RESEARCH ARTICLE

2024, vol. 11, issue 2, 330 - 339
https://doi.org/10.5281/zenodo.#

Metacognition assessment - a literature review of specific instruments used to measure metacognitive awareness in adults

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Abstract:

The assessment of metacognition has been a major research challenge over the years, especially because metacognition is a complex phenomenon encompassing both metacognitive knowledge and metacognitive skills and experiences. The assessment of metacognition is conducted in controlled settings, most commonly using a single scale-like instrument with clearly presented psychometric properties that measures a single dimension or several aspects of metacognition.

Methodologically, the present research is an exploratory literature review, a systematization, which attempts to bring together researchers' concerns and findings on the effectiveness of self-report inventories in measuring metacognitive awareness. Keyword searches were conducted in EbscoHost, ERIC, Scopus, and Web of Science to identify all papers that assess metacognition through self-report. Searching for generic key terms such as Humanities did not return much relevant information, but searching for specific domains such as Literature, Sciences, Linguistics, Psychology, Arts had higher chances of finding papers related to metacognition assessment. It means that the topic is much more complex and requires special attention on each case or subfield. Due to the fact that very few studies refer to the assessment of metacognition in teachers, we decided to carry out a systematic review of articles that target instruments to measure the level of metacognitive awareness of adults, which could be further adapted for teachers reported in career management.

Over the past 30 years, 43 articles have been published using self-report inventories for adults suggesting that self-report provides a useful overview of two dimensions: metacognitive knowledge and metacognitive skills. However, research highlights that metacognitive processes measured by self-report subscales are unclear: the two factors of metacognition are not adequately correlated with metacognitive behavior, but the subscales correlate strongly between self-report and metacognitive tasks. The authors believe that the role of self-reports should be considered when designing research assessing metacognition.

Keywords: metacognition, metacognitive skills, self-report, teacher professional development.

Introduction

Metacognition, a person's ability to regulate his or her own learning processes, is of particular importance both for lifelong learning and for building a successful career. Metacognition is a central component in self-regulated learning. Teachers generally have several common metacognitive professional development skills: participating in different in-service training programs in order to acquire professional credits, initiating and coordinating educational programs, monitoring their own behavior in relation to the development of professional competences, reflecting on career development. However, given the complexity of activities specific to the self-management of teaching careers, primary and pre-school teachers need general metacognitive competences to consciously guide, monitor, control and regulate cognitive and affective processes and states in order to build new skills/capabilities for career development and the most effective own knowledge and learning activities.

In teaching career management, metacognitive skills are revealed in teachers' ability to use methods and techniques of self-analysis, self-assessment, self-reflection and self-regulation, as well as in self-regulated learning, which is essential for teachers' professional growth throughout their careers; these teacher skills are interdisciplinary applicable (Kramarski &Michalsky, 2009). Recent research emphasizes the impact of

metacognitive skills on teachers' professional performance (Fathima et al., 2014), by developing a meta-perspective on their continuing education work as a prerequisite for effective self-management of professional development.

The assessment of metacognition has been a great research challenge over the years, especially because metacognition is a complex phenomenon encompassing both metacognitive knowledge and metacognitive skills and experiences. The development and use of valid assessment tools has been an ongoing concern of researchers who have emphasized that measuring metacognitive awareness in a given domain involves the use of metacognitive literature and research to develop a thorough understanding of metacognition, metacognitive processes and sub-processes.

Assessment of metacognition is conducted in controlled settings, most commonly through the use of a single scale-like instrument with clearly presented psychometric properties that measures a single dimension or several aspects of metacognition. However, Schraw (2000, 2009) emphasizes that no single research method or procedure will provide a complete understanding of a complex phenomenon such as metacognitive awareness, because "most available instruments that measure metacognition have unknown psychometric properties" (Schraw, 2000, p. 301). Hughes (2019) also believes that single-method metacognition research measures metacognition superficially. For this reason, research using multiple, triangulated, and mixed-method approaches is recommended (Pintrich, Wolters & Baxter, 2000; Schraw, 2000, 2009).

Since metacognition is not directly observable, measurement is achieved by collecting self-reported information from participants in correlation with task performance.

1. Assessment of teachers' metacognitive awareness skills in relation to teaching career management

Professional development is the continuous process of improving and acquiring new knowledge and skills to enhance one's career, and metacognition can play a significant role in professional development. By being aware of our own thought processes and learning strategies, we can identify areas where we need to improve and develop new skills. Metacognition can also help us to monitor our own progress and adjust our learning strategies accordingly. For example, if a teacher recognizes that he or she has difficulties with time management, he or she can reflect on his or her own thought processes and identify strategies to improve his or her time management skills. This may involve seeking professional development opportunities related to time management or setting goals and creating an action plan to improve their skills.

Overall, metacognition can help individuals to take an active role in their own professional development by identifying areas for improvement and developing strategies to improve their skills and knowledge. Thomas (2012) asserts that although there are few researchers who question the importance of metacognition in different domains, the recognition of this importance is not reflected in the work of teachers or the practices of educators. The extent to which teachers themselves are metacognitive is unclear, as there is not much research on teacher metacognition, but the development of metacognition could enable more effective professional development activities in this area. Georghiades (2004a) argues that those teachers who happen to be familiar with the notion of metacognition do not have the resources to implement it in their teaching (in terms of both appropriate learning materials and time). Thus, he believes that the current state of the literature in this area has already shown signs of an emerging gap between theory and practice: 'academic studies emphasize the value of metacognition for learning, but attempts to bring metacognition into mainstream classrooms are rare. If metacognition is to find its way into instruction, policy makers must make changes in curriculum and teacher training that facilitate it" (Zohar&Barzilai, 2013, p.7).

The development of metacognitive competences in teachers has an increased impact on both their teaching and the management of their professional development. Teachers need to be able to develop solid content knowledge by critically synthesizing and valuing different resources, adapting to changes in the educational system as well as to the varying demands of the beneficiaries of education. The ability to monitor and control one's own professional development effectively is essential for professional performance according to the teaching career standards. In educational practice, teachers with metacognitive skills ensure that they can do teaching plans, to monitor teaching behavior, to regulate the process of instruction, to select teaching methods, to evaluate teaching performance and to reflect on teaching activities automatically.

Zohar and Barzilai (2013) are of the opinion that in order to have a sound knowledge of metacognition, teachers need a) to have a general theoretical knowledge of metacognition, in particular to know and understand the definitions of the concept of 'metacognition' and its different components; bhave the personal capacity to practice metacognitive thinking about their own professional development activities, which can then be translated into classroom activities.

Therefore, teachers need to explain metacognitive knowledge - MK, and practice metacognitive skills -MS, according to the specific context of the intellectual activities in which they are involved or taking place in the classroom. When using or teaching a thinking strategy, teachers need to know the strategy, when, why and how it should be used - to have declarative, procedural and conditional knowledge about the strategy. They also need to be able to verbalize that knowledge using an appropriate thinking "language" (Tishman, Perkins & Jay, 1995, apud. Zohar&Barzilai, 2013). In addition, teachers need to be able to think skillfully about planning, monitoring, controlling, and evaluating the performance of that thinking strategy during classroom activities.

Referring to the specific activities of teachers' professional development, the evaluative process in the field of metacognition aims at analyzing teachers' abilities to acquire new knowledge about the development of their teaching career, the development of new skills through the permanent articulation between theory and practice, as well as the adoption of appropriate attitudes to ensure their professional success. At the same time, the capacities for reflection and critical analysis of action schemas through transfer, self-regulated learning, and metacognitive and instrumental flexibility through the use of metacognition in action checklists can also be pursued (Wilson & Conyers, 2016).

Assessment of the level of metacognitive awareness in general and metacognitive skills of teachers for professionalization of teaching career is revealed in:

- The ability to diagnose one's own level of development of professional competences, in relation to professional standards, personal expectations and the expectations of the beneficiaries of the educational act;
- Ability to elaborate a complex professional development project, focused on several elements: vision of one's own professional development; definition of strategic objectives of professional (self-)training; proposal of training activities in order to acquire / improve desirable professional and transversal competences; selection of strategies to make the implementation of the professional development project more efficient (managerial strategies, metacognitive strategies, professional learning situations;
- Self-regulation capacities of the training process, through: self-observation, self-monitoring; self-judgement; self-reaction; self-attitude (Schunk, 1996).

The assessment of teachers in the metacognitive domain is mostly carried out through metacognitive inventories, which are based on teachers' ability to self-identify their own level of metacognitive awareness in relation to the activities they are involved in. According to Balcikanli (2011), in the literature, there is no inventory designed exclusively for teachers, apart from the metacognitive awareness inventory for adults pioneered by Schraw and Dennison (1994) that can be applied across the board.

The use of a variety of self-report metacognition measurement instruments that assess metacognitive dimensions results in an inconsistent understanding of the concept of metacognition and may affect how teachers use metacognitive skills in the management of their teaching careers. Therefore, the purpose of this paper is to systematize and analyze inventories measuring metacognitive awareness in adults that can be adapted and applied to teachers.

Methodology

Survey questions:

1. Which metacognitive assessment tools are more effective in measuring adult metacognitive awareness?
2. Which metacognition assessment inventories can be adapted for teachers in relation to career management?

Study objective:

To systematically review the literature on metacognition assessment and synthesize self-report instruments according to their ability to adequately measure dimensions of metacognition in adults.

The method used had three phases: database and keyword identification, selection of papers for analysis and review, data extraction and analysis (Bennet et. al. 2005).

A. Identification of databases and keywords

(1) First phase: search for general terms of the domains (Literature, Sciences, Linguistics, Psychology, Arts) plus metacognition assessment of teachers. Not very successful in finding papers. The search for general terms of domains (Humanities, Arts and Culture) plus metacognition assessment in adults returned 43 studies of which we retained only 27 that met the criteria for analysis.

(2) Second phase: searching for specific sub-domains of each field; the databases were the usual ones selected in this type of research: EbscoHost, ERIC, Scopus and Web of Science, but also using the Google search engine.

B. Selection of papers for analysis

In order to assess metacognition as a whole, a generalizable structure, the participants should be teachers, but because there are no studies conducted on teachers we decided that the participants should be adults to represent the general population. Therefore, items were only included if:

a) only peer-review articles related to the construction of self-report and teacher/adult inventories, as well as research based on empirical and theoretical papers, book chapters, dissertations;

b) statistically evaluated metacognition in the adult population;

c) the questionnaire used was widely applicable and not for a specific subset.

The following exclusion criteria were followed:

a) Articles that do not meet the quality criteria were excluded: explaining the methodological design or having fair written opinions without evidence or arguments;

b) the questionnaire used was constructed for a particular subset of the population;

c) the questionnaire used went beyond metacognition.

C. Data review, extraction and analysis

Dimensions for analyzing the works have tried to identify:

1. Type of study (quantitative, qualitative or mixed)
2. domain
3. Metacognitive knowledge
4. Metacognitive skills
5. Metacognitive experiences
6. Type of intervention
7. Metacognitive strategies
8. Measuring metacognitive awareness among teachers
9. Results and difficulties of metacognitive assessment.

Of all the given dimensions that were easy to track in the analysis, metacognitive experiences and the strategies used for metacognitive assessment are rare.

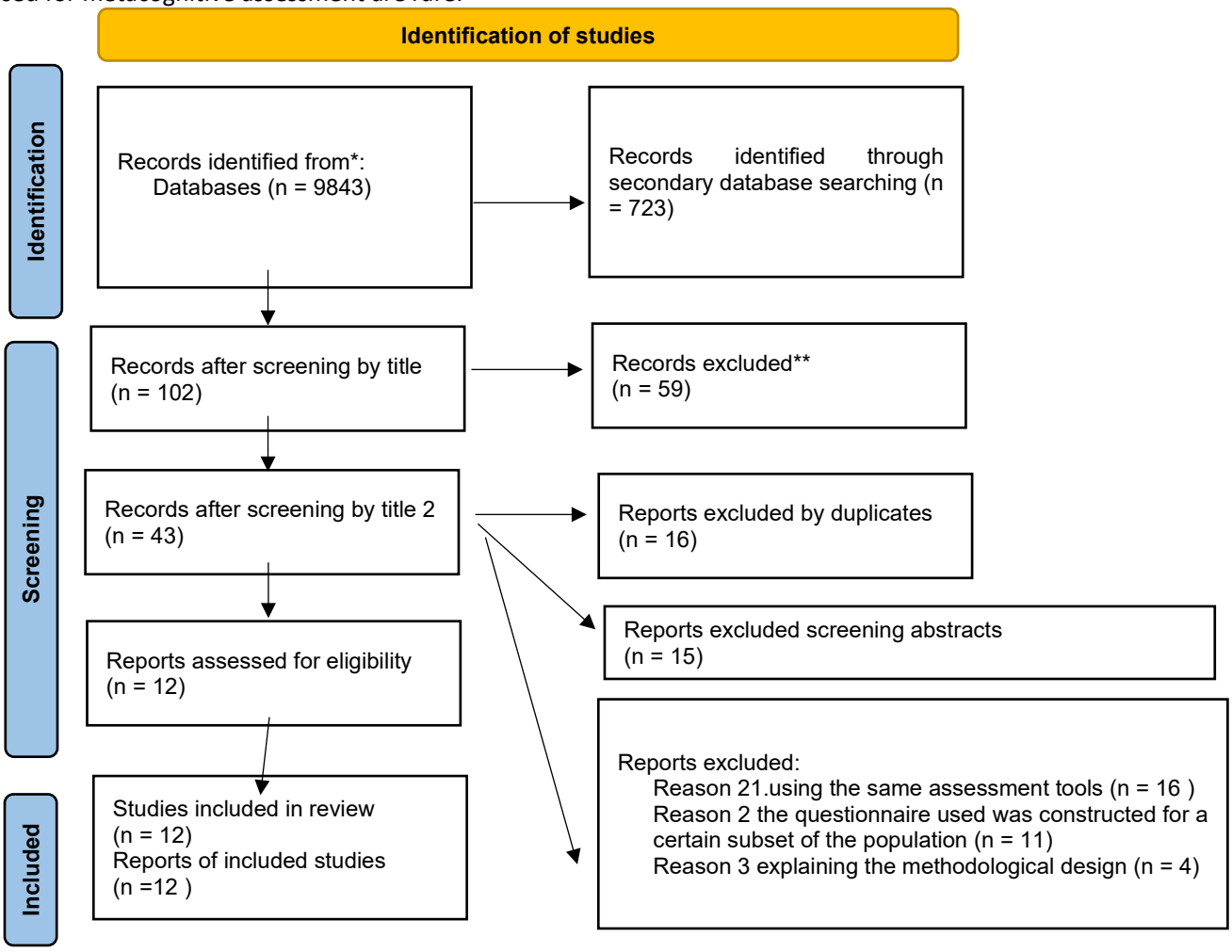

Fig. 1 PRISMA Flow chart of article searches

Results and discussions

After a title search, 43 papers were found, of which 16 were excluded for using the same assessment tools and another 15 based on analyzing the article abstracts using the inclusion-exclusion criteria, 3 articles were kept although they used the same metacognitive awareness inventory because it was tailored to the target population and had high internal consistency values. Thus, each of the 12 items were reviewed for statistical analysis of internal consistency, validity, and fit indices, the measures were reviewed to ensure that they assessed metacognition only, and the participants were reviewed to ensure compliance with inclusion and exclusion criteria and to note possible disadvantages of participant groups. The following table was created to include the data tracked on each item:

Author/year	Article	Instrument name	Dimensions and factors/ factor analysis	Consistency and validity analysis
Schraw & Dennison, 1994	*Assessing metacognitive awareness*	**Metacognitive Awareness Inventory (MAI)** - inventory containing 52 self-report items (created by the authors)	-knowledge about cognition - KOC -Statement -Procedural -Conditional -regulation of cognition -ROC -Planning -Information Management -Monitoring -Troubleshooting/settling -Evaluation	Conbach's alphas α = .95 KOC α = .88 ROC α = .88
Akin et al, 2007	*The validity and reliability of the Turkish version of the metacognitive awareness inventory*	**Metacognitive Awareness** Translated Inventory for the Turkish Adult Turkish Population (MAI) - 52 reworded items (Schraw & Dennison, 1994)	- Retains the factor structure of the original inventory	Validity: r = .93 Cronbach's alpha α = .95
For & Ghanizadeh, 2017	*Validating the Persian version of metacognitive awareness inventory and scrutinizing the role of its components in IELTS academic Reading achievement*.	**Metacognitive Awareness Inventory** translated to Persian (MAI) (Schraw & Dennison, 1994)	- Retains the factor structure of the original inventory	Cronbach's alphas= .72 to .81
Teo & Lee, 2012	*Assessing the factorial validity of the metacognitive awareness inventory (MAI) in an Asian country: A confirmatory factor analysis*	**Metacognitive Awareness Inventory** translated to Chinese (MAI) (Schraw & Dennison, 1994)	-Retains the factor structure of the original inventory	TLI = .756 CFI = .768 RMSEA= .076 SRMR = .068 3-factor (21)

Altindag & Senemoglu, 2013	*Metacognitive skills scale*	**Metacognitive Skills Scale (MSS)** - contains 30 self-report items (created by the authors)	-Learning strategies -Knowledge of own learning -Planning and monitoring	α = .94 35.74% factor variance
Meijer et al, 2013	*The development of a questionnaire on metacognition for students in higher education*	**Awareness of Independent Learning Inventory (AILI)** - self-report inventory with 63 items; there is also a 45-item version (designed by the authors)	-Metacognitive Knowledge (MK) o People o Strategies o Skills -Metacognitive regulation (MR) o Orientation o Monitoring o Evaluation -Metacognitive reactivity (speed of response) (MRs) o Sensitivity to experiences o Sensitivity to external feedback o Curiosity	MK α = .79 MR α = .84 MRs α = .77 G = .79 MK r = .69 MR r = .73 MRs r = .67
Pedone et al, 2017	*Development of a self report measure of metacognition: The metacognition self-assessment scale (MSAS) instrument description and factor structure.*	**Metacognition Self-Assessment Scale (MSAS)** - 18 self-report items (created by authors)	-Self-knowledge o Monitoring o Integration -Other knowledge o Differentiation o Decentralization	Cronbach's alphas= .72 to .87
Semerari et al, 2012	*The development of the metacognition assessment interview: Instrument description, factor structure and reliability in a non-clinical sample*	**Metacognition Assessment Interview (MAI)** - an interview with questions covering 16 facets of metacognition (created by authors)	-Self-oriented knowledge o Monitoring o Integration -Other knowledge o Differentiation o Decentralization	Self α = .90 Other α = .85 All α = .91 54% of factor variance
Balcikanli, 2011	*Metacognitive awareness inventory for teachers (MAIT).*	**The Metacognitive Awareness Inventory for Teachers - MAIT** (created by authors)	The 24-item questionnaire aimed at confirming the theoretical existence of six factors: declarative, procedural and conditional cognition in cognitive cognition and activities such as planning, monitoring and evaluation in regulating cognition.	Cronbach Alpha = .79 to .85
Allen & Armour-Thomas, 1993	*Construct validation of metacognition*	**Metacognition in Multiple Contexts Inventory - MMCI** - is an inventory for the	-Defining the problem -Select options - Strategy selection -Selection of representations - Resource allocation	α = .67 62% of variance

		author - problem-solving skills - 6 factors with 24 items (created by authors)	- Monitoring solutions	
Pintrich et al. 1993	*Predictive validity and reliability of the Motivated Strategies for Learning Questionnaire (MSLQ)*	**Motivated Strategies for Learning Questionnaire - MSLQ** (created by authors)	81 items are divided into the sections Motivation, Affective Strategies, Cognitive and Metacognitive Strategies, Resource Management Strategies and Resource Strategies.	α =.52 to .93
Yingjie Jiang et al., 2016	*Assessing teachers' metacognition in teaching: The Teacher Metacognition Inventory*	**The Teacher Metacognition Inventory (TMI)** - Self-report inventory with a 6-factor structure to measure metacognition in teachers (created by authors)	TME - Teachers' metacognitive experiences. MKP - Metacognitive knowledge about pedagogy TMR - metacognitive teacher reflections MKS - Metacognitive Self-Knowledge. TMP - Planning TMM - monitoring.	Cronbach's Alpha= 0.936 TME=0.784, MKP=0.812, TMR=0.839, MKS=0.769, TMP=0.771, TMM=0.820)

Table 1: Inventory measuring metacognitive awareness in adults

Assessment of metacognition components

In current studies in the literature, metacognition is assessed by different instruments and procedures in relation to its components. According to metacognitive theories, the assessment of different facets of metacognition is mostly carried out through self-report metacognitive inventories, which are based on the ability of individuals to self-identify their level of metacognitive awareness of the activities they are involved in; however, for a more detailed and valid analysis, metacognitive cognition and regulation should be assessed simultaneously using specific tasks from different domains, environments and contexts (Pintrich et al., 2000).

Ideally, measuring the level of metacognitive awareness takes over the interpretability characteristic of the resulting indicators in relation to a knowledge or performance standard (Artelt & Neuenhaus, 2010). The control and regulation of cognition can be assessed by metacognitive judgments (experience component; Efklides, 2011) or by the use of self-reported or actual strategy (skill component; Veenmann & Elshout,1999).

1.1.1. The *assessment of metacognitive knowledge* is carried out by means of metacognitive awareness inventories in the form of questionnaires or metacognitive knowledge tests.

Instruments that assess knowledge about metacognitive cognition can be similar to standard tests, since declarative, procedural, and conditional knowledge sets are considered knowledge already stored in memory (Pintrich et al., 2000). Baker and Cerro (2000) have identified interviews and/or questionnaires as one of the most commonly used methods to assess metacognitive knowledge.

Metacognitive knowledge assessment focuses on how to use the most effective strategies to improve outcomes. Another aspect that is targeted in the assessment process is the individuals' beliefs about their ability to succeed in specific situations, to perform in a targeted domain, including the individuals' self-efficacy.

Questionnaires that measure metacognitive knowledge and beliefs are most useful because they can generate informative and extensive data sets in a short session and can be easily modified to meet a specific research objective. Questionnaires have multiple scales to easily explore people's knowledge of strategies, how they use strategies, and their self-efficacy for learning.

The most commonly applied questionnaires to measure the level of metacognitive knowledge are: *Motivated Strategies for Learning Questionnaire and Inventory of Learning and Study Strategies*, which target general beliefs about learning and reported learning behaviors; *Academic Self-Efficacy Scale and Self-Reported Self-Efficacy and Self-Regulated Learning Scale* measure beliefs about the ability to succeed academically; *Assessment of Knowledge and Use of Effective Learning Strategies* and *Assessment of Knowledge and Use of a*

Specific Effective Learning Strategy, questionnaires assessing learning strategy preferences, use and perceived effectiveness.

1.1.2. Metacognitive skills

Metacognitive skills, also referred to as metacognitive strategies, are subclassified into planning, monitoring and evaluation skills (Flavell et al. 2002 ; Schraw & Dennison, 1994). Such skills are higher-order strategies because they have a role in regulating cognitive or motivational strategies in the management of learning or professional development.

Process control is based on gathering information, tracking thinking and reviewing cognitive activities, their status and effectiveness. Control is a diagnostic tool, an analysis of product and process quality. Adjustment, in turn, is an intervention following the diagnosis, or a judgment resulting from the control activities, consisting of either continuing the approach or abandoning or modifying it. Control and adjustment take place during or after pregnancy. This is very similar to the practices used in reflective thinking: reflection during an activity and reflection on an activity (Lafortune & Deaudelin, 2001).

To measure metacognitive judgments, monitoring and regulation, online assessment processes are used, as well as self-report inventories. Through these measures, the individual is asked what they do and think before, during and after a cognitive task (Baker & Cerro, 2000).

To measure metacognitive monitoring, self-report judgments can be used (Pintrich et al, 2000), an individual's metacognitive judgments about his or her learning and performance - confidence judgments and/or performance accuracy judgments (Boekaerts & Rozendaal, 2010; Nelson & Narens, 1990; Schraw, 2009). These judgments refer to a concrete learning situation and can be elicited before, during or after the learning or testing process. Measures allow a comparison with actual outcomes and therefore maintain a clear standard of assessment. The process of metacognitive fine-tuning emphasizes the accuracy of monitoring the level of knowledge and performance.

Metacognitive tuning can be assessed by several different questionnaires and interview protocols such as the *Learning and Study Strategies Inventory* (LASSI), the *Motivated Strategies for Learning Questionnaire* (MSLQ), and the *Supervised Learning Interview Schedule* (SRLIS). The MSLQ and LASSI aim to use general and domain-specific cognitive strategy for cognitive tuning. The MSLQ is designed to assess repetition, elaboration, organization, and critical thinking. The Supervised Learning Authorized Learning Interview Schedule (SRLIS) contains items about self-regulation given specific tasks starting from a description of a situation. Responses are categorized into knowledge, monitoring behaviors, strategy-using skills, and regulation.

1.1.3. Evaluation of metacognitive experiences

Metacognitive experiences involve cognitive processes that people use to monitor, control and regulate their awareness of processes. Assessment of metacognitive experiences can occur before, during or after a cognitive activity. In the light of the metacognitive knowledge gained through metacognitive experiences, one decides which strategy will be most effective and applies that strategy to achieve the goals related to a particular activity/task to be solved. Metacognitive knowledge is confirmed when the defined goals are achieved as a result of the activity. If goals cannot be achieved, metacognitive knowledge is rearranged in the light of recent metacognitive experiences. If the person decides that the applied strategy is not useful for achieving the goals, then a new strategy is used. As a result of this iterative process, the more metacognitive experiences the person undergoes, the more it becomes possible to decide precisely which strategy is needed for the current situation.

When assessing metacognitive experiences, a combination of self-report measures, observations, and behavioral assessments can provide a more comprehensive understanding of an individual's metacognitive abilities. It is important to consider the context and purpose of the assessment when selecting appropriate measures.

Conclusions

In this review of instruments for measuring metacognitive awareness in adults, the reviewed studies propose the use of the self-report inventory to measure participants' overall metacognition on the dimensions of cognition and regulation as two distinct but relatively basic metacognitive factors. Self-report questionnaires correlate strongly with behavior when subscales are used, but data exploring the relationships between factors and components vary widely.

Metacognitive self-report questionnaires face many challenges, such as not being able to adequately measure the nuances of metacognitive behavior. The inventories studied can provide an overview of metacognitive regulatory knowledge and skills. Relationships between subscales of self-reports and participants' behavior can be measured, and the act itself of responding to a self-report questionnaire requires metacognition and as such can provide researchers with insights into how metacognitive knowledge may differ from metacognitive behavior and experiences.

In this study we synthesized instruments for measuring the level of metacognitive self-reported metacognitive awareness in order to choose the most appropriate inventories that can be used for teachers. Given that we aim to assess metacognitive awareness in relation to teaching career management, we considered the Metacognitive Awareness Inventory for Teachers (MAIT) proposed by Balcikanli (2011) and the Metacognitive Awareness Inventory (MAI) by Schraw and Dennison (1994) to be appropriate. The aim of future research is to adapt and validate the two original instruments for measuring teacher metacognition by estimating all facets of teacher metacognition in the process of professional development; providing convergent evidence of appropriate psychometric properties for each inventory with the proposed number of items, examining their convergent validity and reliability.

The two metacognitive awareness inventories play an important role in helping teachers to realize their strengths and weaknesses in self-managing their teaching careers, and this would benefit from a self-critical and reflective analysis. These inventories are capable of assessing different aspects of teacher metacognition, including planning, monitoring, reflection, experiences during in-service training programs, and knowledge about teaching career management.

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