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**| RESEARCH ARTICLE**

# Assessing Metacognition: An Overview

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**| ABSTRACT**
Metacognition is a complex construct that has been defined in various ways by different scholars, who have divided it into several components. The most well-known categorization comes from Brown (1987), who divided metacognition into two main aspects: knowledge of cognition and regulation of cognition. Knowledge of cognition can further be divided into three types: declarative, procedural, and conditional knowledge. Regulation of cognition includes control and monitoring processes. The assessment of these components has been a topic of debate among scholars, leading to the development of various inventories, interviews, and surveys designed to evaluate students' use of metacognition during or after learning processes. This article provides a synthesis of the different assessment tools discussed in the literature, focusing on metacognitive knowledge, metacognitive control, and metacognitive monitoring. It concludes with a comprehensive inventory that assesses both knowledge and regulation of cognition. Additionally, the article addresses the reliability and validity of the tools presented, offering guidance for researchers on how to improve the internal validity of their data collection processes and research findings.

**| KEYWORDS**

Metacognition, assessing metacognition, on-line measures, off-line methods

**| ARTICLE INFORMATION**

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## 1. Introduction
### 1.1. Defining Metacognition

Metacognition is a perplexing, mystifying, and complex construct (Tarricone, 2011). It has been named a “buzzword”, “ill-defined”, “obscure”, “fuzzy”, “vague”, “faddish”, “messy”, “a many headed monster” and an “epiphenomenon” (Baker & Brown, 1984b; Brown, 1978, 1987; Brown et al., 1983; Brown & Campione, 1981; Efklides, 2008; Flavell, 1981a; Flavell et al., 1993; Kitchener, 1983; Schoenfeld, 1987; Wellman, 1983, as cited in Tarricone, 2011). To achieve this, a thorough analysis of the construct is necessary to select the most effective inventories for assessing students' use of metacognition while studying in or out of the classroom.

Even though many psychologists, theorists, educationalists, and philosophers have made direct or indirect references to metacognition, Flavell (1976) was the first to establish the term. He provided an initial definition, as outlined below:

> Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g. the learning-relevant properties of information or data. . . . Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective (Flavell, 1976, p. 232).

Flavell initiated the scholarly conversation on metacognition, defining it as knowledge about people’s cognitive processes, essentially, thinking about thinking (Jacobs & Paris, 1987). He introduced its main components as knowledge and regulation of cognition, a concept later elaborated on by Brown. Flavell illustrated his definition with the following example:

> For example, I am engaging in metacognition (metamemory, meta-learning, metattention, metalanguage, or whatever) if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I had better scrutinize every alternative in any multiple-choice type task situation before deciding which is the best one; if I become aware that I had better make a note of D because I may forget it; if I think to ask someone about E to see if I have it right. Such examples could be multiplied endlessly. In any kind of cognitive transaction with the human or nonhuman environment, a variety of information-processing activities may go on (Flavell, 1976, p. 232).

He later refined his earlier definition (Flavell, 1978, 1979, 1981,1987) to include his model of metacognitive monitoring (Flavell, 1979, 1981). This model was developed based on Flavell and Wellman's (1977) study of metamemory. Flavell (1977) defined metamemory as "knowledge about anything related to memory" (p. 218). In his 1978 publication, he defined metacognition as "knowledge that focuses on or regulates any aspect of cognitive activities" (Flavell, 1978, p. 30).

Flavell (1987) later defined metacognition as "knowledge and cognition about cognitive objects, that is, about anything cognitive. However, the concept could reasonably be broadened to include anything psychological, rather than just anything cognitive" (p. 21). In other words, metacognition includes not only cognitive processes but also psychological factors.

In 1987, Brown provided a thorough definition of cognition, asserting that it involves understanding and managing people's cognitive systems. As a result, these two early contributions by Flavell and Brown structuralized the main components of metacognition, namely, knowledge of cognition and regulation of cognition. Many recent researchers have braced this categorization (e.g., Schraw, 1998; Schraw & Moshman, 1995). Although it is difficult to differentiate between both sub-components of metacognition (Brown, 1987), this distinction is mandatory for future researchers working on metacognition (Brown, 1987; Weinert & Kluwe, 1987).

In the 1980s, Wellman (1985, as cited in Akturk & Sahin, 2011, p.3732) defined metacognition as "thinking about thinking or a person's cognition about cognition". This is the most widely adopted definition of metacognition among scholars (i.e., thinking about thinking). When individuals control their thinking, they also control their learning activities (Baker & Brown, 1984, p.353). Schraw and Dennison (1994) expanded the term to encompass the "ability to reflect upon, understand, and control one's learning" (p.460).

More recently, Livingston (2003) referred to it as a higher-order thinking ability that actively controls the cognitive processes responsible for learning (p.2). This control can also be over not only cognitive processes but also products or any relatable process as long as it is linked to a clear objective (Hewitt, 2008). In another account, Baker and Cerro (2000) defined it as "knowledge and control of cognition" (p.134).

Subsequently, Baker (2010) broadened the term to include planning our actions, checking the outcomes of our efforts, evaluating our progress, remediating difficulties that arise, and testing and revising our learning strategies (p.204). Mokhtari and Reichard (2002) acknowledged two components of metacognition: awareness and monitoring. Put simply, it is the knowledge and self-control strategies students use while monitoring and regulating text comprehension.

Currently, Fiedler et al. (2019) refer to metacognition as the "top manager" of all cognitive processes. For instance, metacognitive processes regulate the work of memory. It controls and monitors the storage and retrieval of information. They listed several functions that metacognition regulates, namely setting goals for learning, examining the quality of memory storage and retrieval, allocating time to memory processes, choosing among strategies for reasoning, making decisions, and acknowledging achieving goals (p.89). Nelson and Narens (1990, 1994) dissected the term to include both monitoring and control processes.

In short, based on the aforementioned definitions, metacognition is a multifaceted psychological property that people use to regulate and monitor their cognition while engaging in learning activities. It includes two components: knowledge of cognition and regulation of cognition. It is responsible for the storage and retrieval of information from memory.

### *1.2. Theoretical Groundwork of Metacognition*

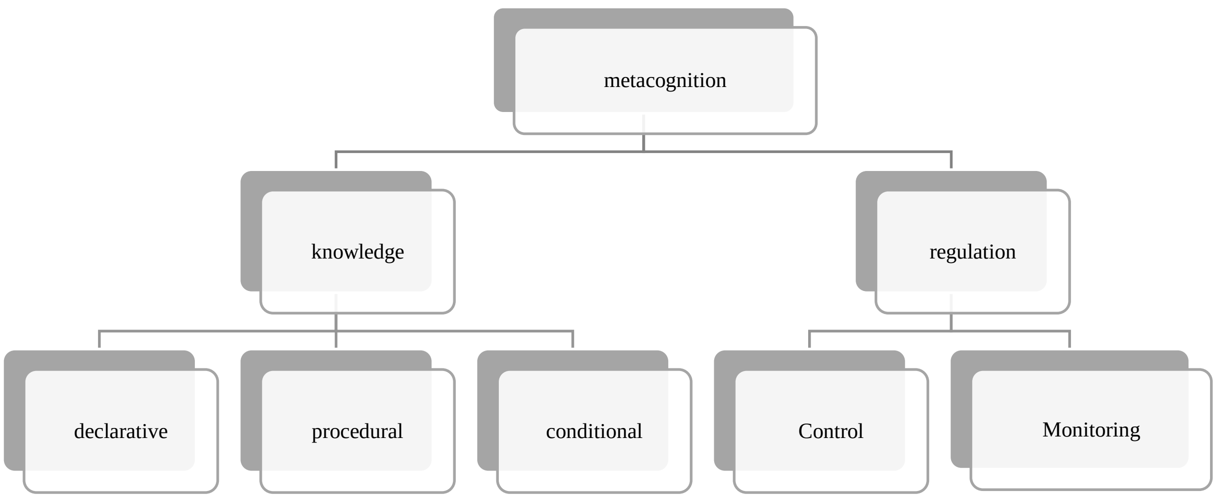
The concept of metacognition has been discussed by various philosophers such as Socrates, Plato, Aristotle, Saint Augustine, Spinoza, and Descartes, as well as psychologists like Dewey and James, who have explored the link between reflection and metacognition. Other notable scholars, including Vygotsky, Piaget, Habermas, Moshman, Kuhn, and Ennis, have also contributed to the discourse on reflection and metacognition. Their contributions have helped to develop the framework for understanding internal verbalization, higher-order reasoning, critical thinking, and critical reflection (Tarricone, 2011, p. 11).

The concept of metacognition, which refers to the ability to think about one's own thinking process, has its origins in several branches of psychology. It can be traced back to cognitive psychology (Hart, 1965; Peters, 2007), cognitive developmental psychology (Piaget, 1950; Steinbach, 2008), and social developmental psychology (Tsai, 2001; Vygotsky, 1962) (as cited in Akturk & Sahin, 2011). Piaget (1950) was a pioneering figure who discussed the ability to "know the knowing" and "think the thinking" (Akturk & Sahin, 2011, p.3731). Similarly, Vygotsky (1962) emphasized the importance of "consciousness" and "conscious control" in the learning process (Akturk & Sahin, 2011, p. 3731). Furthermore, the existence of metacognitive abilities was recognized by ancient philosophers such as Plato and Aristotle (Akturk & Sahin, 2011).

Following these prominent psychologists and philosophers, Flavell was the first scholar to construct the metacognitive monitoring model. Brown's metacognition work differed from that of Flavell as her work was mainly on reading. Eventually, she coined the term "metacomprehension". Baker and Brown, 1984b; Brown, 1981, as cited in Tarricone (2011, p.136), state that "the foundation of metacognition is knowledge. Knowledge informs the regulatory processes and so underpins both knowledge of cognition and regulation of cognition". In her subsequent works, Brown (1978, 1981) classified metacognition into knowledge of cognition and regulation of cognition (see figure 1). Discussing metacognition according to what people know (i.e., metacognitive knowledge) and when, where, and how to use strategies (i.e., metacognitive regulation) helps students to solve problems and do learning tasks (Karbalaei, 2011).

**Figure 1**

*Metacognitive knowledge and regulation categorization according to Brown (1978, 1981)*




## 2. Assessment of Metacognition

Metacognition assessment can be divided into two main groups: off-line and on-line methods (Veenman, 2005, as cited in Bannert & Mengelkamp, 2008). These groups are classified based on the timing of the assessment. Off-line methods are conducted retrospectively or prospectively to learning, while on-line methods are performed during learning. Off-line measures include interviews, teacher ratings, and self-report questionnaires/inventories. On-line methods include think-aloud protocols, accuracy ratings, systematic observations, and eye-movement tracking. Some researchers have suggested combining both on-line and off-line measurements to assess both knowledge of cognition and regulation of cognition. For knowledge of cognition, off-line measures have been used, while for regulation of cognition, both on-line and off-line methods have been employed (Ozturk, 2017).

Pintrich et al. (2000) categorize metacognition into three assessment categories: metacognitive knowledge, metacognitive judgments and monitoring, and self-regulation and control. Thus, we will use the same categorization in our discussion.

### 2.1. Assessing Metacognitive Awareness (Knowledge)

Metacognitive knowledge can be mainly assessed through interviews or questionnaires (Baker & Cerro, 2000) because metacognitive knowledge is stored in people's memory (Pintrich et al., 2000). Various inventories have been utilized to evaluate this knowledge, including the Index of Reading Awareness (IRA) (Jacobs & Paris, 1987), the Reading Strategies Inventory (MARSI) (Mokhtari & Reichard, 2002), and the Survey of Reading Strategies Questionnaire (SORS) (Mokhtari & Sheorey, 2002).

The Index of Reading Awareness (IRA) was developed by Jacobs and Paris (1987) to test metacognitive knowledge (metacognitive awareness) of third to fifth-grade students. The IRA contains 20 multiple-choice items that measure young students' metacognitive awareness in reading comprehension. This questionnaire tests students in the following metacognitive components: evaluation, planning, regulation, and conditional knowledge. The reliability and validity of this instrument were tested by McLain et al. (1991), in which they asked 145 children in third, fourth, and fifth grades to take the IRA. Results revealed that Cronbach's alpha of the scale was low, and the total reliability was .61. Testing the validity of the test; they found that the instrument did not test what it had to test. That is, similar to Jacobs and Paris, they found differences between third and fifth graders. However, McLain et al. (1991) were able to compare fifth graders to the fourth graders in Jacobs and Paris' study. As a result, the IRA is not the perfect tool to test metacognition in young children (McLain et al., 1991).

The second instrument used to test metacognitive awareness is the Reading Strategies Inventory (MARSI) developed by (Mokhtari & Reichard, 2002). This self-report instrument was designed to test adolescent and adult readers' metacognitive awareness and perceived use of reading strategies while reading academic texts. The MARSI instrument contains three categories: Global Reading Strategies (13 items demonstrating strategies used in the global reading of texts), Problem-Solving Strategies (8 items tailored towards solving problems when encountering difficulties in reading texts), and Support Reading Strategies (9 items involving support or functional strategies). It was based on the works of various researchers on metacognition and reading comprehension, such as Alexander & Jetton, 2000; Baker & Brown, 1984; Garner, 1987; Paris & Wino- grad, 1990; Pressley & Afflerbach, 1995 and so on (Mokhtari & Reichard, 2002).

The MARSI initially consisted of 100 items, which were later reduced to 60 items. The final version of the inventory includes 30 items and was administered to 443 students in grades 6 through 12. The reliability and validity of the instrument were assessed, and Cronbach's alpha was calculated for each subscale and grade level. The resulting Cronbach's alpha for the 30 items was 0.89.

This inventory can be used with either individual students or groups of adolescents and adults in grades 6-12, and can be completed within 10 to 12 minutes. The statements in the inventory are rated on a 5-point Likert scale, ranging from 1 (I never do this) to 5 (I always do this). Scoring is straightforward, as students can simply score the different categories and add the scores to calculate a final grade.

The results can be interpreted as follows: high (mean of 3.5 or higher), medium (mean of 2.5 to 3.4), and low (2.4 or lower). Both researchers and teachers can utilize the MARSI for data collection or as a formative assessment. However, caution is advised when using it as it is a self-report instrument. Students might report using or knowing certain strategies when, in reality, they do not use them. Therefore, it is recommended to supplement the use of this self-report instrument with other data collection methods such as think-aloud protocols or interviews.

The Survey of Reading Strategies Questionnaire (SORS) was developed by Mokhtari and Sheorey (2002) based on MARSI. It is designed to assess the metacognitive awareness and reading strategies of adolescent and adult ESL students while reading academic materials. Similar to MARSI, the SORS measures three classifications of reading strategies. It comprises three categories:
1. Global Reading Strategies (GLOB) (13 items): These are used by learners to monitor their reading with a specific purpose in mind.
2. Problem Solving Strategies (PROB) (8 items): These are strategies that learners use to solve problems related to the text, such as guessing the meaning of unknown words and re-reading to improve comprehension.
3. Support Strategies (SUP) (9 items): These are strategies that help learners understand a text, such as using a dictionary or taking notes.

Similar to MARSI, SORS can be scored as high (mean of 3.5 or higher), moderate (mean of 2.5 to 3.4), or low (mean of 2.4 or lower). To obtain more comprehensive data, this data collection instrument should be used in conjunction with other qualitative research methods, such as observation and interviews.

### 2.2. Assessing Metacognitive Judgments and Monitoring

In our previous discussion, we covered different methods and tools used to assess metacognitive awareness (metacognitive knowledge). Now, let us shift our focus to the measures of metacognitive judgments and monitoring. Various approaches have been utilized for this purpose. These include: (1) think-aloud protocols, (2) calibration, (3) error detection, (4) reading times, and (5) questionnaires/interviews (Cromley, 2005), and (6) relative accuracy (Serra & Metcalfe, 2009.

One of the most effective methods for measuring metacognitive monitoring is the use of think-aloud protocols. In simple terms, this involves verbalizing thoughts while reading. Students should express out loud the cognitive and metacognitive strategies they are using while reading, such as clarifying difficult vocabulary or ideas in the text. In addition, students should verbalize the different cognitive strategies they use while reading, such as paraphrasing and summarizing. Previous research has indicated that students with higher reading comprehension use more metacognitive monitoring while reading difficult texts, as demonstrated by the use of think-aloud protocols (e.g., De Grave et al., 1996; Lundeberg, 1987; Meyers et al., 1990; Olshavsky, 1976-1977; Rogers, 1991; Smith, 1991; Steinberg et al., 1991).

One limitation of think-aloud protocols is that students may not verbalize all the cognitive and metacognitive strategies they use while reading (Cromley, 2005). Sometimes, students may possess different strategies but cannot utilize them for various reasons. For instance, they may not know how to use the strategies, or they may use them without being able to articulate them. Another limitation of such a measurement technique is that non-parametric statistics used in the data analysis disapprove of the external validity of the results (i.e., over-generalization).

In a study conducted by Pressley and Afflerbach (1995), a meta-analysis of multiple research studies using think-aloud protocols was performed to examine the behaviors of students while reading. The results indicated that students who actively monitor their reading process tend to be more proficient readers and demonstrate better comprehension compared to those who do not engage in monitoring. Furthermore, the studies identified various aspects of monitoring, including monitoring of text characteristics, self-understanding, comprehension issues, as well as cognitive processes utilized in reading and understanding text (as cited in Pintrich et al., 2000, p. 69).

Calibration is another tool used by researchers to measure metacognitive monitoring. It is linked to confidence judgments, where participants answer reading comprehension questions and then assess their confidence in their answers (Cromley, 2005). Calibration, as defined by Serra and Metcalfe (2009), is "a difference score between the mean of one's predictive judgments and one's performance on the task being judged or predicted" (p.6). Moreover, Pieschl (2009) defines it as "the accuracy of learners' perceptions of their own performance" (p.4). Poor calibration occurs when a participant answers a question incorrectly but believes their answer is correct. Previous research has shown that more skilled readers have better calibration (Maki, 1998; Commander & Stanwyck, 1997, as cited in Cromley, 2005).

Different scholars use different terms to describe calibration. They use the terms accuracy (Dunlosky & Hertzog, 2000; Nelson & Dunlosky, 1991), judgment bias (Schraw & Roedel, 1994), or illusion of knowing (Glenberg & Epstein, 1985) (as cited in Pieschl, 2009).

One limitation of calibration is that, generally speaking, some students may be either overconfident or underconfident, which can negatively affect the results of the calibration method. As a result, the outcomes of monitoring may be biased (Cromley, 2005). Serra and Metcalfe (2009) illustrated this point with the following example:

> Consider hypothetical participants in a laboratory study on metamemory (metacognition about memory). While studying paired associate items (e.g., two unrelated nouns) for the criterion test, the participants make JOLs on a 0%-100% scale indicating the percent-likelihood that they will correctly remember each item on a test. Suppose that the overall mean of their JOLs is 88%. Assuming that the participants correctly remember a mean of 66% of the items on the test, their calibration score will be +22%, indicating overconfidence. A group of participants in such a study would be said to demonstrate "good" calibration if the overall mean of their JOLs did not significantly differ from the overall mean of their performance scores (Serra & Metcalfe, 2009, p.6).

The concept of calibration involves two types: calibration of comprehension and calibration of performance (Glenberg & Epstein, 1987). Calibration of comprehension occurs when a person estimates their confidence in being able to answer a comprehension question. In other words, this type of calibration involves students demonstrating their confidence in answering a question based on their prior knowledge. On the other hand, calibration of performance happens when participants attempt to justify an answer they have already given. The main difference between the two types of calibration is that the first one is conducted before students answer the comprehension questions, whereas the second one is conducted after. Consequently, calibration of performance is considered more reliable because it covers both the material and the test (Maki et al., 1990).

Many previous studies on calibration have yielded positive results (Cromley, 2005; Hacker et al., 2000; Pressley & Ghatala, 1990). However, Nietfeld et al. (2005) and Schraw and Roedel (1994) found negative results related to calibration. As a result, calibration has been considered an important aptitude variable for measuring metacognitive monitoring (Sungur, 2007).

Relative accuracy is another method used to assess metacognitive monitoring. It refers to "how well one's judgments differentiate performance on the cognitive task being judged" (Serra & Metcalfe, 2009, p. 6). To calculate relative accuracy, researchers use gamma correlation. This involves comparing participants' judgments with their actual performance on the same test. Gamma correlation can range from -1.0 to 1.0. A positive gamma indicates that participants' judgments align with their actual recall of items - high judgments for items they will remember and low judgments for items they will not. Conversely, a negative gamma indicates the opposite. If participants assign judgments randomly, the gamma correlation may be zero or incalculable. Relative accuracy of JOLs is calculated based on each participant's scores. If the mean is greater than zero, it suggests that participants' judgments are high (Serra & Metcalfe, 2009).

Error detection is a tool used to measure metacognitive monitoring. Baker and colleagues conducted a series of studies using an error detection framework (Baker 1979, 1984, 1985, 1989a, 1989b, as cited in Pintrich et al., 2000). In these studies, the researchers presented participants with passages or sentences containing errors, omissions, or inconsistencies, and then asked them to identify what made the texts difficult to understand. Students who found more errors were considered better comprehension monitors than those who found fewer problems (Pintrich et al., 2000). Error detection involves inserting mistakes into a text and asking readers to find them (Cromley, 2005, p. 192). Previous studies have shown that efficient readers can detect mistakes in reading comprehension texts better than less efficient readers (e.g., Baker, 1989).

One method of assessing metacognitive monitoring involves analyzing reading times. This entails intentionally including errors in a passage and then recording the frequency with which individuals reread the conflicting information (Cromley, 2005). This approach is typically implemented using a computer, where participants are presented with one sentence at a time, allowing researchers to measure the time taken to reread each sentence. Numerous studies have utilized this method and have yielded positive findings, demonstrating that participants do indeed reread contradictory information, indicating the use of metacognitive monitoring (e.g., Zabrucky & Moore, 1999).

Finally, researchers have traditionally used questionnaires or interviews to assess metacognitive monitoring. They have employed self-report judgments to gauge metacognitive monitoring (e.g., Nelson, 1996; Nelson et al., 1984; Nelson & Narens, 1990). In these studies, participants are given a list of words or paired associates to memorize and are then tested on their ability to remember the information. Before the test, they are asked to rate the perceived easiness or difficulty of the items (i.e., Ease of

Learning Judgments (EOLs). Following this, participants assess their own learning by providing Judgments of Learning (JOLs). Subsequently, they are tested on their recall of the items. Participants also make Feelings of Knowing (FOKs) judgments, which involve estimating the number of items they could not remember. Students who confidently assess their learning are considered good monitors (see Pintrich et al., 2000 for a review).

For example, previous studies using either questionnaires or interviews found that students with higher reading comprehension are better at monitoring their understanding. Myers and Paris (1978) discovered that younger students had limited knowledge of reading strategies compared to older students.

There are several issues with using questionnaires or interviews. Firstly, students may predict the answer the researcher is looking for, resulting in social desirability bias. Secondly, students may not accurately recall their reading behaviors, which is known as retrospective bias. Thirdly, sometimes, people may not fully understand a question and end up giving distorted answers. Finally, questionnaires may not fully address the research question at hand (Cromley, 2005).

### 2.3. Assessing Self-regulation and Control

Regulation of cognition has been mostly measured using on-line methods. Researchers can use techniques such as, "detection of errors in passages; ratings of felt understanding; self-corrections during oral reading; completion of cloze tasks; on-line measures of processing during reading (e.g., eye movements and reading times); and retrospective or concurrent verbal reports (e.g., thinking aloud)" (Baker & Cerro, 2000, p. 102).

Pintrich et al. (2000) claim that metacognitive regulation can be assessed using think-aloud protocols, self-report questionnaires, and interviews. Several questionnaires have been utilized, including the Learning and Study Strategies Inventory (LASSI) (Weinstein et al., 1987) and the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991). The Self-Regulated Learning Interview Schedule (SRLIS) developed by Zimmerman and Martinez-Pons (1986, 1988) has been widely used for interviews.

Weinstein et al. (1987) created the Learning and Study Strategies Inventory (LASSI) to assess cognitive regulation. The LASSI can be administered as a paper-and-pencil test or an online test and consists of 77 5-point Likert-type scale items, ranging from (1) "not at all typical of me" to (5) "very much typical of me". This scale measures attitude, motivation, time management, anxiety, concentration, information processing, selecting main ideas, study aids, self-testing, and test strategies (Baker & Cerro, 2000, p. 113). Despite efforts to establish its validity and reliability (e.g., Weinstein et al., 1988), the LASSI was developed before the concept of metacognition, so it may not be the ideal instrument to measure metacognition effectively.

The Motivated Strategies for Learning Questionnaire (MSLQ), developed by Pintrich et al. in 1991, is a self-report questionnaire used to assess metacognitive regulation. It is designed to measure the motivation and learning strategies used by both adolescents and college students in a college course. The questionnaire consists of two sections: motivation and learning strategies, containing a total of 81 items, with 31 items related to motivation and 50 items related to learning strategies. Within the learning strategies section, 12 items represent self-regulation, focusing on planning, monitoring, and regulating. The scale uses a 7-point Likert scale, ranging from "not at all true of me" to "very true of me". The reliability and validity of the scale have been established, with the internal consistency of the self-regulation items at .79 and an overall correlation of .30.

Zimmerman and Martinez-Pons (1986) developed the Self-Regulated Learning Interview Schedule (SRLIS) to assess high school students' self-regulated learning. This interview model consists of 14 learning strategies related to metacognitive regulation. These strategies encompass self-evaluation, organizing and transforming, goal-setting and planning, seeking information, keeping records and self-monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking peer, teacher, or adult assistance, and reviewing tests, notes, and texts (Zimmerman & Martinez-Pons, 1986). Additionally, an "other" category was included to encompass aspects not directly part of the self-regulated process.

The interview consists of six different contexts, which are a classroom discussion, a short writing assignment, a mathematics assignment, an end-of-term test, a homework assignment, and studying at home (Pintrich et al., 2000). Participants were asked to describe the techniques they used to complete the tasks they were given. When students were unable to provide an answer, they were asked, "What do you do when you have difficulty? Is there a particular method you use?" (Zimmerman & Martinez-Pons, 1988). If the learner could not name any self-regulated learning strategies, the interviewer continued to ask questions about that specific learning context. If the learner did mention any learning strategies, they were asked about how consistently they used them on a 4-point scale ranging from (1) seldom to (4) most of the time.

Zimmerman and Martinez-Pons (1988) created a 12-item scale to assess students' self-regulated learning for teachers to use. They validated the scale through student interviews and teacher ratings. They had 80 high school students describe their use of 14 strategies in six different contexts. Additionally, teachers used the 12-item scale to rate their students' use of these strategies. The results indicated a significant correlation of .70 between the students' interviews and the teachers' ratings, validating the SRLIS interview scale.

### 2.4. Assessing Metacognitive Knowledge and Regulation

Schraw and Dennison (1994) developed the Metacognitive Awareness Inventory (MAI) to assess students' metacognitive awareness. Unlike Mokhtari and Reichard (2002), who consider metacognitive awareness as the first component of metacognition (i.e., metacognitive knowledge), Schraw and Dennison (1994) define it to include both knowledge of cognition and regulation of cognition. According to them, knowledge of cognition comprises declarative, procedural, and conditional knowledge, while regulation of cognition includes planning, information management strategies, monitoring, debugging strategies, and evaluation (p. 460).

Schraw and Dennison (1994) define declarative knowledge as "knowledge about one's skills, intellectual resources, and abilities as a learner". Procedural knowledge refers to "knowledge about how to implement learning procedures (e.g., strategies)". Conditional knowledge is defined in their model as "knowledge about when and why to use learning procedures". As for the components of regulation of cognition, planning is defined as "planning, goal setting and allocating resources prior to learning", and information management as "skills and strategy sequences used on-line to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing)", monitoring as "assessment of one's learning or strategy use", debugging as "strategies used to correct comprehension and performance errors", and evaluation as "analysis of performance and strategy effectiveness after a learning episode" (pp.474-475).

MAI self-report questionnaire consists of 52 items, with at least 4 items per each of the eight different scales: declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, monitoring, debugging strategies, and evaluation of learning. To validate and test this instrument, two experiments were conducted. In the second experiment, 110 undergraduate students majoring in psychology took part. The researchers administered the instrument, which included brief cover instructions, 52 items, and a 100 mm scale for each item. The reliability and validity of the instrument were measured. The coefficient alpha for both scales was .88 for knowledge of cognition and .88 for the regulation of cognition. The 52-item scale reached .93 as internal consistency. Moreover, the correlation between knowledge and regulation of cognition was .45. The results of the second experiment revealed that the MAI had a statistically significant relationship with metacognitive awareness and performance.

## 3. Conclusion

Different methods for measuring metacognition and its main categories have been designed. Since Flavell's initial use of metacognition in 1976, various methods have been employed. One of the most common approaches is the use of self-report questionnaires, which can be either general or domain-specific. General questionnaires assess metacognition without focusing on a specific subject area (Pintrich et al., 1991; Schraw & Dennison, 1994; Sperling et al., 2002). On the other hand, domain-specific questionnaires evaluate students' metacognition in specific areas, such as reading comprehension or mathematics (Mokhtari & Reichard, 2002; Mokhtari & Sheorey, 2002).

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