Integrating digital tools for qualitative literature reviews: an example applied to educators' metacognitive skills*[1,2]

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Abstract

Metacognition plays a key role in teaching and learning processes. Consequently, educators must understand their own metacognitive processes to effectively guide and support students in developing their own metacognitive skills. This systematic literature review investigates educators' metacognitive skills in problem-solving scenarios focusing on how digital tools can enhance research methodologies. Start, Iramuteq, and webQDA, were used to refine and facilitate the literature review process, allowing us to map and analyze articles retrieved from databases like ERIC, ScienceDirect, and Scopus. A total of 233 articles were identified based on predefined inclusion and exclusion criteria, and subsequently narrowed to 60 articles for an in-depth qualitative, exploratory, and interpretive analysis. Our analysis revealed a significant lack of empirical studies addressing educators' metacognitive skills, highlighting the need for further research in this area. Integrating digital tools in planning, organizing, and validating research processes proved to be effective, underlying their value in managing systematic reviews and facilitating

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informed decision-making. This approach both streamlined the literature review process and provided valuable insights into the current research landscape regarding educators' metacognitive skills. Moreover, we underscore the potential of these digital tools to support future investigations into the role of educators in fostering metacognitive skills during problem-solving.

Keywords

Digital tools – Systematic literature review – Qualitative research – Metacognitive skills – Teachers.

Introduction

Metacognition plays a key role in teaching and learning processes, and effective educators can leverage their own metacognition to guide and support students in developing theirs. However, research on educators' metacognitive skills, particularly regarding problem-solving activities, remains somewhat limited.

Balcikanli (2011) adapted the Metacognitive Awareness Inventory (MAI) for adults, developed initially by Schraw and Denisson (1994), creating a valid and reliable inventory called the Metacognitive Awareness Inventory Teacher to measure educators' metacognitive awareness in educational research. Harrison and Vallin (2018) raised critiques regarding MAI validity and its practical use in metacognition research. Hughes (2019) quantitatively analysed metacognitive awareness among 21 professors in technology and engineering education. Discrepancies between MAI data and interview responses suggest that metacognition should be measured using multiple methods and investigation procedures to obtain comprehensive results.

This systematic literature review identifies research gaps concerning educators' metacognitive skills within the scope of problem-solving activities, integrating digital tools throughout the review process to enable comprehensive data analysis. Underlining the imperative for a nuanced understanding of educators' metacognitive skills, this investigation seeks to answer the following research question: How can integrating digital tools contribute to identify educators' metacognitive skills in problem-solving activities?

The study provides a theoretical foundation on metacognition and metacognitive skills, followed by qualitative literature reviews and digital tools for qualitative analysis of textual data. Analysis results revealed a substantial gap in existing research, highlighting the need for in-depth understanding of educators' metacognitive skills in challenging contexts like problem-solving activities. The article concludes with contributions and insights into trends and issues for future studies.

Metacognition, metacognitive skills, and problem-solving

Metacognition defines one's knowledge about cognitive processes and products or any other related subject matter (Flavell, 1976). Since the 1970s, several authors

have related metacognitive processes to problem-solving. According to Flavell (1979), metacognition refers to one's ability to monitor and critically evaluate understanding and learning processes in problem-solving contexts. Metacognition monitors and organises cognitive processes like comprehension, reasoning, problem-solving, and analysis (Kozikoglu, 2019).

According to Schraw (2001), metacognition has two primary components: 1) knowledge of cognition, which refers to what people know about their cognition and includes three subcomponents (declarative, procedural, and conditional knowledge), and 2) regulation of cognition, which encompasses skills that aid in self-control.

Metacognitive skills are key elements within the broader concept of metacognition which includes both metacognitive knowledge and strategies, as outlined by Lee and Mak (2018). The particular abilities examined here are considered 'teachable' and hold direct relevance to the instructional and learning environment (Zohar, 1999).

Activities that require use of metacognitive skills are themselves considered metacognitive. These skills encompass various aspects of problem-solving, including planning the approach (prediction and planning), monitoring progress, and evaluating the proposed solution (Desoete; Roeyers; Buysse, 2001; Siegel, 2012). In short, metacognitive skills refer to the ability to plan, monitor, and regulate one's own thinking processes.

For teachers to use metacognitive strategies, they must recognise their metacognition (Monereo, 1990). By reflecting on their metacognitive skills, teachers can stimulate their students to be aware of their own thoughts and knowledge and procedures used in problem-solving. Thus, teachers can teach students to think and monitor their performance (Schraw, 2001).

Metacognition and higher order thinking skills (e.g., problem-solving) are closely related concepts in theory (Karakelle, 2012), as it affects learning acquisition, comprehension, retention, and application and the efficiency of learning, critical thinking, and problem-solving (Hartman, 1998). Hence, metacognition is a necessary skill for problem-solving (Siagan; Saragih; Sinaga, 2019).

Wall and Hall (2016) highlight the pivotal role of educators as metacognitive models, drawing upon collaboratively generated ideas. Akin to Zohar (1999), they noted a dearth of research on the impact of teachers' metacognitive awareness on student learning, stressing the need for investigations into teachers' abilities. Additionally, Fornari *et al*. (2019) conducted a systematic review of digital tools employed in literature reviews, suggesting their potential integration. Consequently, this systematic literature review integrated digital tools to focus on teachers' metacognitive skills.

Qualitative literature reviews

Literature review is a research method that involves identifying, selecting, analysing, and synthesising published studies on a particular topic. It is an essential step in any research, enabling researchers to understand the current state of knowledge on the subject and identify research gaps (Bandara *et al*., 2015; Snyder, 2019).

Literature reviews can be classified into three main types: systematic, semi-systematic, and integrative. Systematic reviews are the most rigorous type as they

follow a predefined methodology to identify, select, and analyse relevant studies (Xiao; Watson, 2019). Semi-systematic reviews are less stringent, but still follow a predefined methodology. Integrative reviews are the most flexible of the three approaches by not following a predefined methodology, but combining different methods and perspectives to create new theoretical models.

Digital tools for textual data analysis

Digital competencies encompass a range of skills, knowledge, and abilities essential for effectively utilizing digital technologies. They go beyond basic tasks like operating computers and navigating the Internet to include advanced abilities such as creating digital content, critically assessing information, and confidently applying digital tools in various contexts (Basilotta-Gómez-Pablos *et al.*, 2022; Kapasheva *et al.*, 2024). Digital literacy therefore extends beyond technical proficiency to encompass critical reflection on the learning process and the strategic use of technologies to enhance educational practices (Falloon, 2020; Gikandi; Morrow; Davis, 2011).

Incorporating metacognitive processes like planning, monitoring, and evaluation into the use of digital tools can significantly improve teaching methodologies (Carvalho; Santos, 2022; Demirbag; Bahcivan, 2021). Studies suggest that digital literacy is intrinsically linked to metacognitive skills, as it involves the ability to self-regulate and critically assess one's own learning strategies (Anthonysamy, 2023; Greene; Yu; Copeland, 2014; Greene *et al.*, 2018; Pintrich, 1999). Educators proficient in operating digital tools are better equipped to evaluate and adjust their pedagogical approaches, fostering reflective and adaptive teaching practices (Anthonysamy; Koo; Hew, 2020; Caena; Redecker, 2019).

Given the abundance of information and sources available, the use of digital tools is advocated for conducting literature reviews. In this study, we investigated the incorporation of StArt, Iramuteq, and webQDA to facilitate the literature review on teachers' metacognitive skills in problem-solving activities.

StArt (State of the Art through Systematic Review) aids researchers in conducting systematic literature reviews. Developed in Brazil by the Laboratório de Pesquisa em Engenharia de Software (LaPES), Universidade Federal de São Carlos (UFSCar), the software helps researchers to create research protocols, add data sources, and associate them with specific search strings during review execution.

In StArt, the execution stage is subdivided into three steps: 1) Conducting, in which researchers add data sources from which articles will be extracted, create search sessions associating sources with strings, and perform the search; 2) Selection, in which researchers analyse the titles of the articles identified and exclude those that are unrelated to the search strategy or do not meet inclusion, quality, or exclusion criteria; 3) Extraction, in which researchers analyse the abstracts and conclusions of the selected articles and excludes those that do not meet the inclusion, exclusion, or quality criteria. The remaining articles are read in full. Finally, in the summarisation stage, researchers analyse, interpret, and document the review results.

Despite its efficiency in organizing references and eliminating duplicates, StArt is limited in conducting deeper textual data analyses. It primarily serves as a tool for managing and structuring the literature review process, lacking features for qualitative interpretation of the retrieved content.

Iramuteq (Interface de R pour Analyses Multidimensionelles de Textes et de Questionnaires) is an open-source software that enables statistical processing and analysis via textual corpus analysis or tables, resulting in word frequency calculation, similarity analysis, hierarchical clustering, among others (Camargo; Justo, 2013; Sousa *et al.*, 2020). Developed in France, it utilises the Python language and functionalities provided by R.

While Iramuteq excels in quantitative and lexical analysis, it does not provide qualitative context to the results generated. Its outputs, such as word clouds and co-occurrence graphs, rely heavily on researchers ability to interpret the findings meaningfully and connect them to the broader research objectives.

webQDA (Costa; Moreira; Souza, 2019) supports qualitative data analysis (text, image, video, audio) in a collaborative and distributed environment. It can be used by researchers in various contexts who need to analyse qualitative data individually or collaboratively, synchronously or asynchronously. In an academic context, webQDA is particularly useful for researchers' master's and PhD students who conduct qualitative data analysis from any computer with internet access. In a business context, webQDA is applied to analysing market data, such as consumer data.

The software allows researchers to edit, view, link, and organise documents. Simultaneously, they can create categories, encode, control, filter, search, and question data to address the research questions. While robust and versatile, webQDA requires significant time investment for manual coding and data interpretation. Its effectiveness depends on researchers experience in systematically organizing and categorizing qualitative data, which can become labour-intensive for large datasets.

In this study, integrating digital tools provides a comprehensive approach to the literature review on teachers' metacognitive skills in problem-solving activities. By engaging in planning, critical analysis, and ongoing reflection during data processing, researchers and educators can develop adaptive strategies that align with evolving educational and technological demands. This integrative approach underlines the importance of utilising specialised digital tools to optimise literature reviews in qualitative research. The software tools only aid the researcher's work, not replacing their interpretative role in conducting a literature review.

Methodology

As a qualitative study, this review is of an exploratory, interpretive, and descriptive nature, indicating the investigation of a relatively underexplored phenomenon like teachers' metacognitive skills, interpretation of data meaning, and the intention to describe the characteristics of the studied phenomenon (Gil, 2008; Triviños, 2008).

To better understand the development of studies on teachers' metacognitive skills, a systematic literature review was conducted to provide an overview of the topic over recent years by identifying relevant international articles.

The review process comprised three stages: 1) planning, in which the review protocol was developed with (a) research question formulation, (b) literature search, and (c) article selection; 2) execution using software for article selection, presenting results (accepted and rejected articles) and future perspectives on what still requires investigation: (d) data extraction; (e) assessment of methodological quality; (f) data synthesis; (g) evaluation of evidence quality; and (3) writing the review. Accepted articles mentioned metacognitive skills in the title, abstract, or body and were read in full, whereas rejected articles failed to meet the quality and inclusion criteria outlined in the protocol.

Data Analysis

Published articles addressing metacognition in problem-solving situations were searched for in the ERIC, Scopus, ScienceDirect, and Web of Science databases. Selected articles underwent content analysis following Bardin (1977), Costa and Amado (2018), and Krippendorff (2019).

According to Bardin (1977), content analysis consists of four stages: 1) pre-analysis which involves an exploratory data analysis, including floating reading, indexing, indicator development and organising the material, such as selecting documents and objectives; 2) coding, which includes exploring the material by transforming raw data into content representations in the corpus; 3) data inventory and classification, and finally 4) analysing the results through inference and logical interpretation of the textual content.

Content analysis was conducted using StArt 3.0, webQDA (Costa; Moreira; Souza, 2019), and Iramuteq 0.7 Alpha 2, characterised by the pre-analysis and reading stages for article organisation, source coding, article classification, and discussion of results through inference and interpretation.

StArt was utilised to facilitate information management and exclude duplicates. Floating reading, as indicated by Bardin, helped organise the abstracts into webQDA. Given our objective of identifying metacognitive skills present in the literature, textual analyses using Iramuteq were developed considering the articles' abstracts as textual corpus.

In this study, StArt, Iramuteq, and webQDA were selected due to their suitability for facilitating specific tasks within the systematic literature review. The selection criteria consisted of: functionality and specificity since each tool addresses distinct phases of the systematic review, ranging from planning and organizing references to analysing textual data; ease of use and accessibility, as the tools provide intuitive interfaces and are easily accessible to researchers thereby enhancing productivity and minimizing learning curves; relevance to qualitative research since the selected tools are well-suited for handling qualitative data, enabling in-depth and nuanced analyses; integration capability, for the tools complement each other, creating a cohesive workflow that ensures efficiency and rigour throughout the review process.

Integrating these digital tools supports a structured and efficient approach to conduct the systematic literature review (Figure 1):

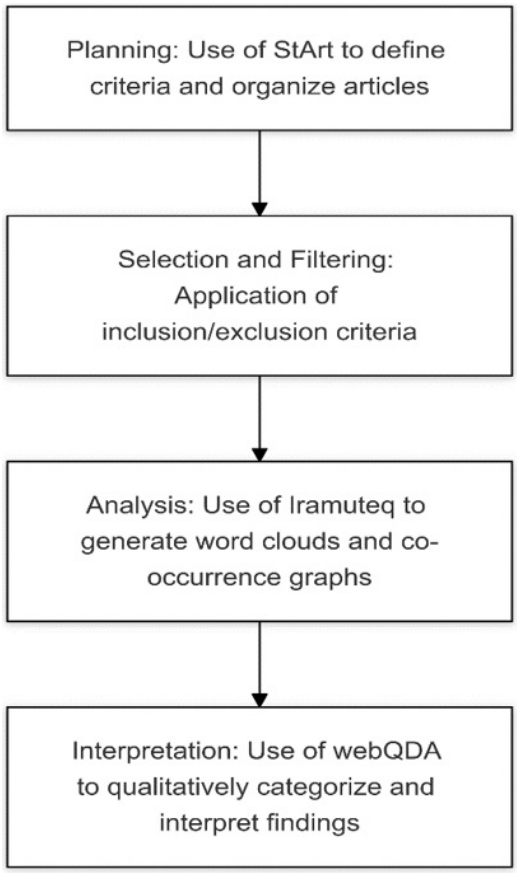
StArt: Used for planning, organizing, and selecting articles by creating research protocols, managing search queries, and filtering relevant studies.

Iramuteq: Applied for analysing and interpreting textual data using statistical methods like word frequency analysis, similarity analysis, and hierarchical clustering.

webQDA: Employed for coding, organizing, and synthesizing qualitative data collaboratively, allowing for detailed categorization and interpretation of the findings.

This integrative approach not only enhanced review depth and rigour but also supported researchers in effectively identifying and analysing teachers' metacognitive skills in problem-solving activities.

Figure 1 – Systematic Literature Review management and data analysis using StArt, Iramuteq, and webQDA.



Source: Authors, 2024.

Planning

After elaborating the research question, 'What metacognitive skills are exhibited by teachers in problem-solving activities?', we defined the search strategy and strings. Inclusion criteria consisted of peer-reviewed journal articles written in English without a publication year filter. Gray literature was not included in this review. The search initially identified over 200 articles.

Conducting the review and search strings

The review strategy employed involved formally searching for articles in scientific databases followed by a 3-stage article selection: consideration of the terms metacognition and problem-solving in the title, abstract reading, and full article reading. Search terms were derived from key terms used in the field and the review's objective. Keywords in the search string were refined using trial and error.

Advanced searches using essential functions– "metacognitive (skills OR abilities)" AND "problem-solving" AND "teachers"– were employed. Manual searches using manual selection methods on Google Scholar were also employed. Terms whose inclusion yielded no additional articles in the search were excluded.

Inclusion, exclusion, and quality criteria

Abstracts, titles, and keywords were reviewed to select studies that met the following inclusion criteria: peer-reviewed articles, empirical research articles, works published and made fully available in the scientific databases searched. Articles that did not meet the inclusion criteria were excluded from the review. To filter out irrelevant articles, we established the following exclusion criteria: articles that did not explicitly focus on metacognition and learning; articles that did not discuss metacognitive skills; theses, dissertations, reports, etc. Hence, the final selection comprised 109 articles.

We adopted three quality criteria: 1) if the research goals and objectives were clearly defined. This criterion was answered positively by 92% of the studies; 2) if the research context was adequately addressed. This criterion was answered positively by 86% of the studies; 3) if the research outcome was sufficient for the research purpose.

Publication selection process

First, adapted search strings were conducted in each databases and the results were exported from the list of returned studies in a suitable format for importing into the StArt systematic review tool.

Selection included analysing each article title and discarding those that were clearly unrelated to the search strategy, did not meet the inclusion and quality criteria, or were related to the defined exclusion criteria. Studies excluded at this stage did not proceed to the subsequent phases.

The selected works underwent extraction, step in which the abstract and conclusions of each study were analysed. Based on this reading, the inclusion, exclusion, and quality criteria were re-evaluated, resulting in the complete list of studies.

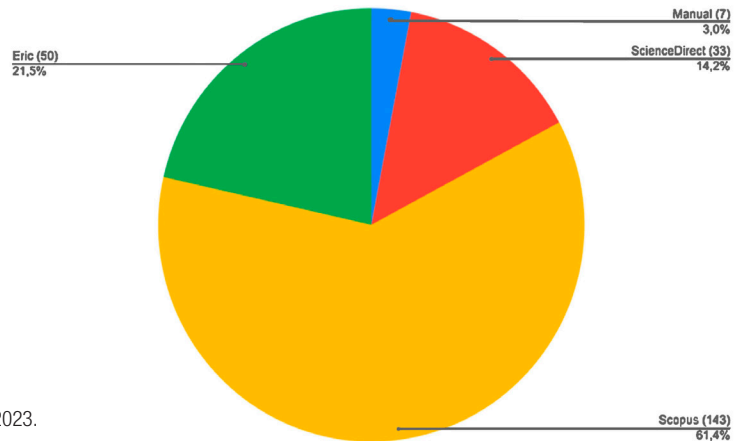
Finally, the selected literature was read in full, followed by quality assessment and extraction of basic characterizing data and specific data related to the research questions, updating the comments fields and attaching the complete study files.

After data extraction, the subsequent steps involved analysis, interpretation, and documentation of the results.

Results

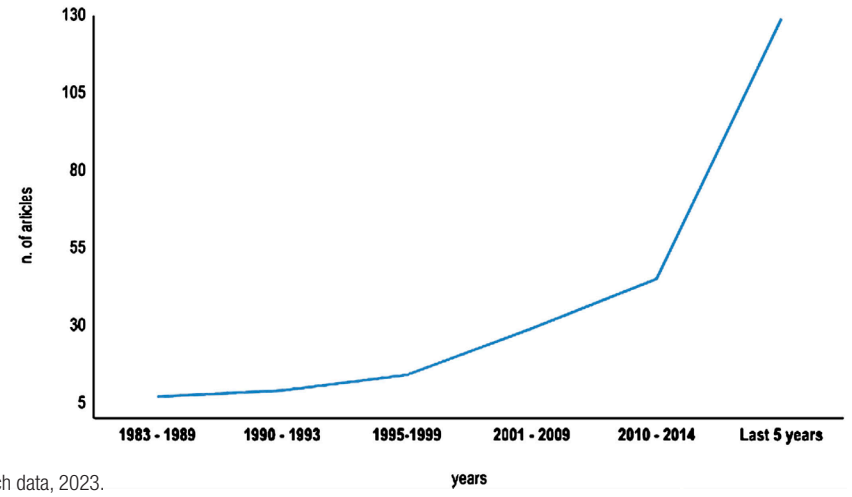
Initially, the review sample totalled 233 selected articles, the distribution of which according to scientific database is presented in Figure 2(a).

Figure 2a – Distribution of selected articles by database (a)



Source: Research data, 2023.

Figure 2b – the number of selected articles by year of publication (b) (n=233)



Source: Research data, 2023.

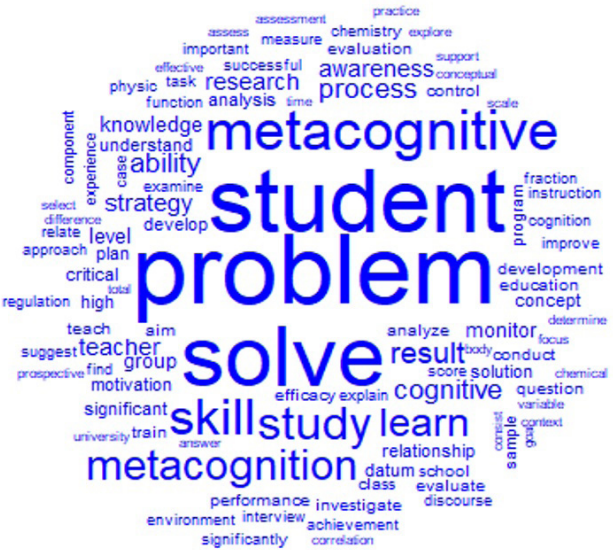
With no year filter used at first, we noticed an upward trend in publications related to the studied topic over the last 5 years (Figure 2-b).

Of the classified articles, 60 met the inclusion criteria and were reviewed in full; 163 were rejected for not meeting the criteria or for not directly relating metacognitive skills and problem-solving; and 10 were duplicates, which appeared more than once in different scientific databases and were identified by StArt.

Using abstracts as the corpus, Iramuteq performed content analysis of the 60 accepted articles comprising word frequency and connections, highlighting recurrence and lexical proximity to analyse the contexts of specific expressions or selected main concepts.

Word cloud is a simple lexical analysis that involves grouping and graphically organising words based on their frequency in the selected abstracts. As only the 125 most frequently occurring active terms were used in this processing, words with larger font sizes are the most relevant due to higher frequent use in the corpus (Figure 3).

Figure 3 – Word cloud of the abstracts of accepted articles (n=60)



Source: Research data, 2023.

Contextually, we observe a more significant occurrence of terms like 'problem,' 'student,' 'resolution,' 'metacognitive skill' and 'metacognition,' indicating that most studies in this review addressed empirical contexts of problem-solving while evaluating student metacognition.

Based on graph theory, the similarity analysis graph (Figure 4) separates clusters of words and relates them. For a more precise analysis of the groupings and visual reasoning we excluded terms with a frequency of less than 10 occurrences.

The association between words used in the abstracts can be analysed by observing the font size, the thickness of the connecting lines, and the polygon gathering the closest

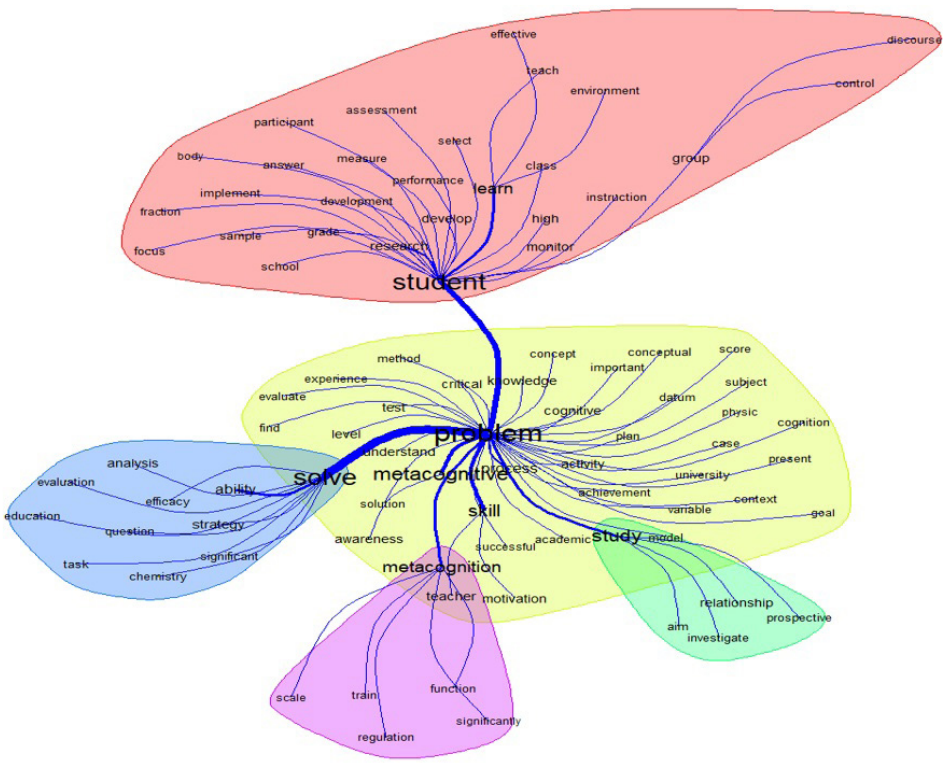
words. Of the five groups identified, the central one is represented by the term 'problem' which connects to all subgroups.

According to the co-occurrence tree, among pairs of associations the word 'problem' shows strongest relation with the terms 'student,' 'resolution,' 'metacognitive,' 'skill,' 'metacognition' and 'study.' Their frequent occurrence highlights the strong emphasis on the association between problem-solving and metacognitive processes, revealing the unique 'fingerprint' of the investigated literature. "Problem" stands out as a central term in the analysed articles because metacognition is predominantly investigated as a tool for understanding, planning, and solving problems in educational settings like mathematics, sciences, and physics. Acting as a key node, 'problem' connects multiple themes in the analysed literature.

Research underlines the role of metacognition in helping students understand problems, plan solutions, and evaluate outcomes (Ali *et al.*, 2017; Imaya; Budiyono; Nurhasanah, 2020; Susilo; Retnawati, 2018). The term 'problem' frequently appears associated with planning, monitoring, and evaluation which align with the key phases of metacognitive processes, as articulated in Polya's problem-solving strategy (Ali *et al.*, 2017).

The groupings revealed a strong correlation between the terms 'problem-solving' and 'students,' suggesting that the selected works more frequently address problem-solving and metacognition focusing on students. Few works investigated teachers' skills.

Figure 4- Similarity analysis between the abstracts of accepted articles (n=60)



Source: Research data, 2023.

We found various research methods regarding the investigation of metacognitive skills. Quantitative approaches featured in 25 scientific articles to examine metacognitive skills in problem-solving activities, whereas 23 studies employed qualitative research methods and 12 studies used mixed methods.

As for research instruments, the studies included interviews (structured and semi-structured), pre- and post-written tests (including specific metacognitive skills tests), metacognitive awareness inventories, Likert-type teacher metacognition scales, think-aloud protocols, audio recordings, teacher notes and lesson plans, self-monitoring questionnaires, instruments for assessing self-regulation and self-reflection competencies, reflections and focus groups, problem-solving inventories, and problems in specific areas of knowledge. The works cover various disciplines, including mathematics (Imaya; Budiyono; Nurhasanah, 2020; Israwati; Johar; Ansari, 2021; Anggo; Arapu, 2018), physics (Ali *et al.*, 2017; Yulianawati *et al.*, 2018), and chemistry (Ijirana; Supriadi, 2018), illustrating the extensive application of metacognition to address complex problem-solving tasks across diverse academic fields.

Problem-solving effectiveness is also linked to cognitive styles. For example, Sugiarto (2017) highlights how reflective learners tend to adopt systematic approaches compared with impulsive peers.

'Student' as a prevalent term in the literature reflects the primary focus on improving learners' skills via metacognitive strategies, particularly in academic tasks that require reflection and self-monitoring. This aligns with the substantial body of research investigating metacognitive skills among students.

'Metacognitive skills' are consistently associated with enhanced problem-solving performance. Numerous studies show how strategies like self-regulation, planning, and evaluation contribute to improve learning outcomes (Ali *et al.*, 2017; Imaya; Budiyono; Nurhasanah, 2020). The prominence of these terms collectively suggests that metacognitive skills are widely regarded as crucial for improving problem-solving abilities in educational contexts.

Figures 3 and 4, along with the webQDA analysis, further confirm the scarcity of studies focused on exploring teachers' metacognitive skills. Notably, in Figure 4, the term 'teacher' appears in a limited, distinct branch of the similarity analysis, indicating a relatively minimal focus on this aspect within the literature. Only nine works in the analysed corpus specifically address teacher competencies, and some of them (Kozikoglu, 2019; Radulović *et al.*, 2023) investigated pre-service teachers.

Chart 1- summarises the analysed articles that addressed the metacognitive skills shown by teachers.

Reference	Objective	Research method	Data collection	Metacognitive skills	Key findings
Radulović *et al.* (2023).	To monitor and longitudinally analyse differences in metacognitive skills of students from the Faculty of Teacher Education, University of Belgrade.	Quantitative	Metacognitive Awareness Inventory (MAI)	Comprehension monitoring, information management strategies, debugging strategies, and assessment.	The study program concept is designed to enhance students' metacognitive skills, allowing them to develop awareness of their knowledge, applied strategies, and effectiveness. Students are trained to continuously develop and monitor their learning strategies based on the progression of their self-awareness.
Guo (2022)	To explore the implementation of a teacher-mediated method designed in workshops, focusing on patterns of teacher-student interactions and the consequent transfer of student learning from cognition to metacognition.	Qualitative/phenomenology	Observation of a dialogic conversation between teachers and students.	Assess, monitor	The explicit method adapted for teacher mediation involves: first, using dialogic conversation to assess what they know and where they are in the thought process, then providing knowledge on what they do not have systemically, and then monitoring the problem-solving process with students to empower them to form tools for independent learning.
Kozulin (2021)	To explore the cognitive and metacognitive abilities of teachers engaged in cognitive training.	Quantitative	Task-solving and note-taking of problem-solving strategies	Reflect	Teachers show a relatively low level of metacognitive and reflective skills.
Temur; Özsoy; Turgut (2019)	To unveil which preschool teachers adopt metacognitive strategies while implementing mathematical activities, examine their behaviours regarding these strategies, and investigate how they structure teaching.	Qualitative/ case study	Semi-structured observation form	Prediction, planning, monitoring, and evaluation	Results indicated that preschool teachers show some metacognition-based behaviours; however, they do not adequately perform metacognitive skills. This evokes the idea that teachers lack adequate metacognitive knowledge.
Kozikoglu (2019)	To determine the extent to which pre-service teachers' metacognitive skills, problem-solving abilities, and academic self-efficacy explain their critical thinking tendencies.	Quantitative	Critical Thinking Disposition Scale, Metacognitive Skills Scale, Problem-Solving Inventory, and Academic Self-Efficacy Scale	Metacognitive skills	It revealed a positive association between the critical thinking skills of pre-service teachers, metacognitive skills, problem-solving abilities, and perceptions of academic self-efficacy.

Chart 1- Summary of the main metacognitive skills used by teachers from empirical articles (continued))

Reference	Objective	Research method	Data collection	Metacognitive skills	Key findings
Ozturk (2017)	To disclose the phenomenon of teacher metacognition focusing on the instrumental role of the teacher during classroom learning. To investigate the metacognition of language instructors and their self-reported competencies for teaching metacognition. To examine whether and how self-reported competencies changed after a professional development (PD) module on metacognition teaching.	Quali-quanti	Metacognitive Awareness Inventory (MAI) and thinking-aloud protocols for instructional planning	Monitoring comprehension and self-regulation of the reading process.	Most participants were highly metacognitive or metacognitive individuals, but initially lacked knowledge and competence in teaching metacognition. After PD, highly metacognitive teachers developed authentic lesson plans that manifest metacognitive instruction, whereas metacognitive teachers adopted similar instructional designs presented during PD. Additionally, half of the participants appreciated teaching metacognitively after PD.
Kaya; İzgiol; Kışan (2014)	To determine the problem-solving skills of pre-service elementary mathematics teachers and analyse problem-solving abilities according to various variables.	Quantitative/ descriptive research	Problem-Solving Inventory (PSI)	Problem-solving	Results showed no significant difference between male and female candidates' perceptions of their problem-solving abilities. A substantial difference appeared in their problem-solving skills and impulsive approach to problem-solving according to their grades.
Wilson; Bai (2010)	To investigate teachers' understanding of metacognition, their pedagogical knowledge, and what it means to teach students to be metacognitive.	Quali-quanti	Teachers' Metacognition Scale (TMS) with 20 Likert scale items.	Monitoring and regulation	Results revealed that teachers with a rich understanding of metacognition report that teaching students to be metacognitive requires a complex understanding of metacognition and metacognitive strategies.
Zohar (1999)	To investigate teachers' declarative metacognitive knowledge about higher order thinking skills.	Qualitative	Audio recordings, notes, teachers' lesson plans	Teachers' intuitive declarative metacognitive knowledge about thinking skills	Teachers' intuitive (i.e., pre-instructional) knowledge about thinking skills metacognition is unsatisfactory for teaching higher-order thinking in science classes.

Source: Research data, 2024.

According to the works analysed, metacognitive skills correspond to understanding the problem, planning and designing problem solutions, implementing plans, evaluating results, monitoring, reflecting, regulating, justifying, and guessing. As for teachers, reflecting, predicting, planning, monitoring, (self)evaluating, problem-solving, managing information, and debugging are the prominent metacognitive skills investigated.

Discussion

Prevalent qualitative research methods suggests a pursuit of rich and detailed data, providing more profound and nuanced insights, whereas quantitative approaches may offer a quicker analysis (Schunk, 2008). Qualitative analysis allows for a deeper investigation of educators' metacognitive skills, as defined by Flavell *et al.* (2002), specifying the metacognitive component that refers to metacognitive skills (cognition regulation) and their expression in teacher activities.

Research on educators' metacognitive skills predominantly employ qualitative methods to explore rich and detailed data, as this approach enables a deeper investigation into the cognitive and metacognitive processes involved in problem-solving beyond quantitative measures that may offer only a superficial view.

Studies by Kozulin (2021), Temur, Özsoy, and Turgut (2019), Shilo and Kramarski (2019), Ozturk (2017), and Zohar (1999) revealed that educators lack metacognition knowledge or exhibit low levels of metacognitive skills, implying the need to teach problem-solving strategies. This gap may significantly impact their ability to teach students effective problem-solving strategies, model metacognitive skills in the classroom, and create a learning environment that encourages metacognition. This finding finds corroboration when studies mention educators' declarative knowledge, showing a lack of ability to translate concepts or knowledge into relevant actions or activities. Declarative knowledge refers to knowing 'about' things, procedural knowledge refers to knowing 'how' to do things, and conditional knowledge refers to understanding the 'why' and 'when' of cognition (Schraw, 2001). In short: declarative knowledge includes knowledge about oneself as a learner and performance-influencing factors; procedural knowledge refers to knowledge about doing things; and conditional knowledge refers to knowing when and why to use declarative and procedural knowledge.

According to Bae and Kwon (2021) and Branigan and Donaldson (2020), student-teacher interactions are essential for developing student metacognitive skills. Studies unanimously concur that teachers should encourage students to improve their metacognitive skills. These are required in problem-solving tasks, where teachers can stimulate activities like reflecting on thinking, setting goals, monitoring progress, and evaluating strategies.

Planning, monitoring, and evaluating skills were the most frequent among studies on educators, with five out of eight studies particularly emphasising the importance of monitoring. In summary, analysis results indicate the need for a greater focus on teachers' metacognitive skills, with significant implications for teaching and learning processes.

By analysing qualitative studies, we can identify how educators regulate their cognition during problem-solving, including planning (How do teachers define goals, strategies, and resources for problem-solving?), monitoring (How do teachers track their progress and adjust their strategy during problem-solving?), and evaluation (How do teachers assess student performance after problem-solving?) (Brown, 2017). This detailed analysis allows for a more comprehensive understanding of teachers' metacognitive skills and how they impact teaching and learning.

Integrating Start, webQDA and Iramuteq facilitated a systematic workflow for reviewing the literature on educators' metacognitive skills. These tools, used in an articulated manner, helped to extract substantial insights from the literature to identify, characterize, and analyse metacognitive skills.

Conclusions

This study systematically reviewed literature on the metacognitive skills exhibited by educators in empirical works, focusing on problem-solving. Integrating digital tools such as webQDA, Iramuteq, and StArt, facilitated the review process by making textual data analysis more agile, concise, and coherent. StArt was used in the review proper, whereas Iramuteq enabled word cloud and similarity analysis, identifying patterns and recurrent skills in the selected articles. webQDA integration streamlined data management, coding, and interpretation, enhancing study efficiency and effectiveness.

The systematic literature review identified gaps in research on educators' metacognitive abilities regarding problem-solving activities by integrating digital tools to perform a comprehensive analysis of the existing body of work.

Analysis results revealed that few works address teachers' metacognitive skills in problem-solving activities, pointing out the need for practical recommendations so that teachers can develop metacognitive knowledge and skills in their students. Co-occurrence analysis revealed a strong association between the term 'problem' and all subgroups identified in the data, suggesting that teachers' metacognitive skills are broadly implicated in various problem-solving activities. Moreover, the analysis identified the strongest correlation the terms 'metacognitive,' 'resolution,' and 'students,' which aligns with the initial research focus on teachers' metacognition in the context of student problem-solving.

Several research gaps were identified and needed exploration. First, most studies focus on assessing and stimulating student metacognitive awareness. No teaching strategies to assist teachers in supporting their students in planning, monitoring, and evaluating their learning was identified, which are the most investigated skills in problem-solving literature. Most articles addressed problem-solving using 'pen and paper' problems, requiring further investigation into how teachers can develop their metacognitive skills in formulating and solving context-rich problems.

Additionally, the literature lacks studies integrating digital tools like webQDA, Iramuteq, and StArt in the investigated context. While these tools have proved useful in systematic reviews, their integration into practical settings to enhance teachers' metacognitive skills is null. Future studies should prioritize experimental investigations to assess their effectiveness in improving educators' ability to plan, monitor, and evaluate effectively.

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