Journal of Innovation in Psychology, Education and Didactics
ISSN: 2247-4579, E-ISSN: 2392-7127
http://www.jiped.ub.ro/
Covered in : EBSCO, CEEOL, ProQuest, DOAJ, Scipio,
International Innovative Journal Impact Factor, CiteFactor,
EuroPub database, Open Academic Journals Index, ResearchBib,
Universal Impact Factor
2022, Volume 26, Issue 2, pages: 217-240, doi:10.29081/JIPED.2022.26.2.07

Rethinking Thinking: Assessing Metacognition in the Classroom - A Systematic Review

Oana ONCIU [1]*

Received: 05 December 2022/ Accepted: 15 November 2022/ Published: 20 December 2022

Abstract

This systematic review provides results on the methodologies and instruments utilized to assess metacognition in children aged 5 to 9 years over the past 8 years (2013-2021). It provides a synopsis for the type of instruments and methodologies utilized, matched to the age considered initially. The main research question of this review is: To what degree, methods, and instruments for measuring and evaluating metacognition in children aged 5 to 9 years have been used in the last 8 years (2013-2021)?. It was developed according to PRISMA guidelines and is based on the inventory of literature published between January 2013 and January 2021 in seven databases: PsycINFO, Web of Science, ERIC, EMBASE, EIB, Google Scholar, SCOPUS. The search was conducted using 6 keywords: metacognition, metaknowledge, metacognition assessment, and early childhood (5-9 years).

Key words: Early Childhood; Metacognition; Metacognition Assessment; Metaknowledge

How to cite*:* Onciu, O. (2022). Rethinking Thinking: Assesing Metacognition in the Classroom - A Systematic Review. *Journal of Innovation in Psychology, Education and Didactics*. *Journal of Innovation in Psychology, Education and Didactics*, *26*(2), 217-240. doi:10.29081/JIPED.2022.26.2.08.

[1] PhD Student, Faculty of Psychology and Education Sciences, Alexandru Ioan Cuza Iasi University, Romania, Email: onciu.oana@uaic.ro
* Corresponding author

1. Introduction

The analysis below discusses how metacognition has been defined, operationalized, and included in tools and methods. This study aims to set out the decision-making procedures adopted in the included research, together with the factual assumption that in such a large and complex area there are conceptual dimensions on which there is no consensus. We hope that the usefulness of this detailed presentation will become apparent to set a theoretical starting point for upcoming studies for the current research segment. More precisely, wherewith Flavell conceptualized metacognition, how the definition of conceptual dimensions has evolved and how much metacognition has been operationalized to the date. Areas such as pedagogy, psychology, and even linguistics have included metacognition as a part (Flavell, 1976).

Since Flavell coined the term "metacognition," the controversy about what metacognition is and how to assess it has widened, and the complexity of these questions has become increasingly apparent over the past years (Wellman, 1985). Therefore, there is much debate about what metacognition is, how it develops, and how it can be measured. Wilson stated that Flavell himself no longer had an in-depth idea for outlining metacognition in the 1980s, and a decade later he added: "Flavell identified this: deeply insightful and distinct, approximately what metacognition is" (Wilson, 1998).

These simultaneous and discordant metacognition statements request a "multiplistic perspective" (Hofer & Sinatra, 2010). Complex conceptual dimensions were introduced and separated as components of the big concept. Notions such as executive control or executive function are terms that are primarily used not in the sciences of education but rather in areas such as psychology and cognitive sciences (Borkowski et al., 2012). For instance, literature distinguishes the difference between executive function and self-regulation, motivational impulse, impulse control, and executive function planning significantly predicted the emergence of metacognitive strategic elements as well as regulation for the academic process (Garner, 2009).

Most researchers today argue that metacognition involves cognitive processes of monitoring and streamlining thinking (Aturk & Sahin, 2011). More specifically, metacognition includes both acknowledgment of one's learning, the ability to assess the criteria for solving the task, and the ability to choose the right strategic elements for the task. Monitoring progress to achieve the goal and ability to recognize the cognitive phenomena of other individuals (Beran, 2012). The following is a brief overview of the methodological overlaps between metacognition and related concepts and examines the subcategories established for metacognition.

2. Theoretical considerations

2.1. Cognition or metacognition

In recent years, several synonymous words for metacognition have come into use. According to the reports cited (Cer, 2019), some researchers prefer the use of the term self-management to address metacognition (O'Neil & Speilberger, 1979), also other authors choose the use of incremental words (Bogdan, 2003) and meta-learning to refer to the main concept (Cross & Steanmand, 1996). Similarly, several different terms are mentioned in the relevant metacognitive literature, such as metacognitive beliefs, leadership, metacognitive components, and learning judgments (Veenman et al., 2006). By scanning the literature, multiple definitions can be found, but the most widely used definition of metacognition is that this phenomenon is the process by which individuals become aware of their cognitive structure and at the same time organize it (Brown; Dunlosky and Hertzog, 2000; Georghiades, 2004; Flavell, 1979; Jacobs & Paris, Livingston, 1997; Schraw & Dennison, 1994; Wellman, 1985). Today, metacognition is generally used as a broad term that includes those structures related to thought processes (Leader, 2008). Initially, Flavell (1979) examined the evidence that children were conscious of the components that influence their cognition, and secondly whether they understood these. The

research later provided precise evidence that children observe and rationalize their own cognitive processes (Brown, 1978), continued post-Flavell studies and focused specifically on understanding information and how to use it effectively. Based on this research, he defined the concept as the awareness of thought processes and their structuring during intentional cognitive contexts. Wellman, defines metacognition as "thinking or knowing about knowledge" (Wellman, 1985). Metacognition is the result of observing and assessing an individual's cognition during a problem-solving context (Ayersman, 1995). Metacognition is also analyzed as a theoretical structure in which subjects take responsibility for their own cognitive processes and develop strategies to direct these processes (Baker et al., 1980). Metacognition can also be explained as the knowledge provided by individuals during the performance of a task and the conscious systematization of cognition (Brown et al., 1983). Swanson defines the concept as the awareness of individuals about their ability to observe and regulate their cognitive activities (Swanson, 1990). It also includes observation of existing cognitive processes and strategic components, with the capacity to analyze these specific processes (Wilson, 1998). To complete the general meaning, metacognition also includes thinking at higher levels about how a learning task is processed and developed (Livingston, 1997). The common denominator connecting most of the existent definitions is the monitoring of learning strategies (Bonner, 1988), as well as the importance of the perception of cognitive processes with their components (Paris & Winograd, 1990). It includes monitoring one's cognitive processes during a work task, observing one's thinking but also that of others, learning and understanding them during the performance of a task, strategizing, and final evaluation (Scott, 2009).

It is necessary to differentiate between cognition and metacognition because although similar, these concepts are different. Knowledge means awareness and understanding, and metacognition is equally awareness and understanding of how to learn and learning itself (Senemo, 2005). While metacognition is a prerequisite for understanding how to solve a task, knowledge is needed to accomplish that task (Hartman, 2001). On the other hand, according to Gourgey, knowledge is necessary to accomplish a learning task, while metacognition ensures that subjects observe and analyze their cognitive processes (Gourgey, 1998). To illustrate practically the relation between metacognition and knowledge, one can take the example of a subject who uses the strategy of introspection while reading. The subject is aware that he does not understand the text (metacognition) but simultaneously suggests the possibility to understand better the text by extracting some keywords (cognition). The relation is specifically illustrated in Figure 1 (Altindağ, 2008).

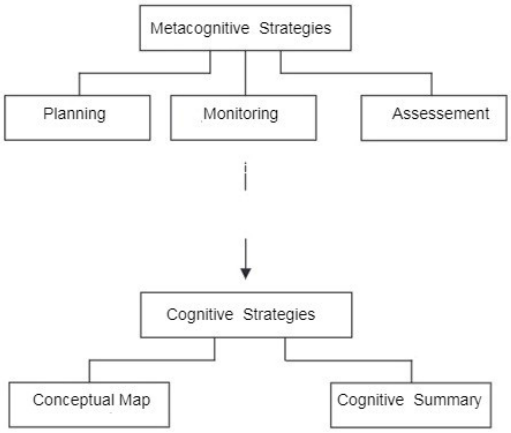

Figure 1. The relation between cognition and metacognition

2.2. Metacognition in children

According to Flavell (2000), young children illustrate a theory of mind before the age of one, a concept often studied in connection with metacognition. This theory brings with it the awareness needed to observe cognition, as well as the ability to evaluate it. Aspects of memory observation occur in children between the ages of three and four, especially if the tasks they perform are considered by children to be very engaging (Lyons & Ghetti, 2010). A four-year-old child learns to understand knowledge, the usefulness of information, and to understand what is needed to acquire new knowledge (Perner, 1991). Mental processes such as "knowing", "thinking" or "remembering" can then be used (Schneider, 2002). Subsequently, metacognitive vocabulary and general metamemory expand during preschool (Schneider, 1999). The effort can be understood and the difference between the difficulties can be remembered (Dufresne & Kobasigawa, 1989; O'Sullivan, 1993). They can also present conditional knowledge to direct their attention according to the requirements of the task. Preschoolers can find simple strategies for remembering objects when their tasks make sense (Schneider, 2002). From the age of four, children can adjust their learning processes, and from the age of six, they can accurately reflect on the knowledge they have (Schraw & Moshman, 1995) and even transfer their strategies to new tasks (Blöte et al., 1999). In terms of cognitive processes and early learning strategies, as long as they are directly connected with children's motivation and interest in the work task, they prove to be successful (Flavell et al., 1995; Magiera, 2008).

2.3. Methodology of metacognition

The presence of this cognitive phenomenon was first explored in the 1960s (Peters, 2007). The research concluded that suggestions on how to solve the problem were predictive of the answers that proved to be correct (Hart & Joseph, 1965). Underwood also asked questions about the beliefs concerning the difficulty of each item, demonstrating that ideas about the difficulty of tasks also influence one's own learning (Underwood, 1966). Other researchers also looked at participants' reasoning about thinking and found that students' reasoning about the personal cognitive experience was extremely exact (Arbuckle et al., 1969). Without an explicit process, measuring metacognition is, of course, difficult, and metacognition is not just an internal process, although individuals are often unaware of these processes. Sandí Ureña defined the methodologies used to assess metacognition using measurements for task completion as probable if done prior to the task, contemporaneously if done concurrently with solving the task, and retrospectively if done after the task becomes a task (Veemann, 2005). The units of measurement used to measure the complex concept of metacognition can be examined in two main categories: narrated reports (questionnaires and interviews) and objective behavioural assessment (observation and monitoring). Depending on the measuring instrument used, the appropriate method for measuring metacognition can also be determined. The most commonly used tools to assess metacognition are "routine and systematic observations aloud" (Rickey and Stacy, 2000). "Think Aloud" protocols enable the examiner to appreciate the processes of the subjects who verbally state how to deal with a certain situation. However, two difficulties arise with this category of instrument. The first is that aloud protocols can inhibit participants from internalizing the given material when verbally expressing their opinions. And secondly, while loudly designed protocols are useful in clinical research settings, they do not work in the same way in the classroom (Scott, 2009). It is also worth mentioning the shortcomings of systematic observations which, although useful for the diachronic determination of nonverbal metacognitive behavior, come with implementation difficulties when used for a small number of participants.

The most used tools remain the questionnaires and the interviews that allow the simultaneous and retrospective evaluation of the metacognition, however, they also have disadvantages. The biggest disadvantage of a self-reflection questionnaire is the probability that the subjects will illustrate their reluctance to express their cognitive processes as well as the

possibility that they do not understand the work tasks (Baker et al., 2000). At the same time, the positive aspects of this type of instrument seem to exceed the negative ones. First, questionnaires allow the simultaneous testing of large groups of students and can be easily distributed and evaluated immediately in an objective way (Tobias & Howard, 1996). Second, unlike interviews, the questionnaires provide a fair collection of data for all participants, which varies according to the initial responses of each individual. The disadvantages of using interviews as a method of measuring metacognition are that they require time and a process of communication and mutual interaction, which starts with asking and then finding answers to questions and cannot always be used in a classroom (Scott, 2009). Finally, in situations where motivation and cognitive involvement cannot be observed, questionnaires can be used reliably (Pintrich & De Groot, 1990).

2.4. Motivations and research objectives

The present study systematically reviews the findings regarding the instruments and methodologies used to measure and assess metacognition in children in the age category of 5 to 9 years over the past 8 years (2013-2021). It contains a summary of the tools and methods utilized to address the central question of the research: to what extent methodologies and tools have been utilized to assess metacognitive components in children aged 5 to 9 years in the last 8 years (2013-2021)?

Furthermore, the purpose of this research was to advance the investigation of probable connections through:

- type of tools, methods, and the age of the participants;
- the association between metacognition and related concepts.

3. Research methods

The prior search was conducted using keywords on the Education Resources Information Center (ERIC) and the British Education Index (EIB) platforms. After creating the search query and completing the search parameters. PsycINFO, Web of Science, EMBASE, Google Scholar, and SCOPUS searches were conducted to find the relevant number of registrations for screening. Detailed information can be found in Annex 1. In order to ensure that the screening process is carried out in a systematic and transparent manner, specific criteria have been established for the inclusion of records from the beginning of the review process. Table 1 demonstrates how the inclusion and exclusion criteria were implemented. At the same time, Table 1 includes the records excluded due to non-compliance with the inclusion criteria: registration date, population sample, empirical data set, language of recording.

3.1. Method

The methods used are based on PRISMA to preserve the cohesion of the study, mainly during the search phase of the screening process. This focuses on the methodologies and instruments utilized by authors to assess metacognition, without aiming at the results or effects of metacognitive interventions (Torgerson et al., 2014). The research is based on the inventory of literature published between January 2013 and January 2021 in seven databases: PsycINFO, Web of Science, ERIC, EMBASE, EIB, Google Scholar, and SCOPUS. The search was performed using 6 keywords: metacognition, metaknowledge, assessment of metacognition, and early childhood (5-9 years). The results offer a perspective of the actual situation concentrating measurement or evaluation of metacognition and the identification of numerous instruments and methodologies used to test metacognition over the last 8 years.

3.2. Screening process

The screening procedure was meticulous, however, the rigor in this phase was significant. Table 2 shows the current figures included and excluded from each database at each stage of the procedure. In the first stage, for each study, there were examined the title and abstract to see if the study corresponded to the topic (e.g., metacognition and associated concepts) and whether the population sample was in the aimed age lot (e.g., early childhood, age 5-8 years). The second screening stage involved a detailed examination of the full text; it focused particularly on the methodological parts, as this data was important in the next data extraction stage. The records at this step were coded for the following variables to include or exclude them, based on the structure provided by (Whelan, 2007):

- full reference details;
- clear and present definition of the concept;
- sample characteristics, such as age group;
- methodological details - methodologies or instruments used.

3.3. Interpretation of data and study results

This review aimed to provide a recent perspective on the subject of metacognition assessment, highlighting key trends and themes from the records included and providing the opportunity for the methodological problems treated by the present research. The major categories of approaches and tools discovered are summarized and described below, based on the results of the review, which contained 48 final records (including titles added by searching for citations) in the categories:

- observations;
- evaluations
- self-reports
- surveys
- tests
- questionnaires
- interviews
- learning-tasks
- multi-methods.

In the first phase, 1204 studies were found and carefully analyzed to select the most relevant papers for this study. To summarize this phase, out of 1204 articles, only 48 were contained in this review. Most of the articles included in the present review were published between 2019 (n = 10) and 2018 (n = 9), followed by 2017 (n = 7), 2020 (n = 6), 2016 (n = 5), 2014 (n = 4), 2013 (n = 4), 2021 (n = 2) and 2015 (n = 1).

Each instrument or method's data was extracted using a template and finalized from the earliest available record (complete with specific methodology and information) for that instrument or approach. Table 1 shows the data extraction template for the 14 instruments from the final data extraction.

The data in this sample were extracted for the IMSR (Metacognitive Self-Regulation Inventory (Howard et al., 2000). The groups were given tools or procedures based on their methodological similarity (contained in Table 2). Which tools or methodological approaches are based, for example, on the questionnaire or on the implementation of a specific task or series of tasks? The methodology used to collect information from the subjects could be described as experimental, observational, or questionnaire-based. Most studies used methods specifically stated as observation (14), while the remaining 34 used survey methods (questionnaires, interviews, self-reporting, calculation tasks). Five research works combined methods and methodologies on a sample of preschool children using standardized tools, the remaining 43 combined or adapted theoretical models and methodologies. In 15 studies, the methodology was

observational, of which 5 studies were variations of them. In 10 cases, the number of children researched was not given. In 5 studies, the authors did not mention how many children participated in the study. Of those who did, the number ranged from 13 to 122 (60 on average). The average age of participants in these studies was 6.14 years. The tools used in the studies were different in number and type: 2 studies used questionnaires, 14 used observations, 6 used interviews, 2 calculation tasks, 3 reading aloud reports, 2 self-reports, and 5 items evaluated on a scale. Another 5 combined different methods in the same study. Information on specific tasks performed during each experiment was provided in 8 studies and from this, we can conclude that metacognition was assessed using tasks adapted from other fields (e.g. reading activities, mathematics, solving specific tasks, or researching social behaviour), with a focus on metacognitive processes such as metacognitive skills (6), problem-solving (6) and awareness, assessment and self/decision making (3). In other 9 studies, the authors offer a brief presentation of the tasks performed in experiments. The remaining 39 studies, did not provide this information.

4. Results

The central objective of the present research was to analyze the current state of the research on the methodology of the concept of metacognition for young children (5-9 years), implicitly the most commonly used types of subsumed tools for the early childhood population. Several studies state that metacognition is crucial in learning contexts (Weinmann, 2019). The current systematic review found the predominant concepts of metacognition with the search criteria: metacognitive instructions, reading aloud reports, SLRs, and interviews (Kim et al., 2016). Several studies have found that metacognition is crucial to academic problem-solving success (Weinmann, 2019). The current systematic review found that metacognitive instructions, reading aloud reports, SLRs, and interviews are the four primary categorizations of notions of metacognition that predominate in the research examined with the criteria sought. The revised studies had a good representation of the entire range of these activities, with a focus on developing specific abilities.

This analysis of the techniques and methodologies utilized to assess metacognition in young children is crucial for future metacognition research because there is currently no review in this field to systematically analyze metacognition and how it is assessed. This study addressed critical questions about the frequency with which different ways of addressing and assessing metacognition are employed, as well as whether they are used at all. Although the focus was not on this component, it is worth emphasizing that two included studies claiming to test metacognition in participants aged 3 to 5 years using McKI (Marulis et al., 2016; Marulis & Nelson, 2021), supporting the evidence acquired by Wall, that metacognitive skills appear at a younger age than previously thought (Wall, 2018).

The combined methods involving observing and triangulating the actions, help to collect metacognitive information that are significant for the assessment of metacognition in early childhood (rather than meta-cognitive skills and abilities). The present study visibly illustrates the path of metacognitive tools or methods and how these have changed over the years. The congruence between the definition and the instrument is necessary for the further development of this field of research (Schmitt & Sha, 2009).

A final example is the description of a conditional questionnaire that is later adapted into two other instruments: IRA and MSLQ (Wolters, 1996). The IRA is adjusted once more when Schmitt and Sha discuss the IMA, which is based on the IRA.

As stated in the introduction, the focus of this review was on tools that explicitly operationalize metacognition, and it went beyond the scope of the review to study specifically how associated concepts are assessed, although this would be a useful next step, such as a future direction to research the comparative use of such metacognitive tools (Garner, 2009).

5. Strengths, weaknesses, and research opportunities

The number of published articles on metacognition and metacognitive strategies is relatively high compared to other peer review research. This can be explained by several factors. First, the number of meta-analyses performed by cognitive or educational researchers is relatively high. Another factor is the growing interest in early education research. Finally, another explanation may be that this period was very dynamic with the development of brain research. Concepts such as "brain fitness exercises" or "brain self-regulation" have gained popularity in recent years, and this has led researchers to start investing more time in exploring metacognition.

Most of the included studies had older population samples than the selection criteria of the present review, and the inclusion conditions have been extended to studies that have at least 50% of the sample young children.

There are many opportunities for further research on early education. First, there are many factors to consider. Childhood is a period in which the memory function seems to be the most developed and one way in which knowledge and cognitive memories are realized is through metacognition. Early on, a lack of metacognition might have an impact on the development of learning abilities and social knowledge. In addition, there are many network effects: school policies encourage more researchers to study children under the age of five. Finally, studies in the current review have shown that even interventions targeting 3–5-year-olds can have a positive effect on memory and cognitive abilities later in life.

In conclusion, there were collected 1204 articles from January 2013 to January 2021. In the first phase, there were selected those written in English to include in our review. Without considering any study or publication written in another language (n = 0). The publications that were chosen for the second phase assessed the impact of interventions on children's metacognition and metacognitive strategies. Hopefully, the present study will provide more evidence to come up with possible recommendations or hypotheses in support of future research, leading to questions such as • Why are self-reporting and observation predominant? • What tools have been rarely used? • What are the limitations of the tools used in relation to the age group?

References

Akturk, A. O., & Sahin, I. (2011). Literature review on metacognition and its measurement. *Procedia - Social and Behavioral Sciences*, *15*, 3731–3736. https://doi.org/10.1016/j.sbspro.2011.04.364

Altındağ, M. (2008). *HacetteÜniversitesiEğitimFakültesiÖğrencilerinin YürütücBiliBecerileri*. 98.

Aras, S., & Erden, F. T. (2020). Documentation panels: supporting young children's self-regulatory and metacognitive abilities. *International Journal of Early Years Education*, *28*(1), 63–80. https://doi.org/10.1080/09669760.2019.1592743

Arbuckle, Tannis, Cuddy, & Lola. (1969). Discrimination of item strength at the time of presentation. *Journal of Experimental Psychology*, *81*, 126–131. https://doi.org/10.1037/h0027455

Ayersman, D. J. (1995). Effects of knowledge representation format and hypermedia instruction on metacognitive accuracy. *Computers in Human Behavior*, *11*(3–4), 533–555. https://doi.org/10.1016/0747-5632(95)80016-2

Bai, B. (2018). Understanding primary school students' use of self-regulated writing strategies through think-aloud protocols. *The system*, *78*, 15–26. https://doi.org/10.1016/j.system.2018.07.003

Baker, L., & Brown. (1980). *Metacognitive Skills and Reading*.

Baker, L., Cerro, L. C., & Baker, L. (2000). *DigitalCommons @ the University of Nebraska - Lincoln 3 . Assessing Metacognition in Children and Adults Assessing Metacognition in Children and Adults*.

Blöte, A. W., Resing, W. C. M., Mazer, P., & Van Noort, D. A. (1999). Young Children's

Organizational Strategies on a Same-Different Task: A Microgenetic Study and a Training Study. *Journal of Experimental Child Psychology*, *74*(1), 21–43. https://doi.org/10.1006/jecp.1999.2508

Blumberg, F. C., Flynn, R. M., Kleinknecht, E., & Ricker, A. A. (2019). Cognitive development and gaming in the digital age. *Ubiquitous Learning*, *12*(2), 39–50. https://doi.org/10.18848/1835-9795/CGP/v12i02/39-50

Bogdan, R. (2003). *Minding minds: Evolving a reflexive mind by interpreting others*. https://books.google.com/books?hl=en&lr=&id=HBYQjmrJ5v8C&oi=fnd&pg=PR11&dq=9.%09Bogdan,+R.+J.+(2000)+Minding+minds:+evolving+a+reflexive+mind+by+interpreting+others+MIT+Press+,+Cambridge,+MA&ots=OGGb97pOlv&sig=B3YWpEeNb0m_J2LBwomKXnIah7g

Bonner, & J. (1988). Implications of Cognitive Theory for Instructional Design: Revisited. *Educational Communications and Technology Journal*, *36*(1), 3–14.

Borkowski, J. G., S Chan, L. K., & Muthukrishna, N. (2012). A process-oriented model of metacognition: Links between motivation and metacognition. *Issues in the Measurement of Metacognition*, 1–41. https://digitalcommons.unl.edu/burosmetacognition

Brown, & L., A. (1978). Knowing When, Where and How to Remember: A Problem of metacognition. *Advances in Instructional Psychology*, 77–165.

Brown, & L., A. (1987). Executive Control, Self-Regulation, and Other More Mysterious Mechanisms. *Metacognition, Motivation, and Understanding*, 65–116.

Brown, L, A., Bransford, D., J., Ferrara, A., R., & Campione. (1983). *"Learning, Remembering, and Understanding". In P. H. Mussen (Ed.). Handbook of Child Psychology*.

Cer, E. (2019). The Instruction of Writing Strategies: The Effect of the Metacognitive Strategy on the Writing Skills of Pupils in Secondary Education. *SAGE Open*, *9*(2). https://doi.org/10.1177/2158244019842681

Cera, R., Mancini, M., & Antonietti, A. (2014). Relationships between Metacognition, Self-efficacy, and Self-regulation in Learning. *ECPS - Educational, Cultural and Psychological Studies*, *7*, 115–141. https://doi.org/10.7358/ecps-2013-007-cera

Cobb, J. B. (2016). Assessing Reading Metacognitive Strategy Awareness of Young Children: The Reading Metacognitive Strategy Picture Protocol. *Language and Literacy*, *18*(1), 23. https://doi.org/10.20360/g2pc74

Day, J., Freiberg, K., Hayes, A., & Homel, R. (2019). Towards Scalable, Integrative Assessment of Children's Self-Regulatory Capabilities: New Applications of Digital Technology. *Clinical Child and Family Psychology Review*, *22*(1), 90–103. https://doi.org/10.1007/s10567-019-00282-4

Dufresne, A., & Kobasigawa, A. (1989). Children's spontaneous allocation of study time: Differential and sufficient aspects. *Journal of Experimental Child Psychology*, *47*(2), 274–296. https://doi.org/10.1016/0022-0965(89)90033-7

Dunlosky, J., & Hertzog, C. (2000). Updating knowledge about encoding strategies: A componential analysis of learning about strategy effectiveness from task experience. *Psychology and Aging*, *15*(3), 462–474. https://doi.org/10.1037/0882-7974.15.3.462

Erdmann, K. A., & Hertel, S. (2019). Self-regulation and co-regulation in early childhood – development, assessment and supporting factors. *Metacognition and Learning*, *14*(3), 229–238. https://doi.org/10.1007/s11409-019-09211-w

Escolano-Pérez, E., Herrero-Nivela, M. L., & Anguera, M. T. (2019). Preschool metacognitive skill assessment to promote an educational sensitive response from mixed-methods approach: Complementarity of data analysis. *Frontiers in Psychology*, *10*(JUN), 1–22. https://doi.org/10.3389/fpsyg.2019.01298

Escorcia, D., & Gimenes, M. (2020). Metacognitive components of writing: Construction and validation of the Metacognitive Components of Planning Writing Self-inventory (MCPW-I). *Revue Europeenne de Psychologie Appliquee*, *70*(1).

https://doi.org/10.1016/j.erap.2019.100515
Flavell, & H., J. (1976). Metacognitive aspects of problem-solving. *The Nature of Intelligence*.
Flavell, J. H. (2000). Development of children's knowledge about the mental world. *International Journal of Behavioral Development*, *24*(1), 15–23. https://doi.org/10.1080/016502500383421
Flavell, J. H., Green, F. L., & Flavell, E. R. (1995). The development of children's knowledge about attentional focus. *Developmental Psychology*, *31*(4), 706–712. https://doi.org/10.1037//0012-1649.31.4.706
Fridman, R., Eden, S., & Spektor-Levy, O. (2020). Nascent Inquiry, Metacognitive, and Self-Regulation Capabilities Among Preschoolers During Scientific Exploration. *Frontiers in Psychology*, *11*(July), 1–16. https://doi.org/10.3389/fpsyg.2020.01790
Garner, J. (2009). Conceptualizing the relations between executive functions and self-regulated learning. *Journal of Psychology: Interdisciplinary and Applied*, *143*(4), 405–426. https://doi.org/10.3200/JRLP.143.4.405-426
Gascoine, L., Higgins, S., & Wall, K. (2017). Context and Implications Document for The assessment of metacognition in children aged 4-16 years: a systematic review. *Review of Education*, *5*(1), 58–59. https://doi.org/10.1002/rev3.3079
Gascoine, & Louise. (2016). *Investigating Developmental Trends in Metacognitive Knowledge with School-aged Children using Pupil Views Templates*. Durham University.
Georghiades, P. (2004). From the general to the situated: Three decades of metacognition. *International Journal of Science Education*, *26*(3), 365–383. https://doi.org/10.1080/0950069032000119401
Goemans, N. (2019). *Learning about learning : An exploration into the An investigation into and how effects of self- on teaching a Latin course metacognition in using the Mathematics classroom. quadrant model fosters agentic learning in students Nicola Goemans Submitted*.
Gourgey, A. F. (1998). Metacognition in basic skills instruction. *Instructional Science*, *26*(1–2), 81–96. https://doi.org/10.1023/a:1003092414893
Hart, & Joseph. (1965). Memory and the feeling-of-knowing experience. *Journal of Educational Psychology*. https://doi.org/56. 208-16. 10.1037/h0022263
Hartman, H. (2001). *Metacognition in learning and instruction: Theory, research and practice* (Vol. 19). Springer Science & Business Media. https://books.google.com/books?hl=en&lr=&id=l7tWaKaIUcQC&oi=fnd&pg=PA1&dq=52.%09Schraw,+G.+(2001).+"Promoting+General+Metacognitive+Awareness".+In+H.+J.+Hartman+(Ed.).+Metacognition+in+Learning+and+Instruction:+Theory,+Research+and+Practice+(pp.3-16).+Dordrecht:+Kluwer+Acdemic+Publishers&ots=uH4UUIjmSQ&sig=NfVk-QD11f2FTxgwXKy3xe6OJPM
Hofer, B. K., & Sinatra, G. M. (2010). Epistemology, metacognition, and self-regulation: Musings on an emerging field. *Metacognition and Learning*, *5*(1), 113–120. https://doi.org/10.1007/s11409-009-9051-7
Howard, B. C., Mcgee, S., Shia, R., & Hong, N. S. (2000). Metacognitive Self-Regulation and Problem-Solving: Expanding. *Educational Research Association*, 13.
J. H. Flavell. (1979). Metacognition and Cognitive Monitoring: A New Area of Cognitive-Developmental Inquiry. *American Psychologist*, *34*(10), 906–911.
Jacob, L., Dörrenbächer, S., & Perels, F. (2019). A pilot study of the online assessment of self-regulated learning in preschool children: Development of a direct, quantitative measurement tool. *International Electronic Journal of Elementary Education*, *12*(2), 115–126. https://doi.org/10.26822/iejee.2019257655
Jacobs, J. E., & Paris, S. G. (1987). Children's Metacognition About Reading: Issues in Definition, Measurement, and Instruction. *Educational Psychologist*, *22*(3–4), 255–278. https://doi.org/10.1080/00461520.1987.9653052
Kallio, H., Virta, K., & Kallio, M. (2018). Modeling the components of metacognitive awareness. *International Journal of Educational Psychology*, *7*(2), 94–122.

https://doi.org/10.17583/ijep.2018.2789
Keren, G., & Fridin, M. (2014). Kindergarten Social Assistive Robot (KindSAR) for children's geometric thinking and metacognitive development in preschool education: A pilot study. *Computers in Human Behavior*, *35*, 400–412. https://doi.org/10.1016/j.chb.2014.03.009
Kim, B., Zyromski, B., Mariani, M., Lee, S. M., & Carey, J. C. (2016). Establishing the Factor Structure of the 18-Item Version of the Junior Metacognitive Awareness Inventory. *Measurement and Evaluation in Counseling and Development*, *April*, 074817561667136. https://doi.org/10.1177/0748175616671366
Kokotsaki, D., Menzies, V., & Wiggins, A. (2014). Durham Research Online Woodlands. *Critical Studies on Security*, *2*(2), 210–222.
Kramarski, B., Desoete, A., Bannert, M., Narciss, S., & Perry, N. (2013). New Perspectives on Integrating Self-Regulated Learning at School. *Education Research International*, *2013*, 1–4. https://doi.org/10.1155/2013/498214
Kuzle, A. (2018). Assessing metacognition of grade 2 and grade 4 students using an adaptation of a multi-method interview approach during mathematics problem-solving. *Mathematics Education Research Journal*, *30*(2), 185–207. https://doi.org/10.1007/s13394-017-0227-1
Kuzle, Ana. (2019). Second Graders' Metacognitive Actions in Problem Solving Revealed Through Action Cards. *The Mathematics Educator*, *28*(1), 27–60.
Leader, W. S. (2008). *METACOGNITION AMONG STUDENTS IDENTIFIED AS GIFTED OR In the Graduate College*.
Lemberger-Truelove, M. E., Carbonneau, K. J., Atencio, D. J., Zieher, A. K., & Palacios, A. F. (2018). Self-Regulatory Growth Effects for Young Children Participating in a Combined Social and Emotional Learning and Mindfulness-Based Intervention. *Journal of Counseling and Development*, *96*(3), 289–302. https://doi.org/10.1002/jcad.12203
Livingston, J. a. (1997). Metacognition: an overview. *Psychology*, *13*, 259–266. http://gse.buffalo.edu/fas/shuell/CEP564/Metacog.htm
Lyons, K. E., & Ghetti, S. (2010). Metacognitive Development in Early Childhood: New Questions about Old Assumptions. In *Trends and Prospects in Metacognition Research* (pp. 1–479). Springer. https://doi.org/10.1007/978-1-4419-6546-2
Magiera, M. T. (2008). *Metacognition in solving complex problems: A case study of situations and circumstances that prompt metacognitive behaviors.Chicago* (Issue December). College of the Illinois Institute of Technology.
Marić, M., & Sakač, M. (2018). Metacognitive components as predictors of preschool children's performance in problem-solving tasks. *Psihologija*, *51*(1), 1–16. https://doi.org/10.2298/PSI161123007M
Marulis, Loren M., & Nelson, L. J. (2021). Metacognitive processes and associations to executive function and motivation during a problem-solving task in 3–5-year-olds. *Metacognition and Learning*, *16*(1), 207–231. https://doi.org/10.1007/s11409-020-09244-6
Marulis, Loren M., Palincsar, A. S., Berhenke, A. L., & Whitebread, D. (2016). Assessing metacognitive knowledge in 3–5-year-olds: the development of a metacognitive knowledge interview (McKI). *Metacognition and Learning*, *11*(3), 339–368. https://doi.org/10.1007/s11409-016-9157-7
Marulis, Loren Marie, Baker, S. T., & Whitebread, D. (2020). Integrating metacognition and executive function to enhance young children's perception of and agency in their learning. *Early Childhood Research Quarterly*, *50*, 46–54. https://doi.org/10.1016/j.ecresq.2018.12.017
Meichenbaum, D. (2019). Teaching thinking. In *The Evolution of Cognitive Behavior Therapy* (pp. 69–88). Routledge. https://doi.org/10.4324/9781315748931-7
Mercer, & N. (2019). Classroom talk and the development of self-regulation and metacognition. *In Language and the Joint Creation of Knowledge*, 318–346.
Merchie, E., & Van Keer, H. (2014). Learning from Text in Late Elementary Education. Comparing Think-aloud Protocols with Self-reports. *Procedia - Social and Behavioral*

Sciences, *112*(Iceepsy 2013), 489–496. https://doi.org/10.1016/j.sbspro.2014.01.1193

Monkeviciene, O., Vildziuniene, J., & Valinciene, G. (2020). The Impact of Teacher-Initiated Activities on Identifying and Verbalizing Ways of Metacognitive Monitoring and Control in Six-Year-Old Children. *Research in Social Sciences and Technology*, *5*(2), 72–92. https://doi.org/10.46303/ressat.05.02.5

Nelson, L. J. (2017). Help-seeking and private speech during a problem-solving task in 2-5-year-olds. *Metacognition and Learning*, *16*, 1–14.

O' Sullivan, J. T. (1993). Preschoolers' beliefs about effort, incentives, and recall. In *Journal of Experimental Child Psychology* (Vol. 55, Issue 3, pp. 396–414). https://doi.org/10.1006/jecp.1993.1022

Olson, M, G., Duffy, & A., S. (n.d.). inking-out-loud as a method for studying real-time comprehension processes. *New Methods in Reading Comprehension Research*.

OZTURK, N. (2017). Assessing Metacognition: Theory and Practices. *International Journal of Assessment Tools in Education*, *4*(2), 134–134. https://doi.org/10.21449/ijate.298299

Paris, S. G., & Winograd, P. (1990). How metacognition can promote academic learning and instruction. In *Dimensions of Thinking and Cognitive Instruction* (pp. 15–51). https://books.google.com/books?hl=en&lr=&id=cMvwdraULp0C&oi=fnd&pg=PA15&dq=41.%09Paris,+S.+G.+and+Winogard,+P.+(1990).+"How+Metacognition+can+Promote+Academic+Learning+and+Instruction".+In+B.+F.+Jones+and+L.+Idol+(Eds.).+Dimensions+of+Thinking+and+Cogniti

Perner, J. (1991). *Understanding the representational mind.*

Peters, E. E. (2007). *The Effect of Nature of Science Metacognitive Prompts on Science Students' Content and Nature of Science Knowledge, Metacognition, and Self-Regulatory Efficacy*. George Mason University.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and Self-Regulated Learning Components of Classroom Academic Performance. *Journal of Educational Psychology*, *82*(1), 33–40. https://doi.org/10.1037/0022-0663.82.1.33

Ramachandran, A., Huang, C. M., Gartland, E., & Scassellati, B. (2018). Thinking Aloud with a Tutoring Robot to Enhance Learning. *ACM/IEEE International Conference on Human-Robot Interaction*, 59–68. https://doi.org/10.1145/3171221.3171250

Rickey, D., & Stacy, A. M. (2000). The Role of Metacognition in Learning Chemistry. *Journal of Chemical Education*, *77*(7), 915–920. https://doi.org/10.1021/ed077p915

Scarr, S., & Zanden, J. (1984). *Understanding Psychology*. Random House.

Schellings, G. L. M., Van Hout-Wolters, B. H. A. M., Veenman, M. V. J., & Meijer, J. (2013). Assessing metacognitive activities: The in-depth comparison of a task-specific questionnaire with think-aloud protocols. *European Journal of Psychology of Education*, *28*(3), 963–990. https://doi.org/10.1007/s10212-012-0149-y

Schmitt, M. C., & Sha, S. (2009). The developmental nature of meta-cognition and the relationship between knowledge and control over time. *Journal of Research in Reading*, *32*(2), 254–271. https://doi.org/10.1111/j.1467-9817.2008.01388.x

Schneider, W. (1999). The development of metamemory in children. *Attention and Performance*, *17*, 487–514. https://psycnet.apa.org/record/1999-02468-016

Schneider, W. (2002). The Development of Metacognitive Knowledge in Children and Adolescents: Major Trends and Implications for Education. *Applied Metacognition*, *2*(3), 114–121.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. In *Contemporary Educational Psychology* (Vol. 19, Issue 4, pp. 460–475). https://doi.org/10.1006/ceps.1994.1033

Schraw, G., & Moshman, D. (1995). DigitalCommons @ the University of Nebraska - Lincoln Metacognitive Theories. *Educational Psychology Review*, *7*(4), 351–371.

Scott, B. M. (2009). Exploring the effects of student perceptions of metacognition across

academic domains. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, *69*(11-A), 4247. http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2009-99090-221&lang=ja&site=ehost-live

Siddiq, & Scherer. (2017). Think-aloud protocols of collaborative problem solving 1. *Computers in Human Behavior*, *76*, 509–525.

Swanson, H. L. (1990). Influence of Metacognitive Knowledge and Aptitude on Problem Solving. *Journal of Educational Psychology*, *82*(2), 306–314. https://doi.org/10.1037/0022-0663.82.2.306

Temur, Ö. D., Özsoy, G., & Turgut, S. (2019). Metacognitive instructional behaviors of preschool teachers in mathematical activities. *ZDM - Mathematics Education*, *51*(4), 655–666. https://doi.org/10.1007/s11858-019-01069-1

Tobias, S., & Howard, E. (1996). Assessing Metacognitive Knowledge Monitoring. *College Entrance Examination Board*, *96*. https://files.eric.ed.gov/fulltext/ED562584.pdf%0Ahttp://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED562584&site=ehost-live

Torgerson, C., Brooks, G., Gascoine, L., & Higgins. (2014). Reading policy and the evidence of effectiveness from a systematic 'tertiary' review. *Critical Studies on Security*, *2*(2), 210–222.

Underwood, B. J. (1966). Individual and group predictions of item difficulty for free learning. *Journal of Experimental Psychology*, *71*(5), 673–679. https://doi.org/10.1037/h0023107

Veeman, M. V. J. (2005). The assessment of Metacognitive Skills: What can be learned from multi-method designs? In *Strategisches Lernen* (pp. 77–99). https://dare.uva.nl/record/1/222029

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, *1*(1), 3–14. https://doi.org/10.1007/s11409-006-6893-0

Weinmann, J. B. (2019). Effect of Task-Specific Self-Regulation Prompts on Science Content Knowledge and Transfer. *ProQuest Dissertations and Theses*, *May 2019*, 140. http://ezproxy.lib.gla.ac.uk/login?url=https://www.proquest.com/dissertations-theses/effect-task-specific-self-regulation-prompts-on/docview/2312284505/se-2?accountid=14540%0Ahttp://eleanor.lib.gla.ac.uk:4550/resserv?genre=dissertations+%26+theses&issn=&t

Wellman, & M, H. (1985). The development of conceptions of cognition. *The Growth of Reflection in Children*, 196–206.

Whelan, R. R. (2007). Neuroimaging of cognitive load in instructional multimedia. *Educational Research Review*, *2*(1), 1–12. https://doi.org/10.1016/j.edurev.2006.11.001

Wilson, & J. (1998). Assessing metacognition: legitimizing metacognition as a teaching goal. *Reflect*, *4*(1), 14–20.

Zhang, H., & Whitebread, D. (2019). Examining Chinese kindergarten children's psychological needs satisfaction in problem-solving: A self-determination theory perspective. *Instructional Science*, *47*(4), 373–398. https://doi.org/10.1007/s11251-019-09490-5

Annex 1

Table 1. Inclusion and exclusion criteria with examples of excluded records

Category	Selection Criteria	Inclusion Criteria	Exclusion Criteria	Excluded study example
Date of publication	*Specific systematic analysis on a given time scale*	*Papers published between Jan.2013-Jan. and 2021*	*Papers published outside the January period. 2013-Jan.2021*	*(Whitebread,2012)"Metacognition in Young Children: Current Methodological and Theoretical Developments",*
Language of publication	*Time constraints would not allow the translation of non-English studies*	*Articles whose language of publication is English*	*Articles whose language of publication is other than English*	*(Le Pichon,2010) "Ce que les enfants savent de la communication (approche contextuelle de l'hétérogénéité de groupes plurilingues)"*
Measured concept	*The object of the study is metacognition and its components*	*A clear notification that metacognition or a subsumed concept is measured and specifically targeted*	*Metacognition is not measured nor are the components • Theoretical explanation of the concept is not related to the results of the measurements*	*Morgan and Brooks (2012) - The focus is on scaffolding and not metacognition.*
Specific lot	*The specific lot of the population must be in the group of a defined age(5-8y.o.)*	*Participants aged 5 years8 years (at least 50%)*	*Participants are not 5-8 years old • Not in regular school • Over 50% of students identified as having additional needs or being gifted*	*Hanson and Williams (2008) - This contains a higher education sample*
Data set and methodologies	*The study must have a thematic empirical data set to be included*	*Empirical data must be collected and there must be a clear and replicable tool or method*	*There are no empirical data or the methodology is not clear or replicable*	*Vermunt and Vermetten (2004) - does not contain a data set*

Table 2. Extraction for the 48 instruments included in the study

DataBase	Total Results	Post Duplicates	Excluded after the first screening	Unavailable	*Results excluded during data collection*	Total number of included studies
PsycINFO	41	38	27	15	5	10
Web Of Science	236	120	90	7	3	4
ERIC	283	92	88	17	10	7
Google Scholar/Academic	134	121	105	28	13	15
BEI	35	30	28	5	4	1
EMBASE	424	202	175	12	3	9
SCOPUS	51	37	10	3	1	2
Total	1204	640	523	87	39	48

Table 3. Data extraction for the 48 instruments included in the study

Used tool	Selection Criteria	Included records	Tool Description	Definition/assessing
1. Coding system of the class for behaviour self-regulation of children	*Explicitly described as an observation*	"Towards a scalable, integrative assessment of children's self-regulation skills: new applications of digital technology" (Day, 2019)	*Thinking becomes observable*	*Metacognitive strategy and task.*
	Explicitly described as an observation	"Documentation panels: supporting young children's self-regulatory and metacognitive abilities" (Aras& Erden, 2020)	*The coding system focused on five areas: attention to instruction, seeking help, monitoring progress, involvement in classroom activities, and metacognitive speech.*	*Self-regulation behaviors in the classroom.*
	Explicitly described as an observation	"Growth effects of self-regulation for young children participating in a combined intervention of social and emotional learning and based on mindfulness" (Lemberger - Truelove, 2018)	*Thinking is assessed by observation (by children talking about their own thinking).*	*Metacognition as a way of self-regulation.*
2. Index for thinking about reading TARI	*Explicitly described as an observation*	"Documentation panels: supporting the self-regulatory and metacognitive skills of young children" (Aras and Erden, 2020)	*Attention to instruction, asking for help, measuring progress, participation in classroom activities, and metacognitive discourse*	*Metacognition is associated with self-regulation as a method of training and development of metacognition.*
	Explicitly described as an observation	"Self-regulation for young children participating in a combined intervention of social and emotional learning and based on mindfulness" (Lemberger - Truelove, 2018)	*Thinking is assessed by observation*	*Metacognition is referred to as „fuzzy" (Wellman & M, 1985).*
3. Measuring Conditional Knowledge (part of a larger questionnaire)	*Self-report questionnaire*	"Modelling the components of metacognitive awareness" (Kallio et al., 2018)	*It allows the evaluation of the conditional knowledge of using the strategy. The strategies included have been adapted from both the IRA*	*The connection between metacognitive knowledge and self-controlled learning /Self-regulatory models.*

			and the MSLQ	
4. Evaluation and Prediction EPA2000 evaluation	*Participants must respond to a selection of Likert Options*	"Assessing metacognition: Theory and practices (Ozturk, 2017)	*Computerized "procedure" that evaluates "the cognitive and metacognitive processes associated with solving mathematical problems*	*Task and technique for metacognitive understanding. Declarative and procedural subtypes are also available. In learning arbitrage, metacognition is a critical factor.*
5. Self-adjusting inventory metacognition IMSR	*Self-report - the Likert scale*	"The metacognitive components of writing: Building and validating the metacognitive components of the writing planning self-inventory" (Escorcia & Gimenes, 2020)	*The goal of this study was to look into metacognitive monitoring and regulation abilities.*	*Knowledge about knowledge, objectivity, problem representation, sub/task monitoring, metacognition assessment and problem-solving are the five dimensions of metacognitive self-regulation (predictors of problem-solving).*
	Described as an observation	"Relationships between metacognition, self-efficacy and self-regulation in learning" (Cera et al., 2014)	*Examine metacognitive monitoring /self-efficacy and self-regulation skills*	*Metacognition is associated with efficacy and self-regulation as a method of training and developing metacognition.*
	Explicitly described as an auto/observation	"Self-regulation and co-regulation in early childhood - development, assessment and supporting factors" (Erdmann & Hertel, 2019)	*Factors that influence and support metacognitive self and co-regulation*	*Metacognition is associated with self-regulation as a method of training and development of metacognition.*
6. Awareness Inventory Metacognitive-Junior JrMAI	*Described as a self-reporting inventory*	"Establishing the factorial structure of the 18-item version of the junior metacognitive awareness inventory" (Kim et al., 2016)	*MAI's JrMAI versions A and B (Schraw & Dennison, 1994) Self-reporting inventories with somewhat varied response scales were utilized in both versions*	*The ability to regulate is said to include metacognitive and regulatory knowledge. It's important to distinguish between metacognitive and self-regulation*

			Self-reporting inventory.	*abilities.*
	Described as a self-reporting inventory	"A systematic review of methods for assessing metacognition in school-age children" (Gascoine et al., 2017)	*Adaptation for MAI (Schraw & Dennison, 1994)*	*Metacognition is associated with efficacy, and self-regulation as a method of training.*
	Described as a reporting invent	"Reviewing Methods for Assessing Metacognition in School-Age Children" (Kokotsaki et al., 2014)	*Adaptation for MAI (Schraw & Dennison, 1994)*	*Separate parts for metacognitive knowledge and metacognitive skills.*
	Described as a self-reporting inventory	"The effect of task-specific self-regulation on knowledge and the transfer of scientific content" (Weinmann, 2019)	*Adaptation for MAI (Schraw & Dennison, 1994)*	*The role of teachers in the development of metacognition.*
	Described as a reporting inventory	"Learning about learning: an exploration of the effects of self-assessment and peer assessment on metacognition in the math classroom" (Goemans, 2019)	*Adaptation for MAI (Schraw & Dennison, 1994)*	*Separate parts for metacognitive knowledge and metacognitive skills.*
	Described as a self-reporting inventory	"Investigating developmental trends in metacognitive knowledge with school-age children using student visualization templates" (Gascoine & Louise, 2016)	*Adaptation for MAI (Schraw & Dennison, 1994)*	*Pupil Views Templates.*
7. Assignment of Metacognitive Assessment MAA	Described as a written test	"MAA investigates developmental trends in metacognitive knowledge with school-age children" (Gascoine & Louise, 2016)	*Assignment evaluation scale of 13 items, adapted from the model of Carr & Jessup (1995)*	*Retrospective references to (Flavell & H., 1976).*
8. Knowledge Test	Explicitly stated as Test	"Metacognitive knowledge in children at early elementary school" Schneider& Löffler, 2016	*A questionnaire with a measure of metacognitive abilities (planning, monitoring, evaluation). Before answering the math*	*Knowledge, monitoring (experience), and regulation are (at least) two components of metacognition*

			problem, the children state (on a 7-point Likert scale) which behaviour is representative of their problem-solving behaviour (1 = never, 7 = often)	*(ability). Focuses on metacognitive information, such as understanding oneself and others as students, understanding task requirements, and understanding techniques.*
	Described as a multi-method study	"New Perspectives on Integrating Self-Directed Learning into School" (Kramarski et al., 2013)	*Variety of methodologies. Quasi-experimental combination of pre / post-control-group design*	*Metacognitive regulation - active process.*
9. Knowledge Interview metacognition (McKI)	*Although the title includes the interview term, the methodology describes a self-report, completed based on the task*	"Assessing Metacognitive Knowledge in 3–5-Year-Olds: Developing a Metacognitive Knowledge Interview (McKI)" (Loren M. Marulis et al., 2016)	*Self/report that investigates metacognitive knowledge, metacognitive skills, monitoring, and self-awareness*	*Knowledge awareness and strategies. Discussions about cognitive as well as metacognitive elements).*
	Described as an interview	"Metacognitive processes and associations with executive functioning and motivation during a problem-solving task in children aged 3-5 years" (Loren M. Marulis & Nelson, 2021)	*MSA (Desoete et al., 2011). 25 items*	*Metacognition means something else to each individual.*
	Questionnaire	"Nascent Inquiry, Metacognitive, and Self-Regulation Capabilities Among Preschoolers During Scientific Exploration" (Fridman et al., 2020)	*Structured interviews and filmed. Individual interview (conducted by an interviewer). Interview questions focused on metacognitive tasks*	*Three types of metacognitive knowledge.*
	Described as an observation	"Assessing Awareness of Metacognitive Reading Strategies in Young Children: The Imaging Protocol for Metacognitive Reading Strategies" (Cobb, 2016)	*Individual interview (conducted by an interviewer). The interview focused on metacognitive tasks observed and sometimes discussed*	*Metacognition categorized into components.*

	Explicitly described as an interview	"Metacognitive components as predictors of preschool children's performance in problem-solving tasks" (Marić & Sakač, 2018)	*Questions about understanding the search for information*	*Separate parts for metacognitive knowledge, knowledge metacognitive and metacognitive skills.*
	Described as an interview	"Help-seeking and private conversations during a problem-solving task with preschool children" Nelson (Nelson, 2017)	*Questions about understanding thinking, learning, and metacognitive knowledge. Original answers and questions scored on a 5-point Likert scale*	*Recognition, adaptation, and awareness/thought expression are the three components of metacognition.*
	Computer Task	"The Impact of Teacher-Initiated Activities on Identifying and Verbalizing Ways of Metacognitive Monitoring and Control in Six-Year-Old Children" (Monkeviciene et al., 2020)	*Computer-based. Items from five final tasks for measuring strategy and knowledge*	*Metacognition is both an awareness and a regulation of strategic skills.*
	Described as interview	"Cognitive Development and Gaming in the Digital Age" (Blumberg et al., 2019)	*Computer-based task Measuring strategy and cognition*	*Cognitive and metacognitive knowledge (person, task, and sometimes strategy).*
10. Problem-solving	*Although described as an interview, the procedure focuses on tasks that have been completed (and videos recorded)*	"Assessing the metacognition of school-age children using an adaptation of the multi-method interview approach" (A. Kuzle, 2018)	*Metacognitive knowledge about the mathematical technique was assessed shortly after it was first applied (for example, why did you choose this path for this problem?)*	*The role of teachers in the development of metacognition.*
	Described as an observation	"Integrating metacognition and executive function to increase young children's perception of and agency in the learning process" (Loren Marie Marulis et al., 2020)	*Measures of prior knowledge, Journal writing treated as mandatory topics*	*Metacognitive factors, Metacognition as a key competence in learning.* . .

Described as a study	"Metacognitive instructional behaviours of preschool teachers in mathematical activities"(Temur et al., 2019)	*The children solved specific mathematical tasks*	*Metacognition comprises distinct components.*
Described as observation	"Metacognitive processes and associations with executive function and motivation during a problem-solving task in 3-5-year-olds" (Loren M. Marulis & Nelson, 2021)	*Metacognition in observation, data collection, and measurement are all examples of metacognition in action*	*Executive control, often known as metacognitive skills, is a type of executive control (planning, monitoring, evaluation).*
Described as a multi-method tool	"Metacognitive components as predictors of children's preschool performance in problem-solving tasks" (Marić and Sakač, 2018)	*Examines the effect of training on the execution of specific task skills*	*Repetition, elaboration, organization, and metacognitive learning strategies are the four categories of learning strategies.*
Described as an observation	"Assessing the Metacognition of 2nd and 4th Grade Students Using an Adaptation of the Multi-Method Interview Approach While Solving Math Problems" (A. Kuzle, 2018)	*MMI (Wilsom & Clarke, 2004)*	*The components of metacognition are: error recognition, adaptability, awareness, and thought/strategy expression.*
Described as observing a multi-method tool	"Integrating metacognition and executive function to increase young children's perception of and agency in the learning process" (Loren Marie Marulis et al., 2020)	*Using metacognition in observation and solving specific tasks.* *Ability to explain reasoning in concluding*	*Planning, monitoring, evaluating.*
Described as a pilot study	"Assessing pre-school metacognitive skills to promote a meaningful educational response from a mixed approach: data complementarity"(Escolano-Pérez et al., 2019)	*The findings show that children who completed specified tasks and those who did not complete specific tasks have different metacognitive capacities*	*Metacognition is developed using metacognitive clues and instructions.*

	Described as a self-report of responses using a Likert scale	"A pilot study of online assessment of self-regulated learning in preschoolers: Development of a direct, quantitative measurement tool" (Jacob et al., 2019)	*Adaptation of the Zimmermann (2000) model as a theoretical basis. A direct, quantitative measurement tool is evaluated to evaluate the LLC in an "online manner"*	*Separate parts for metacognitive knowledge and metacognitive skills.*
	Described as an observation	"Investigating the awareness of children's metacognitive reading strategy: a continuum of development appears" (Cobb,2017)	*A tool for measuring perceptions about the use of strategy (for the reader). Likert scale*	*Metacognitive skills: planning, monitoring, evaluation.*
	Described as interview	*"*Examining the Psychological Needs of Chinese Kindergarten Children in Problem Solving: A Perspective on Self-Determination Theory*"*(Zhang & Whitebread, 2019)	*It examines whether the satisfaction of the psychological needs of kindergarten children mediates the relationship between parental scaffolding and the use of strategic behaviours of self-regulated learning (SRL) by children*	*The interchange of verbal information, comprehension, reading, writing, attention, memory, problem-solving, learning, and self-control are all tasks in which metacognitive skills are vital.*
	Described as interview	"Metacognitive actions of second graders in solving problems with action cards" (Ana Kuzle, 2019)	*Metacognitive behaviours during solving mathematical problems. Adaptation of interview with several methods, whose basic idea is to use action cards consisting of clues metacognitive.*	*SRL Structure.*
11. Loud Thinking Protocol TAP / TAPs	*Thinking out loud report*	"Understanding Primary School Students' Use of Self-Regulated Writing Strategies Through Loud Thinking Protocols"(Bai, 2018)	*Regulating strategies were detected in the sample on many occasions*	*Recognize the connection between writing ability, class level, and the utilization of self-written writing strategies.*
	Thinking out loud report	"Assessment of metacognitive activities: an in-depth comparison of a task-specific	*TAP applied while solving specific language tasks*	*Metacognition as a predictor of learning. The distinction*

		questionnaire with loud thinking protocols" (Schellings et al., 2013)	*(Reference made to (Veeman, 2005)*	*between Metacognitive Ability and Metacognitive knowledge.*
	Computer task	"Think out loud with a guidance robot to improve learning"(Ramachandran et al., 2018)	*Children reading a passage aloud and solve computerized tasks- questions to examines the understanding and understanding strategies- (metacognition)*	*Personality traits, tasks, and learning strategies are connected.*
	Described as an observed interview	"Revealing the processes of student interaction with a new collaborative problem-solving task: an in-depth analysis of loudly thought-out protocols" (Siddiq & Scherer, 2017)	*Metacognition as a predictor of Learning*	*Writing skills and the use of metacognitive strategies are connected.*
	Self-report thinking out loud	"Learning from a text in late elementary school. Comparing aloud thinking protocols with self-reports" (Merchie & Van Keer, 2014)	*Weinstein and Mayer (1986) provided a list of cognitive and metacognitive methods (including planning, monitoring, and regulatory strategies)*	*Recognize the link between reading ability and the usage of self-directed learning techniques.*
13. **Kindergarten Social Assistance Robot (KindSAR)**	*Described as an observation*	"Kindergarten Social Assistive Robot (KindSAR) for geometric thinking and metacognitive development of children in preschool education: a pilot study" (Keren & Fridin, 2014)	*Kindergarten Social Assistance Robot (KindSAR) Is an innovative instrument that helps children's development by integrating them into interactive play activities that encourage social interaction, educate geometric thinking, and boost metacognitive development.*	*It makes metacognitive processes conducive to knowledge formation visible, supports, and helps youngsters in reflecting on them.*
14. Self-Regulated Learning Scale SLR	*Described as a multi-method study*	"New perspectives on integrating self-regulated learning at school" (Kramarski et al., 2013)	*Variety of methodologies. Quasi-experimental combination of pre /*	*"Thoughts, sentiments, and self-generated behaviours that*

			post-control-group design	*are planned and cyclically altered to attain personal goals" are all part of the SRL active process.*
A total of 14 instruments		**48 studies**		