Alex involving locations and order were then presented and the children had to recognise or answer questions in the booklet, as in Session 2.
2) *Memory recall*
   - Session 4: This session had the same aim as Session 1, the only difference being that the children had to reproduce in their booklet the maze pathways shown by the trainer and then recall them.
   - Session 5: The objective of Session 5 was to guide the children in recalling items and locations following the presentation order given by the trainer. The children gave their responses in their booklet.
   - Session 6: As in Session 3, the children were presented with the concept of reverse order recall; however; after the presentation of stimuli and their locations, the children had to recall them in a backward direction.
3) *Everyday memory*
   - Session 7: The main aim of the last session was to generalise sequential-spatial memory processes in everyday life. For this reason, in this session, maps with landmarks (i.e. train station, church, school and so on) were presented and the children had to reproduce the pathways given by the trainer. In the final trials, maps with just street names but no landmarks were presented to familiarise the children with real town maps.

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# Developing a pedagogical problem solving view for mathematics teachers with two reflection programs

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**Abstract**

The study investigated the effects of two reflection support programs on elementary school mathematics teachers' pedagogical problem solving view. Sixty-two teachers participated in a professional development program. Thirty teachers were assigned to the self-questioning (S_Q) training and thirty two teachers were assigned to the reflection discourse (R_D) training. The S_Q program was based on the IMPROVE self-questioning approach which emphasizes systematic discussion along the phases of mathematical or pedagogical problem solving as student and teacher. The R_D program emphasized discussion of standard based teaching and learning principles. Findings indicated that systematic reflection support (S_Q) is effective for developing mathematics PCK, and strengthening metacognitive knowledge of mathematics teachers, more than reflection discourse (R_D). No differences were found between the groups in developing beliefs about teaching mathematics in using problem solving view.

**Keywords:** Elementary mathematics teachers; PCK; Metacognition; Reflection support; beliefs

## Introduction

Standards of mathematics education pose great challenges for the preparation and Life Long Learning education of mathematics teachers (National Council of Teachers of Mathematics [NCTM], 2000; Program for International Student Assessment [PISA], 2003). In mathematics classrooms aligned with the vision of NCTM standards, teaching is focused on problem solving, mathematical reasoning and communication as part of a

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coherent curriculum. These goals maintain that teachers must cope with the complex dynamic process of teaching mathematics with pedagogical content knowledge (PCK) methods that challenge and guide students to gain mathematical ideas (e.g., NCTM, 2000). It is suggested (e.g., Hill, et. al., 2005; Putnam and Borko, 2000) that meaningful teaching should challenge students to shift toward student-centred learning that encourages knowledge construction through self-regulated learning (SRL). Students are self-regulated to the degree that they are active participants in their own learning process (Zimmerman, 2000).

Unfortunately, elementary school teachers continue enter the teaching field unprepared to teach mathematics in the way envisioned by the NCTM standards (Hill, et. al., 2005; Putnam & Borko, 2000). Most elementary school teachers have not experienced mathematics in this manner; they viewed mathematics in an instrumental way. They perceived mathematics as an unrelated set of facts, rules, and skills, to be used as required, rather than a process of reasoning and generalizing (Ernest, 1989). Studies indicate that these prior beliefs often serve as a lens through which the teachers view the new pedagogical knowledge being taught and the new processes of teaching and learning encountered. Therefore, it is essential that teacher educators consider these prior beliefs in teachers' professional education (Pajares, 1992; Kramarski & Michalsky, 2009; Richardson, 1996; Thompson, 1992).

One promising instructional support to develop a process view seems to be the use of reflection. Zimmerman (2000) argues that self-reflection has a central role in achieving self-regulation in learning. If students are to exert influence over their learning activities, they must be aware of these activities and they must reflect during their learning (Bandura, 1986). Our study investigates the effects of two reflection training programs on teachers' pedagogical view, by measuring: mathematical teachers' pedagogical content knowledge (PCK) in the context of problem solving, metacognitive knowledge, and beliefs. Prior to describing the present exploratory study's design, I present a brief overview of each of the variables utilized in this study.

*PCK in mathematical problem solving context*

Lester and Kehle (2003), characterize mathematical problem solving as an activity that involves the students' engagement in a variety of cognitive actions: include accessing and using previous knowledge and experience. Successful problem solving involves coordinating familiar representations and patterns of inference, and intuition in an effort to generate new representations. Evidence from empirical studies suggests that the development of process-oriented learning methods, which emphasize mathematical problem solving is the most difficult topic for elementary school students (Verschaffel, et. al, 2000).

Shulman (1986), described PCK as the way content, pedagogy, and knowledge of students are blended into understanding about how particular topics are taught, represented, and adapted to students' characteristics, interests, and abilities. In terms of PCK, teachers must to know how to teach their subject matter in a way that engages students extensively in tasks that require understanding. To achieve this objective, teachers must first learn to identify students' reasoning difficulties in the specific subject matter domain. Second, teachers must know how to plan lessons or didactic materials to explicitly treat these difficulties. Third, teachers need to know how to implement a curriculum that addresses higher-order understanding. Finally, teachers should know that successful implementation involves a considerable change in teachers' roles. The traditional teacher-centred role of acting as a "source of knowledge" should be replaced by student-centred learning by highlighting the role of initiating and coaching students' inquiries and problem solving (Zohar & Schwartzer, 2005). Such learning principles require self-knowledge and beliefs, motivation, goals, and strategy knowledge, and is indicative of self-regulation in learning (e.g., Pintrich, 2000; Schoenfeld, 1992; Schraw, et. al., 2006; Zimmerman, 2000).

*Integrating SRL into PCK*

Self-regulated learning involves a combination of using cognitive strategies, metacognition, and motivation. Researchers believe that the role of metacognition is especially important (Schraw et al., 2006; Zimmerman, 2000). Metacognition refers to knowledge and control of cognitive skills, and usually involves declarative knowledge and beliefs that refer to what the student knows or believes procedural knowledge that refers to how to use the knowledge, and conditional knowledge that refers to when to use it. Unlike the knowledge component, the control component refers to planning, monitoring, and evaluating learning toward the achievement of personal goals. According to Zohar and Schwartzer (2005), developing PCK requires using knowledge on both the cognitive and metacognitive levels. Knowledge of PCK on a cognitive level means that the teacher uses teaching strategies in the specific subject matter domain. Knowledge of PCK on a metacognitive level means that teachers reflect and verbalize processes of a particular pedagogical case; make generalizations about these processes (e.g., identify difficulties in using specific topic); and describe when, why, and how they use PCK.

*Supporting reflection in SRL*

According to Zimmerman (2000), reflection includes both judgment and reaction components. Judgment refers to students' ability to conduct introspection about their performance by looking back, whereas reaction refers to learners' ability to control and adjust their learning according to their conclusions by looking ahead. Reflection is particularly important for teachers' practice because it helps connect teachers planning to students needs (Schon, 1987). The use of reflection enables teachers to focus attention

on their own planning, and on understanding the activities in which they engage during their learning and teaching (Davis, 2003; Kauffman et al., 2008; Nurckles, et. al., 2009). Although research has indicated the importance of reflection for SRL, students do not seem to implement such behaviours spontaneously.

Reflection support programs aim to increase learning competence by means of providing explicit guidance to students as they think and reflect on their tasks. An explicit approach incorporates the ability both to verbalize thinking patterns and to conceptualize and analyze relational structures that are employed while thinking (Veenman et al., 2006). This approach raises the question about the conditions required to support reflection ability in teacher training programs as teachers think and reflect on their tasks. Our study investigates two reflection support programs: Reflection discourse (R_D) and self-questioning (S_Q).

*Reflection Discourse (R_D) vs. Self-Questioning (S_Q).*

Research indicated the role of reflection discourse with comparable peers for making monitoring and regulation processes overt (Brown & Campione, 1994). Reflection discourse encourages students to share meanings, in order to achieve deeper metacognitive and subject matter understanding. Students must explain their own thinking to other group members and adapt their own thinking to the solutions proposed by other members, which, in turn, may facilitate more efficient use of metacognitive skills. Through critically examining others' reasoning and participating in disagreements' resolution, students learn to monitor their thinking, which in turn strengthens their mathematical reasoning concepts (e.g., Artz & Yaloz-Femia, 1999).

Although the group discourse has potential to develop students' reflection ability research findings indicate that students are often "cognitively overloaded" during the group process, experiencing difficulties in self-observation and reflection, in remembering what they did previously, and in documenting their thinking. This overload prevents from sharing their learning behaviours with other students (Clearly & Zimmerman, 2008; Kramarski & Mizrachi, 2006; Schon, 1987).

Many researchers have emphasized that self-reflection should be attained by systematic support that focuses on promoting learners understanding of the task, planning, monitoring and evaluating through the learning task process (e.g., Clearly & Zimmerman, 2008; Zimmerman, 2000).

Mevarech and Kramarski (1997), designed the IMPROVE metacognitive self-questioning method that represents the acronym of all classroom teaching steps: Introducing new concepts; Metacognitive questioning; Practicing in small groups; Reviewing; Obtaining mastery; Verification, and Enrichment and remediation. The metacognitive questioning encourages students to actively engage in self-regulating their

learning by using four types of questions: Comprehension (e.g., 'What is the problem/task?'); Connection (e.g., 'What is the difference/similarity?'); Strategy (e.g., 'What is the strategy?; 'Why?') and; Reflection (e.g., 'Does the solution make sense?;' "Can the solution be presented otherwise?'). The IMPROVE method questions direct students' thoughts, actions and discourse throughout the SRL processes (Zimmerman, 2000) of planning (what, when, and how), monitoring and reflection (why). In general, research reported that IMPROVE self-questioning (S_Q) demonstrated positive effects on school students' learning outcomes and SRL processes (e.g., Kramarski, 2004; Kramarski, et. al., 2002; Kramarski & Mevarech, 2003; Kramarski & Zoldan, 2008). Recently the IMPROVE method was adapted for pre-service teachers (Kramarski & Michalsky, 2009; Kramarski & Michalsky, in press). However, minimal research exists in investigating such reflection support approaches in professional training programs of elementary school mathematics teachers.

*Current study objectives*

In the present study, teachers participated in one of two professional training programs (see a detailed description of each program in the Method section): either with the reflection discourse (R_D) or the IMPROVE self-questioning method (S_Q). The purpose of this study was twofold. We compared the effects of R_D versus S_Q on the teachers' pedagogical problem solving view as measured: (a) PCK regarding mathematical problem solving; and (b) metacognitive knowledge and beliefs regarding declarative, procedural, and conditional knowledge. We expected that systematic discussing with pedagogical issues with the IMPROVE method (S_Q) embedded within PCK, would help teachers become more actively engaged in comprehending the PCK of problem solving and more aware of metacognitive considerations for student-centred learning. Thus, we assumed the S_Q group will outperform the R_D group in PCK measures. We also assumed that the S_Q method enhances teachers' high level of perceived metacognitive knowledge (procedural and conditional) more than the R_D method.

## Method

Sixty two elementary school teachers from 16 urban schools, participated in this study. These teachers participated in an Israeli government sponsored professional development program for three years. The purpose of the development program was to enhance teachers' mathematical knowledge and pedagogical methods with regard to NCTM standards in mathematics. Teachers were exposed to the Israeli Ministry of Education mathematical curricular: numbers and operations, data, algebra, proportion, space, and shapes. Teachers' knowledge was assessed each year in all professional development centres by uniform government tests based on the topics which were studied. In the beginning of the study there were no significant differences between the two groups in the following variables: Years of

experience in teaching mathematics mathematical knowledge and PCK were assessed by government measures.

*Professional training program*

*Shared structure and curriculum*. Teachers in both groups (R_D and S_Q) participated in five weekly 4-hour workshops during five weeks (20 total hours of training). The aims were: (a) to strengthen teachers' mathematical knowledge for teaching; and (b) to practice pedagogical means for enhancing mathematical understanding (Hill et. al., 2005). Teachers studied the new curriculum standards for early childhood (problem solving, mathematical reasoning, and communication) as an integral part of facilitating students' mathematical understanding (NCTM, 2000). During training, teachers practiced arithmetic exercises (e.g., numbers and operations) and discussed algebraic ideas (e.g., symbols, expressions, patterns, and representations). In addition, teachers studied theories based on student-centred learning (e.g., Brown & Campione, 1994), such as learning by inquiry and participating in discussion.

All four workshops in both groups contained the same structure. First, the instructor presented the lesson's subject and contents to the in-service teachers. Second, the teachers practiced the tasks collaboratively in pairs. Practice was based on (a) solutions of various complexities requiring comprehension of mathematical knowledge and pedagogical episodes, and (b) analysis and evaluation of lesson plans, video-captured lessons, or pedagogical events. Third, each pair of teachers presented their summary of the task solution or lesson evaluation to the class. Finally, teachers participated in class discussions regarding the interpretation of mathematical ideas and pedagogical events, understanding difficulties, and proposing solutions and explanations for problems. In addition, a discourse related teachers' attitudes, beliefs and feelings regarding the training program was organized for the entire class. As part of their training, teachers conducted their actual school lessons while practicing various mathematical and pedagogical activities with their students, and then reflected on and discussed their experiences with their peers in the workshop.

Each group received training from one of two female expert instructors. Both instructors held an MA degree in mathematics education, had 10+ years of teaching experience, and were considered experts in pedagogical development and training programs. For this study, each instructor was trained separately; the instructor assigned to the S_Q group practiced exercises and tasks using the IMPROVE method (see the next section), whereas the other instructor practiced these tasks with the R_D group.

Figure 1 summarizes the main components in each training program.

| [a] Learning Approaches | Self-Questioning S_Q | Reflection Discourse R_D |
|---|---|---|
| Theoretical teaching and learning framework | New curriculum standards (NCTM, 2000) for early childhood education: Problem solving, mathematical reasoning, and communication; numbers and operations and algebraic ideas; Teaching methods for *student-centred* learning; Research review | |
| Teacher training (for 2 instructors) | One-day, 5-hour in-service training seminar, and teachers' observations | |
| Workshop structure | Five weekly 4-hour workshops for a period of five weeks that included 6 main activities:<br>(a) Instructor presented the lesson's subject and contents<br>(b) Practice was based on task solutions, analysis of lesson plans, video-captured lessons or teachers' actual school lessons<br>(c) Teachers practiced tasks collaboratively in pairs<br>(d) Each pair presented their summary of the task solution, lesson evaluation or pedagogical event<br>(e) Teachers participated in class discussion regarding their activities in the workshops and their actual school lessons<br>(f) Instructors implemented procedures for debriefing regarding attitudes, beliefs, and feeling toward the program | |
| Guidance | (a) IMPROVE self-questioning method:<br>Comprehension, connection, strategy and reflection;<br>(b) Systematic practice in both perspectives as *student* and as *teacher* | Reflection discourse on NCTM standards of teaching and learning:<br>(a) Problem solving<br>(b) Mathematical understanding<br>(c) Teaching methods<br>(d) Pedagogical considerations |

**Figure1:** Summary of the mathematics training program by reflection support

*Self-Questioning (S_Q) group*

Teachers in this group received reflection support based on the IMPROVE metacognitive self-questioning model (Kramarski & Mevarech, 2003; Mevarech & Kramarski, 1997). In previous applications of this model for students, we utilized a series of four metacognitive self-guided questions on comprehension, connection, strategy, and reflection. In the present study, we expanded the model to incorporate two perspectives of practice for teachers: as a student (i.e., regarding solving problems) and as a teacher (i.e., in planning lessons involving those problems). In both perspectives, teachers used the metacognitive self-guided questions before, during, and after the solution process, whether or not the given solution involved a task, a lesson plan, or a pedagogical event.

The comprehension questions were designed to prompt teachers to reflect on the problem before solving it, plan a lesson or analyze a pedagogical event. In addressing comprehension questions, the teacher was

required to focus on the basic features of the problem (e.g., givens, terms) or the event. For planning lessons or pedagogical events, teachers had to demonstrate the lesson's topic, mathematical knowledge, and the explanations needed in the lesson. The connection questions were designed to prompt teachers to focus on similarities and differences among problems, explanations, lessons, or pedagogical events that the teachers had already used or planned, and to explain why. In addressing the connection questions, teachers had to focus on prior knowledge, and to define the structural features of the task and the information provided. The strategic questions were designed to prompt teachers to consider which strategies were appropriate for solving or teaching the given problem/task/pedagogical event and the basis for doing so, and for what reasons. In addressing the strategic questions, teachers had to describe "what" strategy they selected, "how" they suggested it should be implemented, and "why" the strategy was the most appropriate one for solving or teaching the problem/task. The Reflection questions were designed to prompt teachers to control their problem solving and lesson planning. In addressing the reflection questions, teachers monitored and evaluated their understanding and different ways to solve problems or using teaching approaches. The metacognitive questions were embedded in the teachers' workshop materials. The teachers were encouraged to use these questions explicitly in solving their tasks, when providing explanations, planning their lessons and conducting team and class discussions. Teachers were asked to provide written responses to metacognitive questions.

The instructor also explicitly presented and discussed research findings about the effects of the IMPROVE method on students' problem solving, mathematical reasoning, pedagogical knowledge and SRL (e.g., Kramarski, et, al., 2002; Kramarski, 2008; Kramarski & Michalsky, 2009). In class, the instructor also discussed with teachers how to use metacognitive self-questioning during classroom learning and teaching.

*Reflection Discourse (R_D) group*

The aim of reflection in this program was to improve teachers mathematical problem solving and actual practice according to the NCTM standards. Teachers were expected to solve mathematical problems, plan lessons, make provisions for classroom learning and teaching and participate in a reflection discourse. Teachers were asked to discuss in small groups and in the whole class their experience on (a) mathematical problem solving; (b) teaching in their actual classes focusing on enhancing mathematical understanding (e.g., ways of solutions, mathematical explanations), (b) teaching methods (e.g., sharing knowledge), and (c) pedagogical considerations of their actual experiences with their students (e.g., task demands, levels of thinking, and students difficulties). The R_D program encouraged teachers to be critical about their work, with the intention that they can effect change in their teaching.

Teachers practiced the same tasks with the workshop materials. The instructor discussed the main research literature in reference to principles and standards of mathematical reasoning and teaching techniques to promote young children's understanding in student-centred learning approaches (Brown & Campione, 1994). The instructor presented Zimmerman's (2000), approach to effective reflection. The approach often involves making a judgment and then to suggests techniques to modify teaching. The instructor also discussed with teachers how to implement the NCTM principles in the class, and modeled how to reflect on the problem solution, lesson plan, or a pedagogical event in actual teaching. The instructor explained that by sharing methods, discussing written work, and reflecting on problems and solutions, teachers could improve the understanding of goals for student learning.

*Supervision of workshops*

During the period of the study, an assistant researcher visited all of the workshops and observed how teachers were engaged in the process. Particular attention was paid to the requirements of participating in reflection discourse. Observations in both groups indicated that 84% of the teachers were involved in reflection discourse.

**Measures**

Three quantitative measures assessed teachers' outcomes (PCK assessment and delayed test, metacognitive knowledge, and beliefs).

*Teachers' PCK assessment*

At both the beginning and the end of the study, we administered a 12-item test adapted from Teo et. al., (2007), to all teachers. The test covered pedagogical issues ranging from the elementary level teaching unit on numbers, operations, and basic algebraic reasoning, referring to pedagogical planning or suggestions for teaching including: (1) presenting the topic (demonstrations, representations and justifications); (2) developing students' understanding (connecting concepts; identifying difficulties and justifications); and (3) fostering student-centered learning (active learning, self-opinion and theoretical justifications). The Appendix presents two PCK tasks. For each item, teachers received a score of either 3 (full answer-referring to the three criteria), 1 or 2 (partial answer-referring to one or two criteria) or 0 (incorrect answer), and a total score ranging from 0 to 36. We translated the scores to percentages. The Cronbach alpha reliability of the test coefficient was .86. The pre-test and post-test versions of these pedagogical knowledge tests shared similar but not identical contents and structure. The scoring criteria across time were consistent.

*PCK-delayed test*

The annual Israeli Ministry of Education end-of-year teacher assessment, administered 5 months after the intervention, assessed a large range of PCK tasks. The mathematical PCK test (14 open tasks) assessed various

pedagogical skills referring to the same mathematical topics like: suggesting a way to explain the topic; identifying students' errors and explaining reasons for them; identifying and analyzing alternative problem solving strategies; building connections between math concepts; and using different representations and demonstrations to teach a mathematical concept (see example items in the Appendix). The Ministry provided a total score in percentages for each teacher.

*Metacognitive knowledge and beliefs questionnaire*

A pre/post 54-item questionnaire assessed metacognitive knowledge and beliefs. The questions were based on the questionnaires of Montague and Bos (1990), Kramarski et al., (Kramarski & Mevarech, 2003; Kramarski & Mizrachi, 2006; Kramarski, 2008; Kramarski & Michalsky, 2009) and Schoenfeld (1992). The questionnaire contains three components: declarative, procedural and conditional knowledge. The declarative component referred to beliefs in teaching for understanding (e.g., 'Lessons in mathematics should based on formulating conjectures, not just performing exercises'); the procedural (e.g., 'during the problem solving process, I asked students for self-opinions and conclusions); and the conditional component (e.g., 'In the class discourse, I asked students to referre others' solutions').

Each item was constructed on a 5-point Likert type scale ranging from 1 (never) to 5 (always). The Cronbach alpha reliability of the questionnaire coefficient was .91; .87; 89, respectively for each component).

## Results

*Teachers' PCK in the context of problem solving*

The first purpose of the study was to examine mathematics teachers' PCK. Table 1 presents the mean scores, adjusted mean scores, and standard deviations based on teachers' PCK, by reflection approach. Effects of the training programs were observed with regard to their view in: Presenting the topic; developing students understanding; and fostering student-centred learning.

MANOVA results indicated that prior to the beginning of the study no significant differences existed between the two treatment groups in teachers' PCK. However, the post-test MANCOVA results indicated that teachers in the S_Q group significantly outperformed their peers in the R_D group, $F(3, 58) = 19.17$; $p < .0001$. Further ANCOVA results indicated differences between the two groups in two of the PCK criteria: Fostering student-centred learning, $F(1, 59) = 4.58$, $p < .01$ ($d = .65$), and developing students understanding, $F(1, 59) = 8.74$, $p < .01$ ($d = 1.14$). However, no significant differences emerged on using ways to present the topic, $F(1, 61) = .57$, $p > .05$ ($d = .24$).

**Table 1.** Means, adjusted means, standard deviations, F values, and Cohen's effect sizes (d[a]) on teachers' PCK, by treatment group[1] (S_Q vs. R_D) and time (pre-test/post-test)

| | Self-Questioning (S_Q) group $n = 30$ | | Reflection Discourse (R_D) group $n = 32$ | |
|---|---|---|---|---|
| | Pre | *Post* | Pre | Post |
| Presenting the topic | | | | |
| *M* | 84.50 | 88.38 | 85.36 | 87.02 |
| Adjusted *M* | | 87.63 | | 86.28 |
| *SD* | 2.45 | 2.76 | 2.87 | 5.76 |
| | | $d = 0.24$ | | |
| Student-centered learning | | | | |
| *M* | 76.62 | 89.41 | 75.83 | 82.34 |
| Adjusted *M* | | 88.27 | | 81.29 |
| *SD* | 15.21 | 7.89 | 15.97 | 10.72 |
| | | $d = 0.65$ | | |
| Students' understanding | | | | |
| *M* | 77.16 | 86.43 | 75.39 | 73.06 |
| Adjusted *M* | | 85.56 | | 72.63 |
| *SD* | 14.32 | 11.75 | 15.80 | 18.71 |
| | | $d = 1.14$ | | |

*Note.* Range: 0-100.

### *Teachers' metacognitive knowledge and beliefs*

Secondary purpose of the study was to investigate metacognitive knowledge and beliefs in the area of problem solving among elementary mathematics' teachers (S_Q and R_D). Table 2 presents the mean scores, and standard deviations based on metacognitive knowledge, by treatment group and time. Effects of the two training programs were observed regarding their declarative, procedural, and conditional knowledge.

**Table 2.** Means and standard deviations of metacognitive knowledge and beliefs by treatment group [2] and Time

| | Self-Questioning (S_Q) group $n = 30$ | | Reflection Discourse (R_D) group $n = 32$ | |
|---|---|---|---|---|
| | Pre | Post | Pre | Post |
| Declarative knowledge and beliefs | | | | |
| M | 3.72 | 3.84 | 3.68 | 3.81 |
| SD | 0.38 | 0.32 | 0.34 | 0.31 |
| | $d = 0.32$ | | $d = 0.38$ | |
| Procedural knowledge | | | | |
| M | 3.84 | 4.10 | 3.86 | 4.03 |
| SD | 0.28 | 0.32 | 0.31 | 0.30 |
| | $d = 0.93$ | | $d = 0.55$ | |
| Conditional knowledge | | | | |
| M | 3.86 | 4.10 | 3.80 | 3.89 |
| SD | 0.36 | 0.33 | 0.35 | 0.34 |
| | $d = 0.67$ | | $d = 0.26$ | |

[1]Range: 1-5.

The data was analyzed by MANOVA for the pre-test, and Repeated Measures for the post-test. In addition, the effect-size ($d$) was calculated by the difference between the means of the pre-test and post-test divided by the standard deviation of the total pre-test.

A multilevel analysis of variance (MANOVA) indicated that prior to the beginning of the study no significant differences were found between the S_Q and R_D teachers in metacognitive measures, $F(2, 59) = 1.82$, $p > .05$. Further analysis of two-way Repeated Measures of variance [groups (2) by time (2)] indicated significant differences in the main effect of time for the declarative knowledge, $F(1, 59) = 12.43$, $p < .01$, procedural knowledge $F(1, 59) = 9.34$, $p < .01$, and conditional knowledge, $F(1, 59) = 6.81$, $p < .01$).

However, a significant interaction was found between groups and time for procedural knowledge, $F(1, 59) = 9.68$, $p < .01$, and conditional knowledge, $F(1, 59) = 7.86$, $p < .01$). The findings indicated that at the end of the study the S_Q teachers improved significantly more in their application of procedural knowledge and conditional knowledge ($d$ = .93; .67), compared to the R_D teachers ($d$ = .55; .26 respectively for procedural and conditional knowledge). We found no significant differences between treatment group and time in improving the use of declarative knowledge in the area of metacognitive knowledge and beliefs in teaching with problem solving approach, $F(1, 59) = .35$, $p > .05$).

*PCK–delayed test*

ANOVA results indicated significant differences between the two groups at the delayed test. The S_Q teachers outperformed the R_D teachers on PCK (S_Q: $M = 82.75$, $SD = 13.45$; R_D: $M = 70.69$, $SD = 13.42$; $F(1, 60) = 10.25$, $p < .01$; $d = .89$).

## Discussion

Findings indicated that systematic reflection support based on IMPROVE's self-questioning (S_Q) is effective for developing PCK in the context of mathematics problem solving. In addition, systematic reflection supports strengthen metacognitive knowledge and beliefs of mathematics teachers more than reflection discourse support. These findings support previous conclusions that self-questioning strengthens pre-service teachers' metacognition and pedagogical ability (Kauffman, et al., 2008; Kramarski & Michalsky, 2009). Our findings highlight the importance of self-questioning support in the different stages of life long learning of mathematics teachers, in the preparation stage as pre-service teachers, and in professional development training as in-service teachers (PISA, 2003).

We suggest two reasons to explain the beneficial effects of S_Q support. Self-questioning encourages students to reflect on their goals, their understanding, making links, and restructuring ideas. Perhaps the systematic explicit use of the questions enable the student to walk through the activities step-by-step, thereby helping students monitor and evaluate

their learning processes. This ability, in turn, affected their metacognitive knowledge and PCK (Davis, 2003; Kramarski & Michalsky, 2009; in press). This conclusion is in line with other researchers who argued that directed support may act as a "more able other," prodding students to consider issues they may not have considered otherwise (Nuckles, et al., 2009; Vygotsky, 1978). In contrast, the reflection discourse exposed the teachers to an open dialogue that enabled them to learn new ideas and pedagogical solution strategies; however such open dialog might increase their cognitive load thereby causing difficulties in integrating ideas and solutions that were raised in the group.

*PCK in mathematical problem solving context*

The current findings concerning PCK indicated that teachers of the S_Q were more successful in integrating content with pedagogy in a deeper level than the R_D group, as found in a test administered immediately after the end of the study, and in a delayed test (government assessment). The S_Q group teachers based their pedagogical considerations and beliefs about student-centred learning (i.e., self-opinions, conclusions, and theoretical justifications) and learning for understanding (i.e., connecting between concepts and identifying difficulties). No differences were found between the two groups on ways of presenting the topic in the class (demonstration, representations and justifications). In contrast, the R_D group teachers focused more on how to transmit the topic without explicit emphasis on students understanding and justifications about their choices.

We suggest two reasons for the beneficial effect of S_Q support on PCK. First, discourse on why and how questions seemed to foster teachers' understanding of task demands and pedagogical decisions. Second, the explicit opportunity to elaborate on different perspectives of problem solving, as both students and teachers, prompted teachers to focus more on deep understanding of task demands and on a student-centred teaching approach in their pedagogical approach. These findings are in line with previous studies that emphasized the importance of using self-questioning in multiple perspectives in learning and teaching (Kramarski et. al., 2001; Kramarski & Michalsky, in press; Kramarski & Revach, in press; Xiaodong et. al., 2005).

*Metacognitive knowledge and beliefs*

Findings on the three components of metacognitive knowledge, self-reported questionnaire indicated that providing teachers with reflection support in both groups (S_Q and R_D) was beneficial in promoting metacognitive knowledge components (declarative, procedural and conditional). However, the effects of S_Q support was remarkable in the metacognitive higher order knowledge (procedural and conditional knowledge). Furthermore, the findings indicated that both approaches were less effective in changing the declarative knowledge and beliefs component, in comparison to the procedural and conditional components. The slight improvement of beliefs

support other conclusions that beliefs are stable and difficult to change (Pajares, 1992; Richardson, 1996; Thompson, 1992).

We found no differences between the two reflection supports in their declarative knowledge and beliefs. At the end of the study, teachers in both groups perceived mathematics as a process of problem solving and reasoning, rather than a set of unrelated facts, rules, and skills. This finding is in line with previous research on pre-service teachers in a Web-based learning environment that shows that IMPROVE's self-questioning strengthens teachers' perceptions about students' ability to construct knowledge with student-centred learning approach (Kramarski & Michalsky, 2009).

The findings indicated minimal improvement of metacognitive conditional knowledge ($d$ = .26) among the R_D teachers. This finding suggests that although the R_D teachers improved their pedagogical beliefs ($d$ =.38), they didn't know when and how to transfer such beliefs into practice. The findings support the conclusion that, teachers' simple sharing of methods, discussion of written work, and reflection on problems, solutions, and beliefs (based on standards in mathematics learning as observed in the R_D group), do not ensure that teachers understand how those standards benefit performance. Obviously, such understanding is critical for optimal use of those standards in classroom instruction (e.g., Kramarski & Revach, in press; Xiaodong et. al., 2005). Current metacognitive knowledge and beliefs outcomes for the two approaches substantiate previous research which concluded that explicit support is necessary for combining beliefs and construction of new knowledge in teachers training programs (Pajares, 1992; Richardson, 1996; Thompson, 1992).

## Implications, further research, and limitations

This study contributes to teachers' theoretical research by examining the role of reflection support in mathematics professional training. To support the vision of the NCTM standards in the mathematics classroom, teachers' professional training programs are being called upon to model different teaching support for understanding and to help teachers develop their knowledge of content, and pedagogy. In particular, it is suggested that educators focus on the importance of helping teachers to become more aware of how their knowledge, beliefs, and actions influence students' learning (Kramarski & Revach, in press).

There are two inherent limitations in this study. First, the present implementation of each support by only one group could be confounded with the instructional support. To strengthen the current claims, further research should examine the effects of reflection support on larger samples of teachers and should expand observations of teachers' class practice. To generalize the present findings, future studies should follow up on the long-term effects of reflection support by explicitly investigating teachers'

professional knowledge on various topics and tasks. These tests should be implemented at different time intervals (e.g., one or two years after intervention).

Second, our study investigated relations between reflection support and cognitive variables (pedagogical and metacognitive knowledge). In addition, the study investigated the development of teachers' beliefs toward problem solving. Future research should be conducted to investigate the proposed relationship between other kinds of beliefs and affective variables and teachers' professional development (Farmer, et. al., 2003).

The present research findings add complementary perspectives to the literature on teachers' professional knowledge, by associating teachers' PCK with metacognitive knowledge and beliefs under reflection support. However, the study does not supply data about student outcomes obtained by the participating teachers. Future studies would do well to examine the assumption that teachers' SRL is extremely important to their success in teaching (Perry et. al., 2006; Randi & Corno, 2000). Toward this end, teachers with varying levels of SRL should be observed, and the data should be correlated to students' understanding, achievement data, and attitudes towards mathematics.

Furthermore, considering the complex nature of professional development in mathematics teaching (Hill et al., 2005), it may be useful to pay attention to the measurement of quality in assessing professional development by using different kinds of complementary methods and styles of coding. Offline (questionnaires) and online (actual teaching) methods such as thinking aloud, observations, and interviews, may shed further light on the benefits of reflection support. In conclusion, we underscore the need to further investigate how to enhance mathematical professional development with reflection support in professional training programs.

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# Metacognition, study habits and attitudes

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**Abstract**

This study is conducted to investigate the relationship between fifth grade students' metacognition levels, and their study habits and attitudes. Participants of the study consist of 221 students, 125 female and 96 male, enrolling to six public primary schools in Turkey. The results revealed that there is a medium positive relationship between metacognitive knowledge and skills and study habits ($r$ = .351, $p$ < .05), study attitudes ($r$ = .415, $p$ < .05) and study orientation ($r$ = .434, $p$ < .05). Additionally, the results of the study showed that there is no significant relationship between metacognition and study habits and attitudes for low and medium achievers but, there is a significant relationship for high achievers.

**Keywords:** *metacognition, study habits, study attitudes, study orientation*

## Introduction

Conscious individuals will be able to take part in society only if they are armed with self-knowledge ability (Morin, 2003). The efforts for educating conscious individuals began to follow a more meaningful trend, with appearance of metacognition and the studies done in this connection. Learners usually have some problems in deciding the amount of time they

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have to allocate for different tasks during studying. To decide the amount of time required for the tasks, learner monitors his/her learning, make decisions regarding the extent to which items have been learned and controls the amount of time allocated based on these decisions. Basically, monitoring and control occurred during the learning process are the two main components of metacognition (Nelson & Narens, 1990).

Flavell defines metacognitive processes as "one's knowledge concerning one's own cognitive processes and products . . . the active monitoring and consequential regulation of those processes in relation to the cognitive objects or data on which they bear" (Flavell, 1976, p. 232). It is observed that modern studies discuss the metacognition under two main headings: Metacognitive knowledge and metacognitive control (Flavell, 1979; Nelson & Narens, 1990; Otani & Widner, 2005; Sungur, 2007). Metacognitive knowledge, in one case, refers to one's knowledge and beliefs in his mental resources and his awareness about what to do. Metacognitive knowledge means one's own cognitive skills; own cognitive strategies and knowledge about what to do under which circumstances (Flavell, 1979). Metacognitive knowledge requires one to accurately and exactly define his/her thought or knowledge. An individual's ability in problem solving depends on effective use of his/her knowledge. If an individual does not have a decent perception about his/her knowledge, (s)he can consider, for example, being a successful student in problem solving as a hard work. In other words, approaches to the problem and insights into how to solve a problem is related to how accurately an individual assesses his/her knowledge (Flavell & Wellman, 1977). However, metacognition requires one, besides the knowledge mentioned above, to use this knowledge effectively. The ability to use metacognitive knowledge, on the other hand, is called metacognitive control.

Also called metacognitive strategies, the metacognitive control skills consists of leading mental operations in metacognitive processes and can be defined as the ability to use the metacognitive knowledge strategically in order to attain cognitive objectives (Desoete, 2008; Schraw & Moshman, 1995). The literature focuses on four metacognitive skills; prediction, planning, monitoring and evaluation (Brown, 1980, Desoete, Roeyers & Buysse, 2001; Desoete & Roeyers, 2002; Lucangeli & Cornoldi, 1997).

Metacognitive control/regulation is considered as the ability to use knowledge to regulate and control cognitive processes. Metacognitive control is related with metacognitive activities that help to control one's thinking or learning (Ozsoy, 2008). Students having the prediction skill think about the learning objectives, proper learning characteristics, and the available time. Prediction skill enables students to predict the difficulty of a task, by this way they use that prediction to regulate their engagement related to outcome. The selection of appropriate strategies and allocation of resources closely related with the prediction skill (Desoete, 2008). Monitoring refers to one's on-line awareness of comprehension and task performance. The ability to engage in periodic self-testing while learning is a good example (Winnie,

1997). Students having the evaluation skill appraise the products and regulatory processes of their learning. Students can re-evaluate their goals and conclusions. Evaluation enables students to evaluate their performance on the task, students can compare their performances with each other and they can use the result of comparison to locate the error in the solution process (Lucangeli, Cornoldi, & Tellarini, 1998).

Students with high metacognitive and self-regulatory abilities actively involve in their own learning process, plan and monitor the task they are focusing on, their own study attitudes and the task and the study attitudes fits together (Zimmerman &Martinez-Pons, 1986).

Forming study strategies that are effective in learning is a very important step in a child's educational development. To make effective study decisions, the child should have ability to differentiate the level of difficulty to learn the items. Research studies showed that this ability is fundamental for strategy formation during study (Son & Metcalfe, 2000; Son, 2004; Thiede & Dunlosky, 1999). Besides, seeking assistance from peers and teachers, having high self-efficacy and effective time management skills and being self-motivated are the characteristics of self-regulated learners (Ley & Young, 1998).

*Study habits*

In the literature, study skills are usually defined as students' ability to manage time and other resources to complete an academic task successfully. 'Study habit' is the amount and kinds of studying routines which the student is used during a regular period of study occurred in a conducive environment. Crede and Kuncel (2008) defines study habit as study routines, including, but not restricted to, frequency of studying sessions, review of material, self-testing, rehearsal of learned material, and studying in a conducive environment. Lastly, students' attitudes toward the act of studying (Crede & Kuncel, 2008) are referred as 'study attitudes'.

There are many factors affecting study orientation expressive of study habits and attitudes of students. Individual differences, effective usage of time, note-taking, study habits training, teacher, family, proper study environment, homework, using library, reading-listening and writing are outstanding common factors. However, interest and will are very important for study habits and attitudes. *Individual differences* can be analyzed in terms of control focus, gender, success dimensions. When the study habits are analyzed in terms of control focus it is revealed that students who have inner control do not need to be controlled too often when they undertake an assignment but students who are controlled with outer factors need guidance and encouragement too often (Bacanli, 2002: 133). Prociuk and Breen (1974) examined the relation between control focus (inner-outer), study habits and attitudes, and academic performance; they stated that there is a positive relation between them. When the differences are examined in terms of gender, it is revealed that female students are more

successful academically than male students and they have better study habits and attitudes (Arslantas, 2001; Brown & Holtzman, 1984; Grabill et al., 2005; Gadzella & Fournet, 1976; Hong & Lee, 2000; Houtte, 2004; Kucukahmet, 1987; Mullen, 1995; Tinklin, 2003). However, the result that students who have proper study habits and attitudes are also successful academically are evident according to many studies (Agnew et al., 1993; Arslantas, 2001; Carter, 1999; Elliot et al., 1990; Gordon, 1997; Jones et al., 1993; Kleijn et al., 1994; Lammers et al., 2001; Lawler-Prince et al., 1993; Schultz, 1989; Slate et al., 1990; Sunbul et al., 1998; Ulug, 1981).

*Effective usage of time* means reaching objectives without losing time when a person started to study (Telman, 1996: 40). Deficiency of skills in terms of effective time management is one of the most important problems of study habits (Glenn, 2003). Cusimano (1999) emphasizes that effective time management is very important for success. The first step of effective time management is making a plan and conforming to it (Ulug, 2000: 48). While being planned is so important for study habits of students, according to a study by Zeyrek et al. (1990) students between the ages of 16-21, only 18% have positive features in terms of organization and planning.

*Note taking* is an important dimension of study habits. Students who use proper study habits containing note taking and studying that notes, can preserve knowledge for longer time (Eliot et al., 2002). Oguz (1999), found a significant difference between the students who received note-taking training, taking notes at lessons and reviewing the notes and students who attending lessons without receiving note-taking training. Studies point out that effective note-taking increases students' success at lessons (Austin, Lee & Carr, 2003; Bretzing et al., 1987). However, many of the students prefer to take the notes of their friends (Wolff, 2001: 11).

*Present study*

The purpose of this study is to investigate the relationship between fifth grade students' metacognitive knowledge and skills and their study habits and attitudes. Besides, this study is also dealing with investigating how this relationship changes with students' GPA levels.

## Method

*Participants*

Fifth grade elementary school students enrolling to six schools in Zonguldak, a medium sized city on northwest coast of Turkey, participated in the study. Participants of the study have been comprised of 221 fifth grade students. Participants' profile has been drawn out by the analysis of demographic questions asked in 'Survey of Study Habits and Attitudes' (SSHA). Gender, age and parents' educational level are asked to gather the related data. There are 125 girls forming the 56.6% of the total sample and 96 boys forming the 43.4% of the total sample. The ages of participants

changed between 10 and 13 and the mean age of the students was 11.28. Table-1 summarizes participants' demographic characteristics.

**Table 1.** Participants' demographic characteristics

| | *n* | % |
|---|---|---|
| *Gender* | | |
| Male | 96 | 43.4 |
| Female | 125 | 56.6 |
| *Mother's Educational Level* | | |
| No graduate | 13 | 5.9 |
| Elementary school | 153 | 69.2 |
| High school | 37 | 16.7 |
| University | 1 | 0.5 |
| Missing | 17 | 7.7 |
| *Father's Educational Level* | | |
| No graduate | 3 | 1.4 |
| Elementary school | 110 | 49.8 |
| High school | 70 | 31.7 |
| University | 18 | 8.1 |
| Missing | 20 | 9.0 |

*Instruments*

*Metacognitive Skills and Knowledge Assessment (MSA-TR).* In order to assess students' metacognitive knowledge and skills an adapted version of MSA (Metacognitive Skills and Knowledge Assessment) was used. The MSA was developed by Desoete, Roeyers and Buysse (2001) and adapted into Turkish by Ozsoy (2007). It is a multi-method inventory in which the predictions are compared with the student performance as well. The MSA assesses two metacognitive components (knowledge and skills) including seven metacognitive parameters (declarative, procedural, and conditional knowledge, and prediction, planning, monitoring, and evaluation skills (Desoete, Roeyers & Buysse, 2001). The inventory consists of 160 items and through this inventory a student can score a minimum point of 0 and a maximum point of 360. During the development process of the inventory (MSA), test-retest correlation has been found as $r = .81$ ($p < .05$) (Desoete, Roeyers & Buysse, 2001). To examine the psychometric characteristics of the metacognitive parameters, Cronbach alpha reliability analysis was conducted by the researchers. For declarative knowledge, procedural knowledge, and conditional knowledge Cronbach alphas were .66, .74, and .70, respectively. For prediction, planning, monitoring, and evaluation Cronbach alphas were .64, .71, .87, and .60, respectively (Desoete, Roeyers & Buysse, 2001). During the adaptation of the instrument into Turkish, Ozsoy (2007) found test-retest correlation as .85 ($p < .05$). Cronbach's alpha values of MSA-TR were calculated as .71 for declarative knowledge, .70 for procedural knowledge, and .79 for conditional knowledge and for prediction, planning, monitoring, and evaluation as .73, .78, .80, and .76 respectively (Ozsoy, 2007).

*Survey of Study Habits and Attitudes (SSHA).* Participants' study habits and attitudes were assessed by administering "Survey of Study Habits and Attitudes" (SSHA) developed by Brown and Holtzman (1965) and adapted into Turkish by Memis (2007). The SSHA consists of 100 items that are arranged into four 25-item subscale named as 'work methods (WM)', 'delay avoidance (DA)', 'teacher acceptance (TA)' and 'educational acceptance (EA)'. SSHA is a 5-point Likert-type scale test. For each statement, the following scale is provided for indicating whether the student does or feels as the statement suggests: rarely, sometimes, frequently, generally and almost always. The subscales are used to formulate two subtotals; summation of scores obtained from WM and DA forms a score for 'study habits (SH)' and the total score obtained from the summation of TA and EA yield a 'study attitudes (SA)' score. The sum of all subscales is labelled 'study orientation (SO)'. Brown and Holtzman (1967) reported test-retest reliability scores for a four-week-interval for each subscale as .93, .91, .88 and .90 for the DA, WM, TA and EA subscales, respectively. During the adaptation process, statements are simplified and clarified and some of them are extracted to make the application of the instrument appropriate for fifth grade students. The last version of the study consists of 52 items with 13 items in each subscale. The Cronbach's alpha value for the instrument is calculated as .90. Each of the subscales has a maximum raw score of 26. The maximum raw score that can be obtained for study habits and study attitudes is 52 and for study orientation is 104.

*Achievement.* Achievement scores of participants are determined by grade point average (GPA). Participants are grouped into low, average and high achievers according to their GPA scores. In this grouping, for this study, low achievers ($n$ = 28) were defined as those who obtained GPA scores between 0 and 54. Participants who obtained GPA scores between 54 and 69 were defined as average ($n$ = 61) and those who obtained GPA scores between 70 and 100 were defined as high achievers ($n$ = 135).

*Procedure*

The study was carried out during the spring semester of 2009. The SSHA and the MSA-TR were administered to the participants on different days. Participants completed instruments independently. Data obtained from instruments were then organized into sub-scores and total scores for each instrument. Pearson $r$ correlation coefficients were computed between total scores on each instrument and between various combinations of sub-scores and total scores.

## Results

*Metacognitive knowledge and skills*

Analysis of the data obtained from MSA-TR revealed that participants obtained a mean score of 18.35 ($SD$ = 7.55) from declarative knowledge subscale and 17.95 ($SD$ = 7.07) from procedural knowledge subscale. For both of these subscales possible maximum score that can be obtained from

the instrument is 40. For the conditional knowledge subscale, possible maximum score that can be obtained is 60 and mean of participants' scores gathered from this part is 33.24 (*SD* = 12.98). The results did not differ too much for the subscales of metacognitive skills part. Mean of participants' scores obtained from the prediction subscale is 21.91 (*SD* = 10.46) and from the planning subscale is 12.52 (*SD* = 9.42). For both of these subscales maximum possible score that can be obtained is 60. For the other two subscales of metacognitive skills; evaluation and monitoring, participants obtained mean scores of 21.91 (*SD* = 12.73) and 21.18 (*SD* = 6.56) respectively. For both of these subscales possible maximum score that can be obtained is 40. Table 3 represents the descriptive statistics obtained from the analysis of MSA-TR scores.

**Table 3.** Analysis of the scores obtained from MSA-TR (*n*=223)

| | Min. | Max. | *M* | *SD* | PMS |
|---|---|---|---|---|---|
| Metacognitive knowledge | | | | | |
| *Declarative knowledge* | 0 | 37 | 18.35 | 7.55 | 40 |
| *Procedural knowledge* | 0 | 35 | 17.95 | 7.07 | 40 |
| *Conditional knowledge* | 6 | 70 | 33.24 | 12.99 | 80 |
| Metacognitive skills | | | | | |
| *Prediction* | 2 | 52 | 21.91 | 10.46 | 60 |
| *Evaluation* | 0 | 57 | 21.18 | 12.73 | 40 |
| *Monitoring* | 1 | 37 | 22.90 | 6.56 | 40 |
| *Planning* | 0 | 40 | 12.52 | 9.42 | 60 |
| Total | | | 148.32 | 43.39 | 360 |

* PMS: Possible maximum score.

### *Survey of Study Habits and Attitudes*

Analysis of the scores obtained from SSHA revealed that participants obtained a mean score of 17.02 (*SD* = 5.59) from WM subscale, 119.00 (*SD* = 8.91) from DA, 17.95 (*SD* = 5.41) from TA and 16.83 (*SD* = 5.08) from EA. Possible maximum score that can be obtained from subscales of SSHA is 26. Participants obtained a mean score of 33.36 (*SD* = 12.26) from SH and 34.78 (*SD* = 9.57) from SA. Possible maximum score that participants can obtain from both parts is 52. From the SO participants obtained a mean score of 68.14 (*SD* = 19.11) and possible maximum score that can be obtained is 104. Table 4 displays the descriptive statistics obtained from the analysis of SSHA scores.

**Table 4.** Analysis of the scores obtained from SSHA ($n$ = 223)

| | Min. | Max. | *M* | *SD* | PMS |
|---|---|---|---|---|---|
| Study Habits | 10.00 | 139.00 | 33.363 | 12.259 | |
| *Work Methods* | .00 | 26.00 | 17.018 | 5.597 | 26 |
| *Delay Avoidance* | 3.00 | 119.00 | 16.345 | 8.916 | 26 |
| Study Attitudes | 6.00 | 51.00 | 34.776 | 9.576 | |
| *Teacher Approval* | .00 | 26.00 | 17.946 | 5.406 | 26 |
| *Educational Acceptance* | 4.00 | 26.00 | 16.830 | 5.088 | 26 |
| Study Orientation | 25.00 | 179.00 | 68.139 | 19.115 | |

*Relationship investigation*

The relationships between metacognitive knowledge and skills, as measured by the MSA-TR, and study habits and attitudes, as measured by SSHA, were investigated using Pearson product-moment correlation coefficients. The results revealed that there is a medium positive relationship between metacognitive knowledge and skills and study habits ($r$ = .35, $p$ < .05), study attitudes ($r$ = .42, $p$ < .05) and study orientation ($r$ = .43, $p$ < .05).

Correlation coefficients are also calculated to investigate the relationship between metacognitive knowledge and skills and study habits and attitudes for participants' with different achievement levels (See Table 5).

**Table 5.** Correlation coefficients of MSA-TR and SSHA scores

| *Low achievers (n = 28)* | | |
|---|---|---|
| MSA-TR | SSHA | *r* |
| MSA-TR | Study Habits | .12 |
| MSA-TR | Study Attitudes | .13 |
| MSA-TR | Study Orientation | .15 |
| *Average achievers (n = 59)* | | |
| MSA-TR | Study Habits | -.09 |
| MSA-TR | Study Attitudes | .13 |
| MSA-TR | Study Orientation | .03 |
| *High achievers (n = 136)* | | |
| MSA-TR | Study Habits | .24* |
| MSA-TR | Study Attitudes | .38* |
| MSA-TR | Study Orientation | .35* |

* Correlation is significant at the.05 level.

For low achievers, the Pearson correlation coefficients revealed that the relationship between the variables is small, positive and non-significant. For

average achievers, the relationship between total score obtained from MSA-TR and study habits was small and negative. For study attitudes and orientation there exists a positive and small relationship with MSA-TR. All the correlation coefficients obtained for average achievers are found as non-significant. Lastly, the Pearson coefficients for high achievers show that all the relationships existing between total score of MSA-TR and subscales of SSHA are positive, medium and significant. Table 5 represents the correlation matrix of MSA-TR and SSHA scores for low, average and high achievers.

**Discussion**

This study deals with principally with the relationship between the participants' metacognitive knowledge and skills obtained by (MSA-TR) and their study habits and attitudes obtained by (SSHA).

Firstly, the scores of MSA-TR scale which was applied in order to evaluate students' metacognitive knowledge and skills, revealed that students have medium-level in terms of metacognition. This situation can be normal because the metacognitive development is associated with age (Schneider & Lockl, 2002) and study group is composed of fifth grade (mean age 11.28) students. On the other hand, metacognitive levels of students are compatible with the results of the measure conducted with the same age group (Ozsoy, 2007; Ozsoy & Ataman, 2009).

When the results of the SSHA which was used in order to define the study habits and attitudes, students' study attitude scores are lower than study habits. Delay avoidance subscale which measures organized and systematic studying, means being accurate and avoiding delay during studying. Teacher approval is a subscale in study attitudes. In this subscale, Students evaluate various criteria about their teachers. The findings are compatible with the results of measurements (Memis, 2005) conducted with same scale and same age group in terms of general averages of both sub-categories.

When the results of both scales are compared, there is a significant relation between the metacognition scores and SSHA scores of students in medium level. Metacognition scores are significantly related to both study habits and study attitudes. Metacognition is explained theoretically and it points out the self-knowledge and ability of individual to control cognitive processes of him/her with the knowledge. Students with high levels of metacognitive knowledge and skills can direct their own learning process successfully and therefore have high levels of study habits and attitudes. This is a predictable situation. Because a student with such a self-awareness would know how to work in certain conditions what (s)he would need and would organize the study attitudes accordingly. The results of the study are compatible with this theoretical prediction.

On the other hand, relations between the test scores of students are compared according to success levels of students. According to the comparison, there is a significant relation between the MSA-TR scores and

SSHA scores of successful students; but, there is not a significant relation between the scores in students with medium-low success rates. According to former studies, both metacognition (McDougall & Brady, 1998; Naglieri & Johnson, 2000; Ozsoy, 2009; Teong, 2002; Victor, 2004), and SSHA results (Memis, 2005) are related in terms of student achievement. Therefore, results of the study are compatible with former studies.

While former studies point out that there is a significant relation between metacognition and academic achievement (Case, Harris & Graham, 1992; Desoete & Roeyers, 2002), traning of metacognitive skills also increases the achievement (Kramarski, Mevarech & Arami, 2002; Lioe, Fai & Hedberg, 2005; McDougall & Brady, 1998; Schoenfeld, 1985; Schurter, 2002; Teong, 2002; Victor, 2004). However, according to literature review, there is not a study about the relation between metacognition and study habits and attitudes. Relational data acquired from the present study point out that metacognition is not only important for achievement but also for study habits and attitudes of students. Therefore we hope that present study should shed light for the following studies in the field.

• • •

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# Calibration of comprehension and performance in L2 reading

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**Abstract**

Comprehension monitoring is crucial for successful reading. Although the researchers appreciate the importance of comprehension monitoring in L2 reading, there are only a few studies done on the comprehension monitoring ability of L2 readers. The main aim of this study was to investigate the comprehension monitoring abilities of university students while reading expository texts in L2. The results showed that the students' were not able to calibrate their comprehension at above chance level whereas they were able to calibrate their performance. The results were discussed comparative to findings from earlier research in L1 reading.

**Keywords:** metacomprehension, second language, calibration

## Introduction

Metacognition refers to any "any knowledge or cognitive activity that takes as its object, or regulates, any aspect of any cognitive enterprise" (Flavell, 1979). There are two facets of metacognition identified by many researchers namely, metacognitive knowledge and metacognitive skills (Baker & Brown, 1984; Veenman, 2005; Veenman & Elshout, 1995). Metacognitive knowledge is what we know about the operations of our cognition (Flavell, 1979; Pintrich, 2002). This knowledge allows us to contemplate our planning, goal setting, processing of tasks, monitoring of progress, and recognition and

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repair of problems (Grabe & Stoller, 2002). Metacognitive skills are series of activities that support the individuals in controlling their own learning processes (Schraw, 2002). Metacognitive monitoring, that refers to a person's on-line awareness of his or her own cognitive processes (Dunlosky & Lipko, 2007; Pieschl, 2009) is an important metacognitive skill (Nietfeld, Enders, & Schraw, 2006; Pieschl, 2009). Metacognitive monitoring enables learners to assess their performance and use appropriate fix-up strategies in case of failure (Schraw & Moshman, 1995). Accurate metacognitive monitoring is crucial for successful reading (Cromley, 2005; Dunlosky & Lipko, 2007; Wiley, Griffin, & Thiedei, 2005; Zhao & Linderholm, 2008).

*Comprehension Monitoring*

Comprehension monitoring, which is a form of metacognitive monitoring (Baker & Brown, 1984), is the readers' awareness of the degree to which they understand what they are reading. If readers believe that they have understood the text well, there is no reason for them to go on processing. However, if the reader believes that he fails to comprehend, this awareness leads to the reprocessing of the text. Therefore, monitoring of comprehension is a prerequisite for the effective implementation of comprehension strategies (Kimmel & MacGinitie, 1984). Inaccuracy in comprehension monitoring judgements leads to uncorrected errors in comprehension. Learners with poor comprehension monitoring will not be able to use their judgements to correct their errors and guide their learning appropriately (Nietfeld, Enders & Schraw, 2006).

The three paradigms, widely used by the researchers studying metacognitive monitoring in reading are error detection (e.g., Kolic-Vehovec & Bajsanski, 2006; Otero, Campanario & Hopkins, 1992; Zabrucky & Moore, 1994), calibration of comprehension and calibration of performance (e.g., Dunlosky & Rawson, 2005; Glenberg & Epstein, 1985; Lin & Zabrucky, 1998; Miesner & Maki, 2007; Lin, Zabrucky & Moore, 2002). In error detection paradigm, subjects read a text containing syntactic, lexical and/or semantic errors, and their comprehension monitoring behaviour is assessed by their ability to detect these inconsistencies (Otero, Campanario, & Hopkins, 1992).

In calibration of comprehension paradigm, students read a text and then are asked to make metacognitive judgements before answering the questions (e.g. Epstein, Glenberg, & Bradley, 1984; Glenberg & Epstein, 1985). Among the metacognitive judgement types that are mostly studied are; task difficulty or ease of learning judgements (EOL), learning and comprehension monitoring or judgements of learning (JOL), and confidence judgements (CJ). In EOL, the calibration of comprehension is the relation between easiness and performance. In JOL, it is the relation between understanding level and performance. In case of CJ, it is the relation between predicted performance and actual performance (Lin, Moore & Zabrucky, 2001). In calibration of performance paradigm, students read a

text, answer the questions related to the text and judge how sure they are about the accuracy of their answers. Calibration of performance is the relation between performance judgements and actual performance (e.g. Nietfeld, Cao, & Osborne, 2005; Zabrucky, Agler, & Moore, 2008). In the present study two of these paradigms, *calibration of comprehension* and *calibration of performance*, were used.

*Comprehension Monitoring in L1 Reading*

Comprehension monitoring in L1 reading is a widely researched topic. Early studies, using calibration paradigms, showed that readers were not able to judge their comprehension levels accurately. Glenberg and colleagues reported that their readers' comprehension monitoring judgements are far from being accurate. Gamma correlations between confidence judgements and performance scores were never higher than .20 and only differed from zero by chance. Readers often overestimate how much they have comprehended (Glenberg & Epstein, 1985, 1987; Glenberg, Sanocki, Epstein, & Morris, 1987). In a study by Weaver and Bryant (1995), it was reported that under certain conditions Gamma correlation coefficient reached .35 level. Maki (1995) reported that Gamma correlations between reading performance and comprehension judgements of adult readers were never higher than 0.27. In 36 different studies carried out in Dunlosky laboratory, similar results were obtained (Dunlosky & Lipko, 2007). Lin, Moore and Zabrucky (2001) assessed their students' calibration performance using the students' pre-test judgements of understanding, confidence, easiness and interestingness. The researchers reported that the students were able to calibrate their comprehension at above chance level. The mean Gamma correlation coefficients were .15, .14, .14 and .14 for understanding judgements, confidence judgements, easiness judgements and interestingness judgements respectively. Although the students were able to calibrate their comprehension at above chance level, their calibrations were still very low.

With regard to the relation between comprehension monitoring and reading performance, research results suggest a weak link between these variables. According to Cavanaugh and Perlmutter (1982) and Pressley and Schneider (1997) there is no strong empirical evidence linking monitoring accuracy to measures of reading comprehension. In a study by Begg, Martin, and Needham (1992), the relation between accuracy and test performance were investigated. They found that participants that less accurately monitored their learning were more successful than participants that more accurately monitored their learning. Several studies by Dunlosky and his colleagues (Dunlosky & Connor, 1997; Connor, Dunlosky & Hertzog, 1997) had similar results. Their research showed that the groups that differed in performance did not differ in monitoring accuracy. In a study by Lin, Moore and Zabrucky (2001), students' understanding, confidence, easiness, and interestingness judgements did not correlate with their reading performance, indicating that good comprehenders were not necessarily good

monitors, or vice versa. In contrast, Metcalfe (2009) asserted negative correlations between accuracy of metacognitive monitoring judgements and study time allocation found in most studies in their laboratories. According to Metcalfe (2009) accurate metacognitive monitoring judgements are prerequisites of successful learning. Accurate metacognitive monitoring judgements lead to successful learning but only with the provision that the learners/readers are able to use this information to determine their study behaviours i.e. implementing appropriate strategies. In a similar vein, Thiede, Anderson and Therriault, (2003) study indicated that learners with accurate monitoring judgements study more strategically and become more successful.

*The Present Study*

Although metacognition is a research area deemed important by L2 reading researchers, most studies are limited to pedagogical interventions and strategy use reading (Morrison, 2004). Comprehension monitoring in L2 is rather a "neglected essential", as stated by Casanave (1988), for L2 reading researchers.

According to Casanave (1988), comprehension monitoring in L2 reading is neglected because most L2 reading studies are schema theory-driven. According to the schema theory, people adjust their memories of a culturally unfamiliar story to fit a "schema" that is more consistent with their own culturally familiar knowledge of the typical content and structure of stories. This theoretical view caused L2 reading researchers to deal more with the effects of content and structure of texts on reading comprehension of L2 readers and to neglect what the readers do while trying to comprehend the text in L2.

Block (1992), who underscored the importance of comprehension monitoring in L2 reading, asserted various reasons for this importance. Firstly, L2 readers may be able to reflect on their cognitive processes. This awareness, then, brings about more appropriate judgements when reading in L2 than reading in L1. Secondly, reading in L2 is more difficult than reading in L1 as L2 readers encounter more unfamiliar language and need more awareness of the reading processes in order to use appropriate fix-up strategies when they experience comprehension failure.

Not more than a few studies can be found on the metacognitive monitoring processes of readers while reading texts in L2. It can also be seen that there are only a few studies done on the comprehension monitoring ability of L2 readers and that the researchers have used only the error detection paradigm in those studies.

What has especially compelled the researchers of the present study to further investigate this subject is that little is known about the calibration accuracy in L2 reading, while much more is known about L1 reading. Therefore, the first aim of this study is to examine students' accuracy of calibration of comprehension and calibration of performance in L2 reading.

For the calibration of comprehension, three indices were used; namely, Judgement of Learning (JOL), Ease of Learning (EOL) and pre-test Confidence judgements (PreCJ). For the calibration of performance, students' post-test Confidence judgements (PostCJ) were used. The second aim of the study is to investigate the intercorrelations between different calibration measures. The third aim of the study is to examine the relationship between L2 readers' metacognitive knowledge and their calibrations.

## Method

*Participants*

Participants were 42 undergraduate TEFL (Teaching English as a Foreign Language) students at Yildiz Technical University, Turkey. The mean age of the participants was 20.95 year (*SD* = .31). All the participants spoke Turkish as their first language and English as their second language. Most of the students (*n* = 38) started to learn English at the age of 12. The remaining students' (*n* = 4) starting age was seven. 31 out of 42 students could speak a third language other than Turkish and English. None of the students have the experience of living in a country other than Turkey. Of all the students, only 1 student visited an English-speaking country. All the students volunteered for the study.

*Materials*

Students' metacognitive knowledge was assessed by The Metacomprehension Scale (Moore, Zabrucky & Commander, 1997). The Metacomprehension Scale (MCS) consisted of 22 statements under seven subscales. Agreement with each statement was indicated on a 5-point scale (1=disagree strongly - 5= agree strongly). The seven subscales were Regulation (methods of resolving comprehension failures), Strategy (techniques to improve reading), Task (knowledge of basic comprehension processes), Capacity (perception of comprehension abilities), Anxiety (stress related to comprehension performance), Locus (control of reading skills) and Achievement (importance of good comprehension skills). Cronbach's alpha reliability coefficient is .77 for this study, indicating a reasonably reliable measure of metacognitive knowledge for this sample.

The reading texts and comprehension questions used for this research were taken from standardized YDS examinations for the study. The YDS (abbr. for *Yabancı Dil Sınavı*) examinations, designed to test some certain aspects of linguistic competence in either of the three languages, English, French, German, are taken by the candidates for the BA programmes offered by Turkish universities in the fields of the literature or the teaching of a language other than Turkish. The examination is designed and administered by the *OSYM*, a testing centre coordinating a number of standardized tests in Turkey.

The texts were chosen from the YDS for two reasons primarily. Among our major concerns was designing a valid and reliable testing instrument to be utilized in the research. YDS exam items are piloted for validity and reliability via statistical tools and can be confidently used for the purpose of the research. Our second concern was providing a testing instrument that is levelled suitably for the target group. A suitable testing instrument must have the linguistic level not any higher than the participants'. The participants of the this study had already taken an English test of a similar difficulty level to be admitted for the university BA program, English Language Teaching, which lead the researchers to the assumption that the YDS item difficulty is suitable for the subjects to perform the required monitoring processes.

Eight single paragraph expository texts were chosen for this study. The longest text was 195 words and the shortest was 115 ($M$ = 170; $SD$ = 26.1). Flesch-Kincaid Reading Ease scores ranged between 33. 4 and 68.2 ($M$ = 52.1; $SD$ = 11). The students' text comprehension performance was assessed by four inference questions for each text.

Three prediction-rating scales for calibration of comprehension (JOL, EOL, and PreCJ) and one postdiction scale for calibration of performance (postCJ) were prepared. The first prediction scale (JOL) referred to how well the subjects think they understand the text and ranged from 1, designating "not at all", to 4, designating "very well". The second prediction scale (EOL) referred to how easy the subjects find the text and ranged from 1, designating "not easy at all", to 4, designating "very easy". The third prediction scale (preCJ) referred to how certain the subjects feel about their answers to the inference questions about the text and ranged from 1, designating "not sure at all", to 4, designating "very sure". The Postdiction scale (post-CJ) referred to how certain they are that they answer all the questions correctly and ranged from 1 designating "not at all sure" to 4 designating "very sure".

*Procedure*

The students were tested in a group session. The entire session took approximately two hours. Texts were distributed in a booklet form. The order of the texts was the same for all the participants. The students were given three minutes to read each text. After the students read each text, they were asked to complete three sets of Likert-type scales. When the students finished their task with the scales, the marked scales were collected from the students so that they would not make any changes later. This step was followed by the distribution of the comprehensions questions about the texts read to the students. The students were allowed to refer to the texts as they were answering the questions. The entire session took approximately an hour. The second session took place one day after the first session. The students filled out The Metacomprehension Scale. The entire session took approximately half an hour.

## Results

*Descriptive Statistics*

*Metacognitive Knowledge.* Students' metacognitive knowledge scores, assessed by Metacomprehension Scale, ranged between 54 and 1001. Mean metacognitive knowledge score for 42 students was 74.14 (*SE* = 1.44).

*Comprehension Performance.* Students' local and global comprehension performance scores were determined. Local comprehension performance scores were based on the total number of questions the students answered correctly out of 4 multiple choice questions for each text. Mean local comprehension scores for 42 students were for 2.98 (*SE* = .16) for text one; 2.60 (*SE* = .17) for text two; 3.38 (*SE* = .12) for text three, 2.36 (*SE* = .16) for text four; 3.07 (*SE* = .10) for text five; 3.17 (*SE* = .14) for text six; 2.55 (*SE* = .18) for text seven; and 3.48 (*SE* = .10) for text eight. Global comprehension performance scores were based on the total number of multiple-choice questions the students answered correctly out of 32 multiple choice questions. Mean global comprehension score for 42 students was 23.60 (*SE* = .65).

*Calibration Measures.* Students' calibration of comprehension and calibration of performance were determined by correlating students' ratings for each text and their actual performance on that text. To find out the relations between students' ratings and their actual performances, Gamma correlations were used. Gamma (G) is a non-parametric correlation that requires ordinal data and recommended for the data of this type (Nelson, 1984). Gamma is a symmetric measure of association. It ranges from -1 (if higher ratings are always paired with lower performance) and +1 (if higher ratings are always paired with higher performance). Zero correlation indicates that there is no correlation between variables. Students' comprehension performance was based on the total number of multiple-choice questions they answered correctly.

With the purpose of determining the calibration of comprehension, three contingency tables were prepared for each student. The first table contained the student's JOL rating for each text (ranging from 1 to 5) and local performance score for each text (ranging from 0 to 4). The second table contained the student's EOL rating for each text (ranging from 1 to 5) and local performance score for each text (ranging from 0 to 4). The third table contained the student's CJ rating for each text (ranging from 1 to 5) and local performance score for each text (ranging from 0 to 4). Gamma correlations were computed to determine the relations between each scale rating and the local performance scores. The average Gammas for the three judgements were calculated. The mean JOL, EOL and CJ gammas for this study were .140 (*SE* = .092), .046 (*SE* = .086) and .113 (*SE* = .085)

respectively. One-sample t-tests for JOL, EOL and CJ gammas were also computed to investigate whether these Gamma correlations were beyond chance levels, that is, if they were significantly different from zero. The results were ($t(41) = 1.519$, $p > .01$), ($t(41) = .540$, $p > .01$) and ($t(41) = 1.332$, $p > .01$) for JOL, EOL and CJ respectively. None of results was significant, that is, these results indicated that the students were not able to calibrate their comprehension at above chance levels.

With the purpose of determining the calibration of performance, a contingency table was prepared for each student containing post-test CJ rating for each text (ranging from 1 to 5) and local performance score for each text (ranging from 0 to 4). Gamma correlations were computed to determine the relations between the scale ratings and the local performance scores. The average Gamma for post-test CJs was computed. The mean post-test CJ Gamma in this study was .51(SE= .056). One-sample t-test for post-test CJs showed that this Gamma was significantly different from zero ($t(41) = 9.132$, $p > .01$) indicating that the students were able to calibrate their performance at above chance level. These results indicated that students in this study were not able to calibrate their comprehension whereas they were able to calibrate their performance at above chance level.

*Correlations*

*Interrelations among Calibration Measures.* Pearson product-moment correlation coefficients were computed to investigate the interrelations among JOLs, EOLs, pre-test CJs, post-test CJs Gamma coefficients. The results are presented in Table 1. All the calibration of comprehension measures (JOL, EOL, and PreCJ) are correlated significantly and positively with each other whereas the calibration of comprehension measure (postCJ) has only significant correlation with EOL judgements and the correlation is negative. These results indicate that the students with poor EOL calibration are good at calibrating their past performance whereas the students with good EOL calibration are poor at calibrating their past performance (See Table 1).

*Calibration Measures and Comprehension Performance.* Pearson product-moment correlation coefficients were computed to investigate the correlations between each calibration measure and global comprehension performance. Global comprehension performance (GCP) is only correlated significantly with EOLs and the correlation is negative, that is, students with good EOL calibration are poor comprehenders whereas students with poor EOL calibration are good comprehenders. The other calibration measures did not significantly correlate with global performance scores (See Table 1).

*Calibration Measures and Metacognitive Knowledge.* Pearson product-moment correlation coefficients were computed to investigate the correlation between calibration measures and metacognitive knowledge. The results showed that metacognitive knowledge is only correlated significantly with

postCJs, that is, students with high levels of metacognitive knowledge are better performance calibrators than students with low metacomprehension knowledge. No significant correlations are found between comprehension calibrations and metacognitive knowledge (See Table 1).

**Table 1.** Correlations among Calibration Measures, General Comprehension Performance and Metacognitive Knowledge

| | Calibration of Comprehension | | | Calibration of Performance | | |
|---|---|---|---|---|---|---|
| | JOL/C | EOL/C | PreCJ/C | PostCJs | GCP | MK |
| JOL/C | / | | | | | |
| EOL/C | .42** | / | | | | |
| PreCJ/C | .74** | .45 ** | / | | | |
| PostCJ/C | -.19 | -.47** | -.19 | / | | |
| GCP | -.13 | -.34* | -.21 | -.04 | / | |
| MK | -.24 | -.26 | -.11 | .31 * | -.11 | / |

*Note:* JOL/C= Calibration based on JOLs, EOL/C= Calibration based on EOLs, PreCJ/C= Calibration based on pre-test CJs, PostCJ/C= Calibration based on post-test CJs.
* $p < .05$; ** $p < .01$

## Discussion

The accuracy of metacognitive judgements in L1 reading is a widely researched topic among reading researchers. However, in case of L2 reading, there are few studies conducted to investigate the accuracy of readers' metacognitive judgements.

Major goal of this study is to investigate accuracy of L2 readers' metacognitive judgements through the calibration of comprehension and the calibration of performance paradigms. In the present study, the measures used to assess calibration of comprehension involve three metacognitive judgements; JOL (i.e. judgments of understanding and confidence), EOL (i.e. judgments of text-easiness) and preCJ (i.e. pre-test confidence judgements). Calibration of performance was assessed through postCJs (i.e. post-test confidence judgements). The students in this study were not able to calibrate their comprehension at above chance level. According to the "Cognitive Effort Hypothesis" of Maki, et al. (1990), if the to-be-learned text is easy for the reader, calibration of comprehension for the text is low since the readers do not attend much to the details. However, in the case of texts those require higher levels of cognitive processing, calibration of comprehension increases. The difficulty level of the texts used in this study was similar to the difficulty level of the texts used in examinations for candidates of BA programmes. As all the students in this study had succeeded this kind of examination, they may have found the texts easy. In further research, investigating students' metacognitive monitoring judgements while reading L2 texts with various levels of difficulty can shed light on the influence of task difficulty on metacognitive monitoring while reading texts in L2.

Low calibration Gammas in this study is also inconsistent with previous research findings in L1 reading. Previous research in L1 reading showed that the readers could calibrate their comprehension at above chance level although calibration Gammas were very low. This difference may be attributed to the lack of knowledge of discourse organisation, which is very important for L2 readers especially in the case of reading advanced level academic texts. Students may not follow the particular way of development of the text, the new information or the arguments presented in the text because of their inefficient discourse knowledge; but, if they are familiar with most of the vocabulary and grammatical structures, they may think that they understand the text well.

In case of calibration of performance, the students in this study were able to calibrate their performance. This result is consistent with previous research findings in L1 reading. Most studies showed that readers' postdictions are more accurate than their predictions. According to Lin et al. (2001) postdictions are more accurate than predictions, because readers use additional information from performing on a test as feedback to make more precise judgements. However, the calibration Gammas in this study are much higher than those reported in L1 reading research. High performance calibration Gammas in this study may be explained by the difference between L1 and L2 reading. According to Grabe and Stoller (2002), readers are more aware of the processes in L2 reading than in L1 reading since L2 is usually learned with conscious effort whereas L1 is learned spontaneously. This difference in awareness may be the reason for higher Gammas in this study by comparison with the studies in L1 reading. Obviously, further studies are needed to investigate students' metacognitive monitoring in L1 and L2 reading within the same study to detect the differences.

Alternatively, high Gammas for postdiction judgements in this study may be attributed to the cultural differences between western students and Turkish students. In a study by Zabrucky et al. (2008), the researchers investigated the Taiwanese students' calibration of performance in L1 reading. The results of this study were rather different from the ones conducted with western students since Taiwanese students' calibration Gammas were much higher. The performance calibration Gammas were found to be higher than .50. The researchers asserted that this difference might be due to cultural differences between Taiwanese and western students. Most of the studies on the accuracy of metacognitive monitoring judgements were conducted with participants from western culture. Little is known about the nature of metacognitive monitoring judgements of people from a cultural background other than that of the western world. Cross-cultural studies would be useful to investigate whether the judgements of metacognitive monitoring are influenced by cultural tendencies.

The finding that there is no significant correlation between students' calibrations and their GCP is consistent with much research conducted in L1 reading (e.g. Dunlosky & Connor, 1997; Dunlosky & Hertzog, 1997; Lin,

et al., 2001). This finding is quite acceptable since, as articulated by Metcalfe (2009) and Thiede and Dunlosky (1994), accuracy of metacognitive judgements is necessary but not sufficient for successful learning if the learner cannot convert these judgements into appropriate strategies for study. Nevertheless, there are studies that found evidence for a significant relationship between students' calibrations and their GCP in L1 reading (e.g. Lin & Zabrucky, 1998; Zabrucky et al., 2008). These conflicting results from several studies indicate that more studies should be conducted to investigate the nature of this relationship.

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# Do university students know how they perform?*

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**Abstract**

The aim of the research is to study the capacity for self-evaluation of University students undergoing tests involving mathematics, linguistic and formal reasoning. Subjects were asked to estimate the number of correct answers and subsequently to compare their performance with that of their peers. We divided the subjects into three groups on the basis of performance: poor, middle and top performers. The results demonstrate that all the subjects in all tests showed good awareness of their level of actual performance. Analyzing comparative assessments, the results reported in literature by Kruger and Dunning were confirmed: poor performers tend to significantly overestimate their own performance whilst top performers tend to underestimate it. This can be interpreted as a demonstration that the accuracy of comparative self-evaluations depends on a number of variables: cognitive and metacognitive factors and aspects associated with self-representation. Our conclusion is that cognitive and metacognitive processes work as "submerged" in highly subjective representations, allowing dynamics related to safeguarding the image one has of oneself to play a role.

**Keywords:** metacognition, self- evaluation, cognitive performance, university students, self- image.

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## Introduction

*Metacognition*

Metacognition is the totality of psychic activities overseeing the cognitive function (Cornoldi 1995). These activities comprise the knowledge an individual has in relation to mental functions and mechanisms of control and self-regulation activated whilst carrying out first level cognitive activities.

Metacognitive knowledge refers to what a subject knows or believes about a number of cognitive processes, such as memory, understanding, studies, etc. It may include ideas about cognitive functioning in general, convictions about one's own skills, the awareness of the existence of cognitive problems and one's ability to solve them, knowledge about the efficacy and use of strategies and personal strengths and weaknesses in this regard. All these elements may derive from personal experience or from the observation of the behaviour of others (De Beni & Moè, 2000).

Control and self-regulating mechanisms, on the other hand, play a guiding and supervisory role over cognitive processes. They include, for example, planning of the task, anticipating the performance, choosing a suitable strategy and verifying the choices made on the basis of the evaluation of results.

The distinction between knowledge and metacognitive control derives from studies carried out in three parallel areas of research and which are the origins of the two leading aspects attributed to metacognition: studies into cognitive development following the developmental theory of Piaget (1974, 1975), the work of Vygotskij (1978) on the social origin of cognitive control and studies based on the *Human Information Processing* (HIP) model (Richard, 1990). Whilst references to developmental psychology and, in particular, to Piaget's theories, have stressed the *awareness* of the subject in relation to the functioning of his/her mental states, studies based on cognitive psychology and the HIP model have pointed to the role of *control* the subject can exercise over his/her cognitive activities. References to Vygotskij have underlined the central role of *regulation mechanisms*, the importance of *cultural transmission* and the educational role of the adult in relation to both metacognitive knowledge and the use of the various strategies.

From the historical point of view, the origin of the metacognitive theory resides in the studies of Flavell at the beginning of the seventies. The term 'metacognition' was used for the first time, in fact, by Flavell in his pioneering work of 1976, mainly in relation to studies on memory.

In his model Flavell (1981) included regulation aspects in his definition of metacognition, meaning by it "the totality of knowledge or cognitive activities which have as object or regulate all the aspects of mental acts" (Flavell, 1981, p. 37): alongside knowledge metacognitive experiences are

introduced, understood as ideas, thoughts, sensations, relating to cognitive activities acting at all levels of the task, before, during and after.

Beginning with these initial models, there was then a proliferation of studies which gradually attributed greater and greater importance to control and monitoring aspects, alongside the aspects linked to knowledge of cognitive processes, going so far as to affirm that metacognition influenced cognitive activities, among other ways, through monitoring, regulation and orchestration (Brown, A. L., & DeLoache, 1978; Campione & Brown, 1978).

The model put forward by Brown (1987) focused specifically on the monitoring activity that accompanies carrying out the task and suggested that there are various types of metacognitive control processes: anticipation of the performance level, planning, monitoring and evaluation.

In 1985 Borkowski put forward a model in which various metacognitive skills of control and regulation can be identified, including: awareness of one's own cognitive function and of this function in general, expectation, planning, monitoring, metacognitive review, evaluation, abstraction and transfer.

Similarly, Pintrich, Wolters and Baxter (as cited in Borkowski, 1996, p.393) distinguished between three correlated aspects of metacognition: Knowledge, Judgement-Monitoring and Self Regulation.

Consequently, the most recent metacognitive models have been enriched by contributions from emotive-motivational theory (Borkowski & Muthukrishna, 1995; De Beni & Pazzaglia, 1991; Hultsch, Herzog, Dixon & Davidson, 1988; Moè & De Beni, 1995), describing metacognition as a complex interactive system with diverse components: variables associated with personal and motivational states (attributive style, motivation to use a strategic form of behaviour), self-esteem and self-efficacy (sense of personal value, knowledge of possible selves, awareness of one's aims), in addition to knowledge of strategies and control processes.

*Self-image and causal attributions*

Within these variables it seems that an important place is occupied precisely by those personal factors which may act as a driver to activate, maintain and, if necessary, correct one's cognitive activity: the concepts of self-efficacy and the expectation of a result (Bandura, 1986, 2000; Mazzoni, 2000). The first referred to the degree of confidence of an individual in relation to the likelihood of achieving an objective he has set himself. The second referred to the relationship between the way a task is carried out and the result the individual expects to achieve, given the way the task is to be carried out. Evaluations of self-efficacy varied on the basis of three dimensions: difficulty of the task, degree of generality/specificity of the evaluation and the strength of the evaluation. The generality/specificity dimension referred to the awareness an individual has of possessing some or many skills, whilst the intensity of the sense of self-efficacy referred to the

degree of conviction an individual has in relation to his skills. There was a positive correlation between a high degree of conviction and good performance. This is because those with a high sense of self-efficacy persist in tasks where they initially fail (Bandura, 1986).

Moè and De Beni (1995) distinguished between an objective of mastering a task (or learning aims) and the aim to achieve personal success. According to the authors, those who had the aim to achieve mastery wish to improve their culture, believed in co-operating with others and wanted to learn new strategies, applied themselves and thought that understanding is more important than memorizing. On the contrary, those who seeked personal success were motivated by the need to feel superior to others, they believed this was necessary in order to be successful without making much effort (Ames & Archer, 1988). Clearly this model was close to that of Dweck (1999) who distinguished between motivation based on mastery and motivation based on performance.

Petter (1992) distinguished between direct motivations, based on the quality of the activity or prestige, and indirect motivations associated with "projects" or "problems" and extrinsic motivations, represented by marks, rewards and punishments.

Closely linked to motivation is the subject's style of attribution. The process of attribution takes place when an individual, observing an event, attributes to that event a specific cause (Frieze & Bar Tal, 1980). The importance of attributions is given by the fact that they influence cognitive performances and learning at school, persistence, the choice of a task, emotions and expectancies, contributing to produce success and failure.

Heider (1958) was one of the first researchers to propose a classification based on the attribution of inner or outer causes, distinguishing between events attributed to oneself and events attributed to external causes.

Other authors, including Weiner, Frieze, Kukla, Reed, Rest and Rosenbaum (1978), introduced the analysis of stability in relation to the cause, distinguishing between stable causes such as skills and unstable causes such as luck. The dimension of stability influences changes in the expectations of the individual after a success or failure.

Weiner (1986) further enriched these classifications by introducing the idea of the controllability of these causes or lack of it. He pointed out that emotions linked to self-esteem (for example satisfaction, confidence, guilt, etc.) are closely correlated with the attribution locus. The attribution of a success to oneself (inner attribution locus, e.g. skill), generates good self-esteem, whereas the attribution to oneself of a failure causes a lack of self-esteem. If the cause of success/failure is attributed to the task, the result may be a sense of satisfaction (for a success) or sense of guilt (for a failure).

In the situations in which the attribution is for an external attributive locus (e.g. the help of others), the feelings are of gratitude in the event of success and anger in cases of failure.

In the light of all these theories and models it seems clear that, in relation to metacognition, alongside cognitive factors, motivation and processes linked to emotions/affections play an important role.

In this regard, the formulation of Nisbett and Ross (1980) was particularly lucid: the biases of human inference may be attributed to logical errors the subject commits while processing information, or to the interference of motivational or emotional factors which disturb and deform the resulting representations. In the authors' definition, explanations of the first type are "cold" cognitions, those of the second type are "hot" cognitions. Although specifying that there are no scientifically validated reasons for opting for one interpretation or the other, Nisbett and Ross declared their preference for "cold" explanations; and, in fact, it is known that their paper was one of the crucial moments in heuristic research and in cognitive processes "with limited rationality".

Finally, as Rivière (1999) pointed out, these two approaches (hot vs. cold) can also be found in studies on the development of meta-representative thought where they are focussed on computational models based on the processing of information and on models based on the construction of representations of a socio-cognitive nature

*Self-evaluation of cognitive performance*

An interesting sector within the metacognitive approach, where metacognitive knowledge, control processes and emotional-motivational aspects are intertwined, is the area of metacognitive assessments. Self-evaluation of performance and cognitive skills is considered a fundamental dimension of the control functions carried out by metacognitive monitoring and depends, as we have already seen, on a number of cognitive, metacognitive and emotional-motivational variables (Cadamuro, 2004; Cornoldi, 1995; Flavell, 1981; Izaute & Chambres, 2002; Mazzoni & Nelson, 1998; Schwartz & Perfect, 2002).

Metacognitive assessments are subjective judgements relating to the personal ability to succeed in a given task (De Beni & Moè, 2000). When preparing to carry out the task and in assessing the results, there is a spontaneous anticipation of the likely performance and reflection about the results. This becomes the basis for modifying forecasts of results in subsequent tests.

The awareness of one's own cognitive performance limits was studied in depth by Kruger and Dunning (1999). The authors asked various subject samples to carry out tests involving logical reasoning, to assess examples of humour, to undergo tests involving syntactical skills and then to evaluate their performance and skills in each area. Subjects were asked to provide

these assessments referring to the "average performance and skills of students at their University", using a percentage scale of 0 to 100, whose meaning was self-evident but was also explained. The results showed one phenomenon very clearly and, to some extent, paradoxically: the subjects who obtained the lowest actual performance scores overestimated both their performances and their skills in relation to performance. On the other hand, the subjects with the highest scores tended to underestimate their performance and skills. The explanation of the phenomenon seems to involve a lack of metacognitive skill, accompanied by low skills as shown by the tests. In other words those who do not know how to do things also don't know that they don't know how to do them; they also fail to properly assess others' skills as some of the variations of the experiment of Kruger and Dunning show. For example, some of the subjects who had been tested for syntactical skills were later asked to look at the tests of 5 others with similar scores. The least able in terms of the test were also the least able in assessing others' tests and the most able in terms of the tests were also the best able to assess others' tests.

The underestimation by the most able subjects may be due to the difficulty in assessing the average performance of others, an effect called "false consensus" consisting in over-optimistic assessments of the abilities of others. In order to verify this hypothesis, Kruger and Dunning asked low scorers to undergo first a test of logical reasoning, then training in logic to provide them with the cognitive and metacognitive skills required to correct their overestimations. This training significantly reduced errors in self-evaluation in the lowest scorers, confirming, in the authors' opinion, the hypothesis that poor basic skills are accompanied by low metacognitive awareness. For the high scorers, it was enough to give them some low-scoring tests to correct their optimistic assessments of the average skills of others.

In 2002 Krueger and Mueller joined the debate by objecting that the phenomenon reported by Kruger and Dunning (1999) was in fact due to the joint action of heuristics called *better-than-average* and the statistical effect of regression.

This heuristics consists in the tendency of people to assess themselves as above average: this excess of optimism is a highly irrational bias in that it is logically impossible for everyone to be above average (on the other hand, the assessments are given individually and hence the question does not arise in these terms).

The phenomenon of regression consists in the fact that the average of many repeated measurements tends to nullify the extremes: hence the self-evaluation values of subjects tends towards the average.

Krueger and Mueller (2002) replicated the research of Kruger and Dunning (1999) applying some statistical controls to nullify the regression effect. In this way they highlighted the effect of focussing on oneself and the

degree of confidence in estimates of performance as intermediate variables in the process. To sum up, in their opinion the hypothesis based on statistical regression and the heuristics of *better than average,* provide a more complete explanation of the results in question. In the same edition of the journal, Kruger and Dunning reaffirmed the consistency of the phenomenon even after statistical controls of regression.

Burson, Larrick and Klayman, in a study dated 2006, also supported the hypothesis that the results were due to methodological artificiality: in this case the variable responsible for the observed effect in the research of Kruger and Dunning (1999) were the perceived difficulty of the task. When subjects perceived the task as extremely hard, they believed they will encounter difficulties and their performance will not be very good and, failing to properly account for the degree to which others also experience this difficulty, assessed their performance as worse than average. Burson and colleagues argued that, if everyone produces similar estimates (estimates that are high for tasks perceived to be easy but low for tasks perceived to be difficult) what dictates accuracy is less a matter of greater insight on the part of some participants, more a matter of perceived difficulty. When a test seems easy, everyone believes they have performed well in relation to their peers but only top performers are accurate, leaving bottom performers overconfident. When the test is thought to be hard, however, everyone thinks they have done poorly in relation to their peers and bottom performers will be more accurate than their more competent peers. In short, Burson et al. (2006) argued that whether top or bottom performers are most inaccurate was a result artificially produced by the perceived difficulty of the task.

Burson and colleagues took their results as evidence that the Kruger and Dunning (1999) pattern of over- and underestimation of relative performance was simply a function of using seemingly easy tasks and, as such, did not provide evidence of a relationship between skill level and accuracy in self-assessments.

More recently, Ehrlinger, Johnson, Banner, Kruger and Dunning (2008) examined the relationship between self-insight and level of competence. They considered three explanations for the overconfidence observed among the unskilled: it is a statistical or methodological artefact, stemming from insufficient motivation to be accurate and from a genuine inability to distinguish weak from strong performance. The studies described here are consistent with Kruger and Dunning's (1999) explanation that a lack of skill leads individuals to perform poorly and makes them unable to recognize their poor performances. They found that overestimation among poor performers emerged across a variety of tasks in real world settings too (in which participants had a reasonable amount of prior experience and feedback on the tasks). They asked undergraduates to estimate how well they had performed on course exams and asked members of college debating teams to evaluate their tournament performance. They

provided evidence against the possibility that overestimation among poor performers was a product of insufficient motivation to provide accurate assessments.

They offered incentives (monetary and social) to encourage participants to provide accurate self-assessments and the results demonstrated that not only did incentives failed to improve assessment skills, but actually had the opposite effect: poor performers under incentives became more overconfident. Furthermore, this pattern of overestimation cannot be attributed to a mere statistical artefact, as suggested by Krueger and Mueller (2002), based on notions of statistical reliability and measurement error.

The phenomenon in question, i.e. the overestimation of one's own skills and/or the performance of less skilled subjects, is pervasive and can also be documented in areas which are very different from those of classic cognitive operations. It can be found in the appreciation of practical and professional skills: research carried out on chess players, hunters, doctors and nurses has reported the same phenomenon (Dunning, Johnson, Ehrlinger & Kruger, 2003).

If anywhere, the problem arises in the interpretation of these results and the explanation of the phenomenon: as we have seen, one of the most crucial problems relates to broadening the explanatory model via the inclusion of the variables Nisbett and Ross (1980) call "hot" and Piaget "extra-logical" and which, essentially, are related to one's self-image.

It should also be stated that the phenomenon in question has strong applications significance in any learning process; in fact, as we highlighted in the introduction, the evaluation of the results of a test to a large extent determines the outcome of the process.

**Present Study**

The aim of the study was to investigate the ability to self-evaluate performance in tests of reasoning of a linguistic, mathematical and formal nature, in a group of University students.

Subjects were asked to provide one objective evaluation (number of correct answers) and two comparative evaluations (comparison with the performance and abilities of a group of peers).

More specifically, following the example of Kruger and Dunning, we intended to verify the hypothesis that subjects less skilled in cognitive tasks tend to overestimate themselves compared to their peers and that more skilled subjects, on the other hand, tend to underestimate themselves.

We expected that, although the subjects can assess their performance quite accurately in objective terms, when asked to make a comparative assessment, they may make errors due to a lack of metacognitive skills and affective components. As Borkowski's model explains (Borkowski, Chan, &

Muthukrishna, 2000), successful information processing results when there is an integration of these metacognitive and affective components.

*Instruments*

Three cognitive tasks, each with 20 item, were created using item taken from Test di Struttura dell'Intelligenza (Calonghi, Polácek & Ronko, 1974) and from Test di Intelligenza Non Verbale (Pearson & Wiederholt, 1998):

- a task of arithmetic involving the completion of number sequences according to a pattern;
- a task of formal reasoning, taken from the, requiring subjects to complete sequences of geometrical shapes;
- a task of linguistic reasoning asking subjects to identify linguistic analogies, choosing two out of six words linked semantically.

*Procedure*

Our sample comprised 65 female students at the Faculty of the Science of Primary Education at the University of Reggio Emilia. Mainly female students attend this Faculty, but, as known from the literature, gender does not play a role in self-assessment abilities.

Tests were set in groups and in such a way that upon completion, subjects were asked to estimate:

- how many correct answers they thought they had given (from 0 to 20);
- on a scale of 10, to assess their performance in that specific task "in relation to people who are similar to you";
- on a scale of 10, to assess their general ability in that domain, "in relation to people who are similar to you".

Essentially, with the last two assessments, we asked subjects to give themselves a mark from 1 to 10. To compare these assessments with actual scores (from 0 to 20) in the tests, we converted the scores out of 20 into a score out of 10.

Subjects were divided into three groups, poor, middle and top, each with about a third of the total sample, on the basis of the actual scores (see act.score) obtained in each task.

For each task (arithmetic, formal reasoning and linguistic) a ANOVA, for repeated measures, 3 (groups*: poor, average and top performers*) x 4 *(act. score, est. score, est. perf., est. abil.*) was conducted to verify the effect of the group variable (*between)* on the scores (*within).*

These were as follows:

- actual score *(act. score)* for the test (transformed into a mark out of 10);

- estimated score (*est. score)*, i.e. the number of correct answers the subject thought she had given (also transformed into a mark out of 10);
- comparative assessment of performance (*est. perf.)*, i.e. the score out of 10 attributed to herself by the subject;
- comparative assessment of ability (*est. abil.)*, i.e. the score out of 10 attributed for ability.

We assumed that the data we took a sample from were normally distributed.

## Results

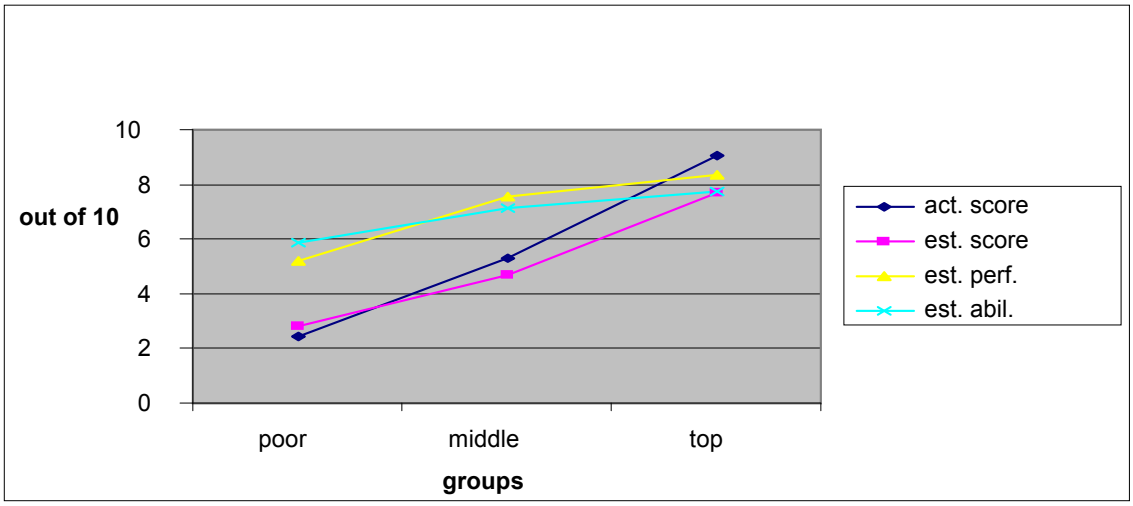
The results of ANOVA [$F(6, 114) = 11.16$; $p < .0000$] showed significant differences among the three groups (poor, average, top performers) for the arithmetic test. (See Table 2). The group of "poor" performers obtained an actual score of $M = 2.42$ ($SD = .60$), out of 10 whilst the self-evaluation score was 5.22 for performance (see Table 1 and Graph. 1) and 5.89 for ability. In the group of "top" performers the actual score was $M = 9.07$ ($SD = .79$) with an average for self-evaluation 8.37 for performance and 7.75 for ability.

**Table 1.** Average values out of 10 for actual scores, estimated number of correct answers, estimated performance and estimated ability for the "arithmetic task"

| | Poor performers *M* (*SD*) | Average performers *M* (*SD*) | Top performers *M* (*SD*) |
|---|---|---|---|
| Actual Score | 2.42 (.60) | 5.31 (1.33) | 9.07 (0.79) |
| Est. score | 2.83 (2.75) | 4.71 (2.06) | 7.73 (3.09) |
| Est. perf. | 5.22 (2.59) | 7.56 (1.21) | 8.37 (2.19) |
| Est. abil. | 5.89 (2.52) | 7.13 (1.09) | 7.75 (1.84) |

**Table 2.** ANOVA: Group (3) x scores (4) for self-assessment of the arithmetic task

| *Source* | *Type III Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* | *Partial Eta Squared* |
|---|---|---|---|---|---|---|
| Scores | 108,021 | 3 | 36,007 | 24,738 | 0,000 | 0,394 |
| Scores*group | 97,444 | 6 | 16,241 | 11,158 | 0,000 | 0,370 |
| Error (Arithmetic) | 165,930 | 114 | 1,456 | | | |
| Intercept | 5.797,791 | 1 | 5.797,791 | 628,981 | 0,000 | 0,943 |
| Group | 407,250 | 2 | 203,625 | 22,090 | 0,000 | 0,538 |
| Error | 350,275 | 38 | 9,218 | | | |




**Graph 1.** Real scores and self-evaluation for the arithmetic task for the three groups.

A second ANOVA was conducted on formal reasoning with group (poor, average, top performers) as independent variable and actual score, estimate score, estimate performance and estimate ability as dependent variables (see Table 4).

The results of ANOVA [$F(6, 123) = 8.42$; $p < .0000$] showed significant differences among the three groups.

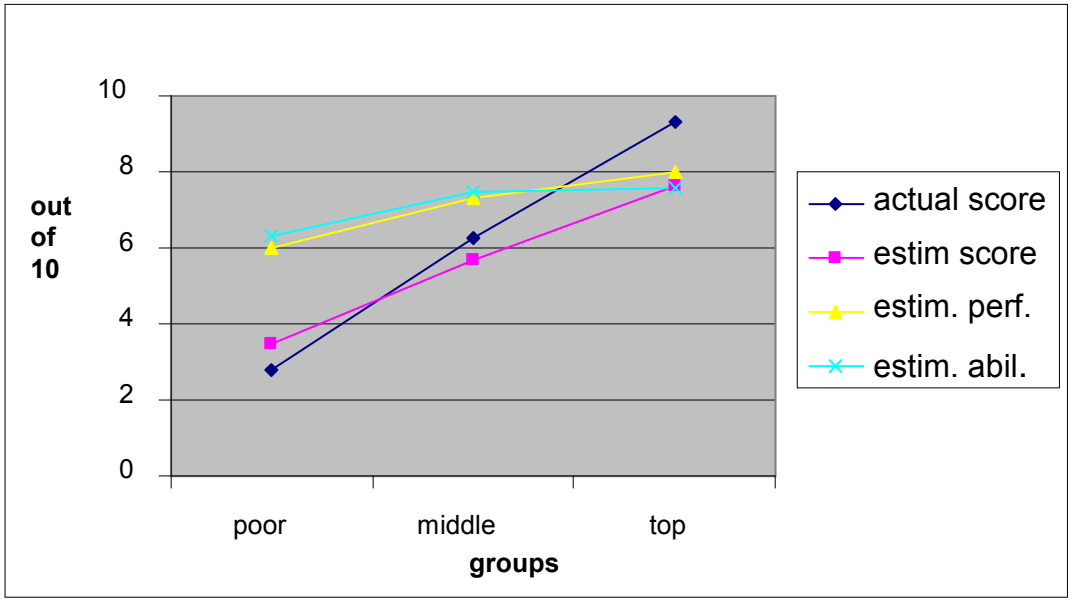
For formal reasoning (see Graph 2), the group of "poor" performers obtained an actual average score, out of 10, of $M = 2.80$ ($SD = .84$), whilst the self-assessment of performance was 6.00 and the self-assessment of ability 6.30. In the "top" performers the average actual score was $M = 9.29$ ($SD = .54$), the average self-assessment of performance 8.00 and the average self-assessment of ability 7.58. (See Table 3 and Graph 2).

**Table 3.** Average values out of 10 for actual scores, estimated number of correct answers, estimated performance and estimated ability for the "formal task"

| | Poor performers *M* (*SD*) | Average performers *M* (*SD*) | Top performers *M* (*SD*) |
|---|---|---|---|
| Actual Score | 2.80 (0.84) | 6.27 (1.43) | 9.29 (0.54) |
| Est. score | 3.50 (2.36 ) | 5.66 (2.90) | 7.32 (1.66) |
| Est. perf. | 6.00 (1.33) | 7.32(1.25) | 8.00 (1.28) |
| Est. abil. | 6.30 (1.49) | 7.46 (1.14) | 7.58 (1.50) |

**Table 4.** ANOVA: Group (3) x scores (4) for self-assessment of the Formal task

| *Source* | *Type III Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* | *Partial Eta Squared* |
|---|---|---|---|---|---|---|
| scores | 66.511 | 3 | 22.170 | 12.113 | .000 | .228 |
| scores*group | 92.509 | 6 | 15.418 | 8.424 | .000 | .291 |
| Error (Formal) | 225.123 | 123 | 1.830 | | | |
| Intercept | 6.618.282 | 1 | 6.618.282 | 1,212.136 | .000 | .967 |
| group | 265.117 | 2 | 132.558 | 24.278 | .000 | .542 |
| Error | 223.861 | 41 | 5.460 | | | |




**Graph 2.** Actual scores and self-evaluation for the formal task for the three groups

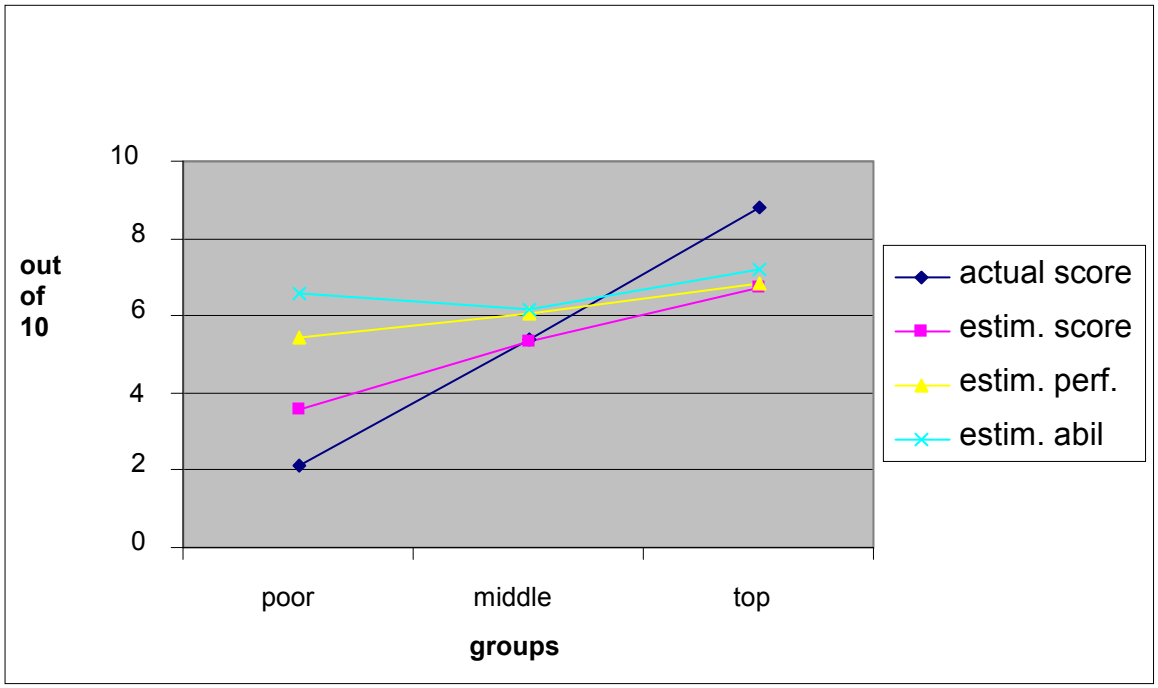
A third ANOVA was significant for the linguistic test [$F(6, 114) = 7.94$; $p < .0000$] (See Table 6). The group of "poor" performers obtained an actual average score was $M = 2.11$ ($SD = .97$), whilst the self-assessment of performance 5.43 and the self-assessment of ability 6.57. In the "top" performers the average actual score was $M = 8.81$ ($SD = .94$), the average self-assessment of performance was 6.86 and the average self-assessment of ability 7.21 (see Table 3 and Graph 3).

**Table 5.** Average values out of 10 for actual scores, estimated number of correct answers, estimated performance and estimated ability for the "linguistic task".

| | Poor performers *M* (*SD*) | Average performers *M* (*SD*) | Top performers *M* (*SD*) |
|---|---|---|---|
| Actual Score | 2.11 (0.97) | 5.38 (1.24) | 8.81 (0.94) |
| Est. score | 3.59 ( 3.23 ) | 5.37 ( 2.83) | 6.74 ( 2.58) |
| Est. perf. | 5.43 (1.90) | 6.05 (2.01) | 6.86 (1.87) |
| Est. abil. | 6.57 (2.22) | 6.15 (1.81) | 7.21 (1.89) |

**Table 6.** ANOVA: Group (3) x scores (4) for self-assessment of the Linguistic task

| *Source* | *Type III Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* | *Partial Eta Squared* |
|---|---|---|---|---|---|---|
| Scores | 42,908 | 3 | 14,303 | 6,380 | 0,000 | 0,144 |
| Scores*group | 106,784 | 6 | 17,797 | 7,938 | 0,000 | 0,295 |
| Error (Linguistic) | 255,579 | 114 | 2,242 | | | |
| Intercept | 4.669,537 | 1 | 4.669,537 | 472,982 | 0,000 | 0,926 |
| Group | 184,248 | 2 | 92,124 | 9,331 | 0,001 | 0,329 |
| Error | 375,157 | 38 | 9,873 | | | |




**Graph 3.** Real scores and self-evaluation for the linguistic task for the three groups.

Finally a post-hoc analysis was conducted using the Tukey method to verify significant differences among groups for the ability to estimate the number of correct answers in the three tasks (see Table 7). Analysis showed that in the highly skilled group the estimated number of correct answers was always less than the actual number of correct answers and this difference was significant in the linguistic task. In this group there is also a significant trend for the arithmetic and formal task.

**Table 7.** Significance of differences between actual scores and estimated scores (Tukey test).

| Test | Poor | Average | Top |
|---|---|---|---|
| Arithmetic | .99 | .96 | .08 |
| Formal | .99 | .94 | .11 |
| Linguistic | .79 | .99 | .01 * |

*. Post hoc differences are significant at the 0.05 level

## Discussion

In our study we found that self-assessment of the number of correct answers (estimated score) differed between the above average, average and below average performers.

In general there was an increasing numerical difference between the actual score and the average self-evaluated score, which was smallest for the estimate of the number of correct answers and largest for the estimate of ability. This showed that subjects were accurate when assessing the number of correct answers in a test, but they were increasingly unskilled when comparing themselves with their peers.

The group of poor performers, which provided a very low number of correct answers, and were aware of the fact, when asked to provide comparative evaluations of performance and ability, overestimated its own abilities.

Top performers were the opposite, underestimating themselves in relation to others. Their self-evaluation of number of correct answers coincided almost perfectly with the comparative evaluation of performance and ability.

It can therefore be concluded that subjects were fairly accurate self-assessors. However, this accuracy in terms of performance and evaluation was not perfect and it was in the inaccuracy that the phenomenon under investigation was revealed.

## Conclusions

In this manuscript we examined the capacity for self-evaluation of University students. We intended to verify the hypothesis that subjects less skilled in cognitive tasks tend to overestimate themselves compared to their peers and that more skilled subjects, on the other hand, tend to underestimate themselves.

The results demonstrated that all the subjects in all tasks showed good awareness of their level of actual performance. Analyzing comparative assessments we found that poor performers tend to significantly overestimate their own performance whilst top performers tend to underestimate it.

We found also an increasing numerical difference between the actual score and the average self-evaluated score, which was smallest for the estimate of the number of correct answers and largest for the estimate of ability.

Even within the comparative evaluations, there was an important difference: the evaluation of performance, in the specific test, was presumably very influenced by the feedback concerning the test: the subject knew if he/she has given the right answer to each question. The more general evaluation of ability for that type of test seems to reflect more self-image, irrespective of the test carried out.

To formulate an explanatory hypothesis, we could begin with one fact (which was also observed in the second study carried out by Kruger and Dunning in 1999): in the poor performers, the estimate of correct answers ("estimated score" in the graphs) was very close to the actual number of correct answers ("actual score" in the graphs).

This means that the poor performers were well aware of how few questions they had got right. The discrepancy between self-evaluation and actual performance emerged only in the comparative evaluations, a metacognitive operation based on an uncertain, and essentially fictional, reference group. Comparative evaluation obliged subjects to refer their self-evaluation to an average level of performance that they did not and could not know, and this lack of any concrete data allowed them to fall back on defence mechanisms to safeguard their self-image; the lack of determination gave them room to use highly subjective criteria of self-evaluation. It's a bit like saying: "I didn't do the test well but I didn't do any worse than most other people". This leads to a kind of optimism in self-evaluation reinforcing one's self-image and seems to be centred more on the person than on the task. What comes to the fore is a *self-focused* defence mechanism which seems to correspond to the heuristic *better than average*, the general tendency to overestimate oneself compared to the average. In reality, in our opinion, it seems more that poor performers assessed average performance on the basis of their own performance, and hence underestimated it.

On the other hand in the top performers group the estimated number of correct answers was always less than the actual number of correct answers and this difference was significant in the linguistic task. In this group there is also a significant trend for the arithmetic and formal task. This might be due to the expression of particularly rigorous and strict epistemic motivations: these subjects performed extremely well but also doubted that they performed so well: a sort of "methodical doubt"? This

particular metacognitive style, expressed in the self-assessments of top performers could be correlated with the level that Mason (2001), citing Kitchener (1983) and Kuhn (1999), indicated as the third "epistemic" level, above the cognitive and metacognitive levels.

A further contribution to the interpretation of data may be provided by the motivational theories of Dweck (1988; 1999) and Moè and De Beni (1995). The two motivational styles, focused on "learning - and mastery-oriented" versus "performance-oriented", seem to match to the behaviours we observed in the poor and top performers. Motivation focused on performance involves the need to protect one's self-image from the possibility of failing, which is precisely what happened in the poorly performing group. On the other hand, the top performers, who underestimated their performance and ability, seem to be more focused on the margin of error and hence more interested and motivated by the possibility of improving themselves (De Beni & Moè, 2000).

A more general way of looking at the phenomenon could start with the consideration that cognitive and metacognitive processes are regulated by highly subjective representations of oneself and the world around us.

Nisbett and Ross (1980) dealt with these matters at the crossover of "hot cognition" (in which "errors" are explained by emotional and motivational dispositions) versus "cold cognition" (in which errors are the result of mistakes in processing information), and were led "to confess a prejudice on our part […] that errors of inference and judgement originate not from motivational factors but from perception and cognitive factors" (Nisbett and Ross, 1980, p. 46).

Examining the phenomenon of "self-overestimation" and "self-underestimation" respectively in poor and top performers, we confess an opposite prejudice. We believe we have found some data supporting the "hot cognition" hypothesis. The evident functional and motivational significance of the phenomenon of overestimation indicate that explanations are to be sought in the safeguarding of the self-image.

It is also clear, however, that the phenomenon requires further extensive investigation of the variables and context to clarify the real forces in play.

First of all a larger and more representative sample would be necessary in order to confirm the results also in the Italian population.

Second, there is a possibility that attributional processes play a role, linked to the nature of the task (easy vs. difficult), as well as personality variables such as those discussed above in relation to motivational systems (performance vs. mastery) and *locus of control* (internal vs. external). Finally, of particular significance, from various points of view including applications, may be evolutionary-genetic research of the phenomenon to study how it begins and develops in children.

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