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Review Paper

A Systematic Review of Group Metacognition Researches on Online and Face-to-Face Learning Environments

Gamze Türkmen*[a]

[a](ORCID ID: 0000-0002-4695-9159), Department of Computer Education and Instructional Technology, Manisa Celal Bayar University, Manisa, Turkiye, gamze.turkmen@cbu.edu.tr

*Corresponding author

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ABSTRACT

Group metacognition involves a collective understanding of cognitive processes and collaborative problem-solving mechanisms within a group. This study, conducted through a systematic review of 54 studies, aims to present the evolutionary trajectory of research on group metacognition in (predominantly) online and face-to-face learning environments. It explores the definitional shifts, methodological trends, and potential connections between the quality of collaboration and studies on group metacognition in online learning environments. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to report the study's results. In investigating determinants influencing group metacognition, the research examined the distribution of effective variables such as group size, composition, task complexity, and time constraints. This systematic review provides an overview of the evolutionary path for definitions of the group metacognition concept, accumulated methodological approaches, and key insights into studies that may be associated with group metacognition. Thus, it underscores the importance of customized interventions that appropriately consider variables that could affect group metacognition effectively.

INTRODUCTION

Group metacognition refers to the collective awareness and comprehension among a group of individuals regarding their own cognitive processes and methods of problem-solving (Biasutti & Frate, 2018). It denotes the capability of a group to introspect on their own thinking and evaluate the efficacy of their decision-making procedures. The implementation of group metacognition can significantly enhance group performance by enabling members to pinpoint areas of errors or the disregard of important information. Through open discussion of their cognitive processes and critical analysis of their decision-making, members of a group can acquire a mutual comprehension of approaching intricate problems and work collaboratively with greater efficiency (De Backer et al., 2017; Zion et al., 2015). To achieve effective group metacognition, it is imperative to foster open communication, trust, and a readiness to actively listen and learn from others (Pillay et al., 2007). Its importance is especially significant in situations that require complex choices, like those found in the fields of business, education, and governance.

Upon reviewing the literature, it becomes evident that the term *group metacognition* is often utilized in conjunction with other interchangeable concepts. Despite this, discrepancies in definitions do exist due to disparities in conceptual expressions. Nevertheless, by taking into account shared sub-concepts, investigations of *social metacognition* and *collaborative metacognition* within this study are also deemed relevant to the broader examination of group metacognition. Social metacognition is characterized as the cognitive process of self-reflection and regulation during social interactions (Zion et al., 2015). This involves the capacity to identify and acknowledge one's own mental state, as well as that of others, and to utilize this awareness to actively participate in social exchanges in an effective manner. Moreover, collaborative metacognition is a concept that shares similarities with group metacognition, as it emphasizes the importance of mutual awareness and regulation of cognitive processes, but with a specific emphasis on cooperative endeavors (Mathabathe & Potgieter, 2017; Wu et al., 2020; Zheng et al., 2023). The process involves group members' capacity to introspectively analyze and assess their own and their colleagues' cognitive processes, oversee and regulate collaborative interactions, and employ this comprehension to enhance the overall quality of collaborative performance. Finally, group metacognition denotes the collective understanding and control of cognitive processes within a group setting (Biasutti & Frate, 2018; Ouyang et al., 2022; Zheng et al., 2019). This encompasses the competence of group constituents to meticulously analyze and assess both their personal cognitive mechanisms and those of their peers. This involves overseeing and coordinating group dynamics, and leveraging this comprehension to optimize the collective efficacy of group endeavors. To encapsulate, these

three concepts share a shared emphasis on the approaches by which individuals engage in metacognitive activities within social or communal contexts. This encompasses the aptitude for introspective evaluation and regulation of one's own cognitive processes, alongside the proficiency to recognize and respond to the cognitive processes of fellow participants within social or collaborative frameworks.

Benefits of fostering group metacognition

Encouraging the development of group metacognition is significant as it enables members to comprehend their own thinking processes and those of others in the group (Hadwin et al., 2018; Lobczowski et al., 2021; Pifarré et al., 2014; Schnaubert & Bodemer, 2019; Wang et al., 2017). Metacognition pertains to the capacity to reflect on one's thinking and involves monitoring, regulating, and reflecting on thought processes. By acquiring metacognitive skills, group members are more capable of recognizing their cognitive strengths and weaknesses and identifying areas where additional support or resources are required. Furthermore, they are better equipped to recognize the thinking processes of their peers, which can enhance communication and collaboration (De Backer et al., 2015a, 2015b, 2017; Leinonen et al., 2017; Schünemann et al., 2017). Moreover, promoting group metacognition has the potential to establish a more inclusive and equitable learning environment. By prompting individuals to examine their own thinking processes, it becomes possible to increase their awareness of personal biases and assumptions, thereby fostering greater openness to the experiences and perspectives of others (Yang et al., 2020; Zheng et al., 2021). In conclusion, cultivating group metacognition can facilitate more effective and efficient group learning, improved communication and collaboration, and a more *inclusive* and *equitable* learning environment.

Inclusive learning environments encompass students with low performance levels as well, alongside other diverse groups. Fostering group metacognition within low-achiever students is crucial because it can help them to become more aware of their own social thinking and the thinking of others in social situations (Sobocinski et al., 2017; Yang et al., 2020; Zheng et al., 2021). Low-achiever students may struggle with academic performance due to a lack of social and emotional support, and group metacognition can help address this issue. By developing group metacognitive skills, students can become more attuned to social cues, better able to regulate their emotions, and more effective in communication and collaboration. Group metacognition can also help low-achiever students to recognize and challenge negative self-talk and beliefs that may be hindering their academic performance. By becoming more aware of their own social thinking, students can develop more positive self-concepts and beliefs about their ability to succeed academically. Moreover, fostering group metacognition can help low-achiever students to develop stronger relationships with their peers and teachers by being more attuned to the social thinking of others.

Group metacognition in online and face-to-face learning settings

The relationship between group metacognition and online learning is noteworthy, given the emphasis on collaboration and group work in online learning environments. Group metacognition is particularly valuable in these settings, as it can help facilitate effective group communication, coordination, and decision-making. The development of group metacognition skills enables students to work together more efficiently and effectively to attain shared learning objectives (Hadwin et al., 2018; Tang et al., 2022). Furthermore, online learning platforms offer opportunities for students to reflect on their own and others' learning processes, track their progress, and receive feedback, all of which can contribute to the growth of group metacognition (Wu et al., 2020).

There are a range of methods that can be employed to encourage group metacognition in online learning environments, as outlined by several academic sources (Biasutti & Frate, 2018; Binali et al., 2021; Hadwin et al., 2018). One key approach is to establish clear learning objectives and goals for collaborative tasks, ensuring that all members of the group comprehend their roles and responsibilities. It is also important to foster open communication and discussion within the group to enable the exchange of ideas and perspectives. Providing opportunities for group members to reflect on their own and others' learning processes is another crucial factor, which can be facilitated through mechanisms such as self-evaluations, peer assessments, or online discussions. Structured feedback methods can be implemented to help group members evaluate and monitor their own and others' contributions to the group, thus enhancing collaboration (Leng et al., 2021). Additionally, creating a positive and supportive learning environment that encourages group members to take risks, ask questions, and learn from mistakes is essential. Collaborative tools and technologies such as video conferencing, shared documents, and online whiteboards can also be employed to promote group work. Finally, online tutorials or resources on effective group communication and problem-solving can be offered to provide guidance and support for group members to develop their metacognitive abilities. By adopting these strategies, online educators can assist their students in developing the metacognitive skills required for effective collaboration and problem-solving in various settings, whether online or offline.

However, there may be some differences in how group metacognition is promoted in face-to-face versus online learning environments. For example, in face-to-face settings, nonverbal cues and interactions may play a more significant role in promoting effective communication and collaboration among group members. Additionally, face-to-face learning environments may offer different opportunities for reflection and feedback, such as in-class discussions or one-on-one meetings with instructors (De Backer et al., 2015b, 2021; Hogenkamp et al., 2021). Overall, while there may be some differences in how group metacognition is promoted in different learning environments, it remains an important aspect of effective collaboration and problem-solving in both online and face-to-face settings.

Understanding the relation between group metacognition and quality of collaboration

Effective collaboration is an essential element in the improvement of metacognitive processes within a group (Khosa & Volet, 2013). The exchange of feedback and ideas and sharing of knowledge and perspectives, that takes place during effective collaboration, enables group members to collectively monitor and regulate their thinking and learning strategies. Effective collaboration supports the development of individual metacognitive skills and enhances the emergence of group-level metacognition. In this regard, the group can evaluate their collective learning and modify their collaborative practices. In contrast, low-quality collaboration can hinder metacognitive processes by fostering misunderstandings, biases, and conflicts that undermine the group's ability to regulate their thinking and learning. Therefore, it is necessary to promote high-quality collaboration to enhance effective group metacognition.

When we analyze collaboration, considering both low-quality and successful aspects enhances our understanding of effective collaboration. Low-quality collaboration can adversely affect group metacognition, given that effective collaboration depends on communication and collective understanding of a shared goal. In situations of low-quality collaboration, these crucial elements may be absent, impeding the group's involvement in meaningful metacognitive processes. Groups experiencing low-quality collaboration may encounter difficulties in sharing diverse perspectives, allocating tasks efficiently, and maintaining effective communication (Fonteijn & Dolmans, 2019). This can lead to misunderstandings, misinterpretations, and a lack of shared mental models among group members. Consequently, the group may struggle to collectively monitor and regulate their cognitive processes, contributing to increased learner anxiety levels (Brannen et al., 2021). Moreover, successful collaboration is commonly regarded as a catalyst for group metacognition, allowing members to merge their individual cognitive abilities and collectively contemplate their thinking and problem-solving methods. Conversely, inadequate collaboration or a more competitive setting may impede these processes, limiting the group's capacity to utilize the collective intelligence and metacognitive skills of its members (Pesout & Nietfeld, 2020).

Understanding variables regarding group metacognition

In order to design effective interventions to promote group metacognition, educators and researchers must understand the various variables that can influence it. One such variable is group size, and smaller groups have been found to be more effective in promoting metacognitive processes than larger groups (Ouyang et al., 2022a). Another important variable is group composition, with research showing that *diverse groups may be more effective in promoting metacognition*. The complexity of the task is another variable that can affect group metacognition, with more complex tasks requiring greater reflection and monitoring of cognitive processes among group members (Teng & Huang, 2021). Additionally, the level of interdependence among group members can affect group metacognition, with interdependent tasks requiring greater collaboration and coordination among group members. Time pressure is also a variable that can impact group metacognition, as it may increase the need for group members to reflect on and regulate their own and others' thinking processes (Biasutti & Frate, 2018). By taking these variables into consideration, educators and researchers can design interventions that effectively promote group metacognition. This, in turn, can help students develop the necessary skills for successful collaboration and problem-solving in a variety of settings.

While literature suggests that factors like group size, time constraints, and task complexity impact group metacognitive processes and, subsequently, group performance, it is imperative for researchers and practitioners to develop interventions and strategies based on the accumulated results of recent studies. In general, the various viewpoints regarding group metacognition exhibit significant similarities, as well as notable dissimilarities. It is still necessary to establish how these diverse perspectives have been practically implemented in the ongoing discourse surrounding group metacognition, and have produced outcomes relating to learning outcomes in groups that exhibit metacognitive behaviors. The distinct theoretical foundations have resulted in disparities in the starting points and advancement of empirical research, specifically concerning the employed research methodologies.

Despite the absence of a systematic review specifically focusing on group metacognition before, there is a study on the social shared regulation of learning from 2015 (Panadero & Järvelä, 2015). In this study, a total of 17 articles, including 13 experimental ones, were examined. Considering the inclusion of studies conducted before 2015 in the research, it is important to recognize the potential of research that has continued to the present. However, the current study is structured around group metacognition in light of the above information.

To summarize, by expanding upon theoretical models and examining the methodologies utilized by researchers to investigate group metacognition, it is possible to comprehend the overall advancements made in research within the last seven years. The present study conducted a systematic literature review on the topic of group metacognition in online and face-to-face environments to address the following research inquiries:

1. How has the conceptualization of group metacognition evolved among researchers over time, and is there concurrence between the theoretical perspectives presented in the theoretical framework and those observed in current empirical research?
2. Over time, what are the research methodologies employed by researchers to investigate group metacognition, including the study designs, data collection techniques, target groups, and sample sizes?
3. What knowledge have researchers acquired over time regarding the promotion of group metacognition? What kinds of insights have been found regarding the role of the quality of collaboration in studies in supporting group metacognition?

METHOD

The objective of this systematic review is to provide a comprehensive overview of the literature pertaining to the research questions. Adopting a systematic review approach offers the advantage of offering a comprehensive understanding of the extent, aims, and range of research endeavors pertaining to a phenomenon (Newman & Gough, 2019). The subsequent section provides a brief account of the systematic review methodology utilized in this study. The PICOS framework, prioritizing Population, Intervention, Comparison, Outcome, and Study Design, has been applied to guide the literature selection in this study. Additionally, the systematic screening process has been visualized using the PRISMA flow diagram. Detailed descriptions pertaining to the data acquisition and coding scheme processes have been provided in this context.

Literature search

Literature was collected in July 2022 using the following databases: ERIC, APAPsychnet and the search engines Social Sciences Citation Index [Web of Science], Science Citation Index Expanded [Web of Science], Arts & Humanities Citation Index [Web of Science], and Web of Knowledge (databases included: Web of Science). The principal scholarly sources were discerned via the utilization of ERIC. A comprehensive exploration of alternative databases failed to produce a substantial volume of supplementary literature, and no literary material was selected from APAPsycnet.

A comprehensive and methodical exploration was carried out to locate keywords linked to group metacognition, with a segregation of terms such as "collaborative" and "metacognition" due to their widespread usage in numerous articles. In order to strike a balance between identifying the maximum number of potentially pertinent publications and ensuring their relevance, a search was performed using the following term combination:

("Collaborati*" OR "SOCIAL" OR "GROUP" OR "SHARED") AND "METACOG*"

Abstracts from three online databases - Education Source, ERIC, and Web of Science - were searched to obtain relevant publications. During the initial search, no limitations were imposed on the type or year of publication. The searches were carried out in July 2022 and resulted in a total of 21,082 publications. The identified references were subsequently transferred to an Excel document.

Inclusion and exclusion criteria

For the literature review, publications were required to satisfy six distinct criteria before being considered eligible for inclusion:

(1) the publication date is between the years 2013 to 2022;
(2) appears in an SSCI and peer-reviewed journal;
(3) is written in English;
(4) under the focus of educational research;
(5) must explicitly address both collaboration and metacognition simultaneously; and
(6) as relevant to the discourse on group metacognition.

The first criterion ensured that only publications published from 2013 to 2022 were considered, given that the field of online learning environments, metacognition, and collaborative learning is relatively new and tends to be explored more recently. The second criterion aimed to include only high-quality articles from SSCI-indexed journals. The third criterion was used to identify publications that were highly accessible. Criterion 4 was employed to determine if the study's implications and interventions were relevant to the educational research area. To evaluate the relevance of 54 publications, criteria 5 and 6 were employed. The researcher procured and examined the full-text versions of each article, assessing which ones had the potential to be related to group metacognition (see Table 1).

Table 1. Inclusion and notes for exclusions

Inclusion criteria	Notes for exclusions
➔ English language ➔ SSCI ➔ Peer-reviewed journal article ➔ Educational research ➔ Date between 2013 and 2022 ➔ Healthy people population	➔ Psychopathological human population ➔ Review study papers

Information retrieval process

In the primary phase, there was an engagement in the encoding of fundamental attributes inherent to the articles present within the database. These attributes encompassed the identities of the author(s), the year of publication, the title of the work, and the geographical location in which the author(s) or co-author(s) were situated. The utilization of these encoded indicators facilitated the systematic classification of each article into distinct categories, specifically denoted as theoretical, empirical, or review-oriented contributions. Notably, in the context of empirical works, an extended process of categorization transpired, whereby an intricate differentiation between qualitative, quantitative, and hybrid qualitative-quantitative paradigms was effectuated. It is imperative to underscore that the primary encoding process was essentially designed to furnish a comprehensive overview of the corpus of articles contained within the database. Subsequently, within the ensuing phase, a more refined level of information encoding ensued, singularly directed at articles germane to the specific research inquiries at hand.

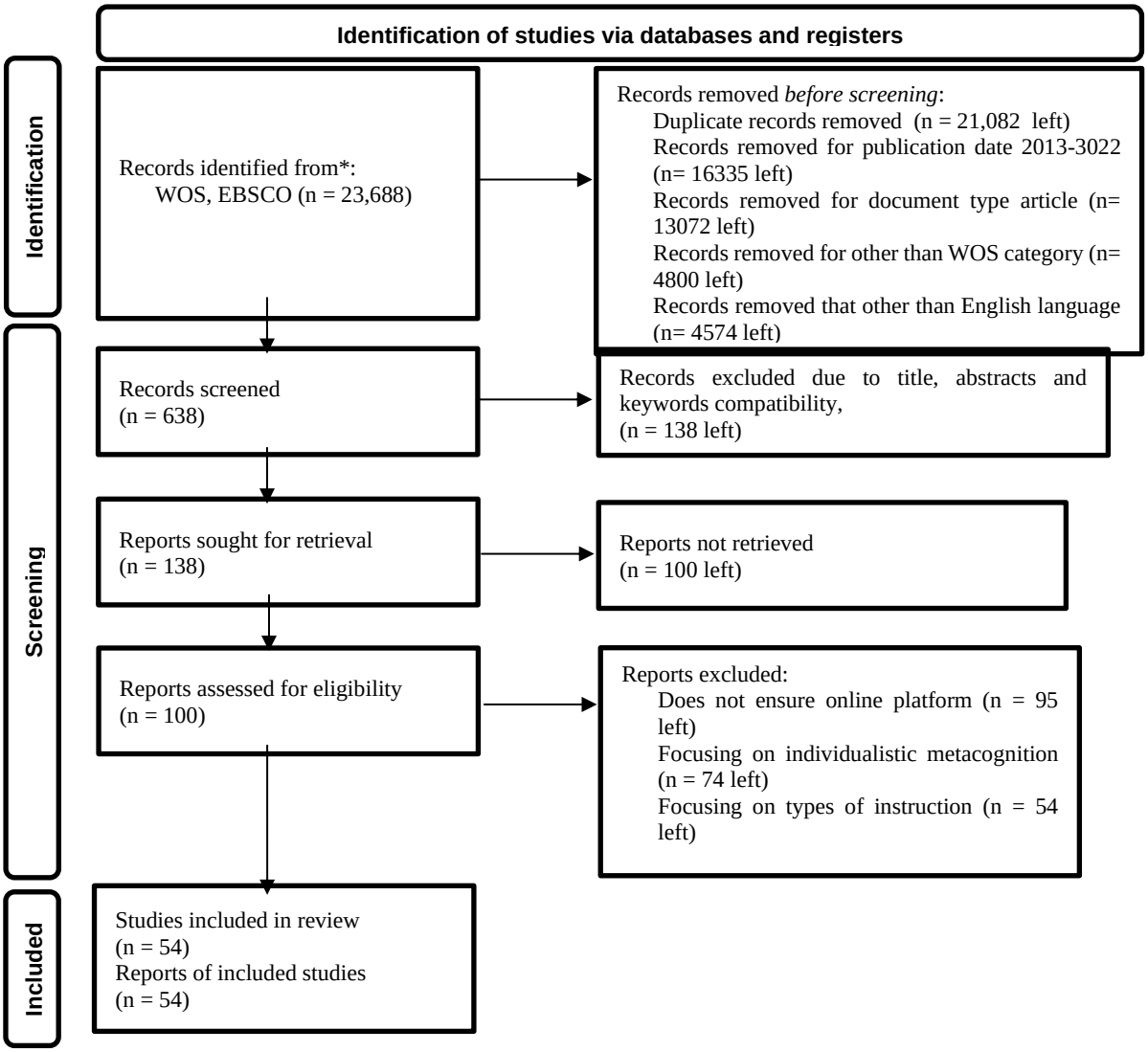

Figure 1. PRISMA flowchart of the study (Page et al., 2021)

Coding scheme and analysis

The journal articles selected were analyzed based on the research questions. A complete list of the journals for the article can be found in tables in Appendix I, Appendix II and references with an asterisk. The structuring of the first research question to demonstrate the dissemination of existing studies, along with observing the subject area, measurement scenario, and implementation

procedure within the selected year intervals, is crucial for providing a comprehensive overview of the studies. Thus, with respect to RQ1, categorization for (i) *publication (*year and journal*),* (ii) *conductance procedure,* (iii) the *topical area* and (*iv*) the *assessment scenario* was conducted. For the *conductance procedure*, the existing studies were differentiated based on what kind of measurement tools and instructional design they used. For the *assessment scenario*, the given scenario for the students was categorized as collaborative or individual conceptual understanding, collaborative knowledge construction, and individual or collaborative performance.

The second research question aimed to provide a general overview of methodological details, classifying included studies based on research design, the nature of the research design, and the type of implementation. Thus, with regard to RQ2, methodological information from the studies was extracted, such as (v) *nature of the research design,* (vi) *research design,* (vii) *way of conduct,* (viii) *type of analysis,* (viii) *target group,* (x) *group size,* and (xi) *study duration.* The code for *nature of the research design* includes qualitative, mixed-method and quantitative natures, while the code for *research design* embodies case study, comparative case study, experimental study, grounded theory and quasi-experimental study. *Way of conduct* refers to face-to-face, face-to-face and online, and online targeting studies. Although the number of face-to-face studies was limited regarding group metacognition, they were included due to extending the suggestions for researchers targeting online learning environments providing resources for face-to-face learning environments. In addition, *target group*s in studies were distinguished as elementary school, elementary and high school, high school, high school and undergraduate, undergraduate and graduate. Group size was distributed based on the number of students involved in the studies as two, three, four, five, six and bigger than ten.

The third research question aims to present a classification of studies that identify the potential relationship between relevant variables and the quality of collaboration on group metacognition. The titles of the associated variables were evaluated in four categories: metacognitive, cognitive, motivational, and contextual. The selection of these four broad categories is motivated by the structure of educational research, which tends to focus on metacognitive processes due to the social, motivational/emotional, cognitive, and ultimately, the focus of the study. Many studies address motivation, cognition, and social variables within the scope of the study's focus, attempting to understand the connection with metacognition, particularly in the context of self-regulated learning and the social shared regulation of learning. Thus, RQ3 led to the category (xii) *measures and variables of group metacognition* and (xiii) *potential impact of quality of collaboration.* For *measures and variables* stated in the studies, group metacognition measurements, related independent and dependent variables were listed. Moreover, the availability of positive or negative *impact of quality of collaboration* was declared.

Dissemination of Group Metacognition Studies (RESULTS FOR RQ1)

Distribution of Publication (by Year)

The number of publications by year can be seen in Figure 2. It seems that the group aspect of metacognitive regulation has been gaining popularity in the recent years. The results suggest that even though the data search involves only the first six months of 2022, an increase in the number of studies conducted may be expected to continue.

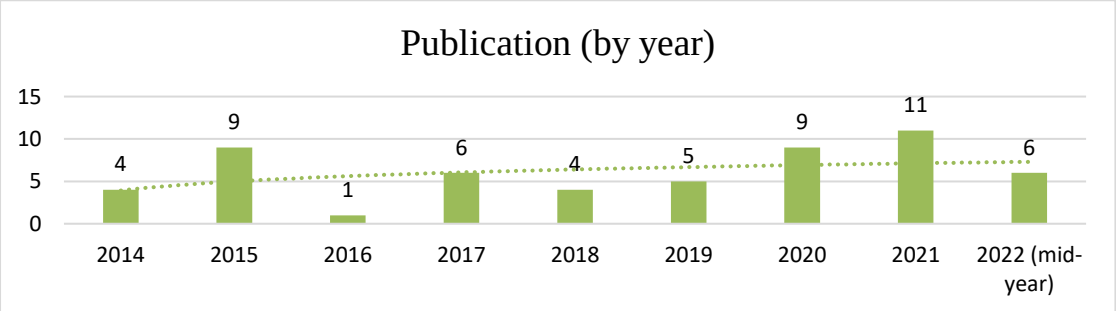

Figure 2. Distribution of publication by year

Categorizing Publication Regarding Focused Definition

Studies utilize various definitions of group metacognition, as evident from the diverse terminologies presented in Table 2 (see Appendix I). Between 2013 and 2022, the term "socially shared metacognitive regulation" appears to be the most frequently employed term with multiple definitions. Although there is a lack of common terminology associated with group metacognition, the terms *collaboration*, *social context*, and *shared* are frequently utilized in the analysis of related terminologies. Despite the lack of a standard definition, these definitions exhibit both similarities and differences. This suggests that the concept of group metacognition may entail regulatory processes and that emotional, cognitive, and contextual factors are interrelated and shape one another.

Categorizing Publication Regarding Their Conductance Procedure (Platform and Instructional Design), Assessment Scenario and Topic

The conductance procedure, assessment scenario and topic area in researches related to *group metacognition* were illustrated in Table 3 (see Appendix II). When the implementation procedures of the studies were examined, it is seen that online cooperative learning platform, cooperation application, electronic learning platform and face-to-face learning strategies are used. In most of the studies, an online collaborative learning platform is used, and it can be seen that tools such as Wiki and Knowledge Forum are used interactively. Moreover, when instructional designs of the studies were examined, it is seen that these designs are mainly shaped within the scope of the course or the task in which the study is applied. It is seen that courses such as educational psychology, biology, mathematics, physics, computer science are predominantly used in these studies.

Methodological Information (RESULTS FOR RQ2)

Distribution of the Studies Regarding the Nature of the Research Design

The nature of the research design by years can be seen in Figure 3. It seems that the number of reviewed studies on group metacognition has an increasing effect over the years. This does not mean that the phenomenon gained popularity over the years because of a lack of studies. Rather, the data suggest that among the reviewed studies, those that were qualitative or mixed-method in nature had higher numbers compared to those that were quantitative in design. Revealing that there is a need to list the related indicators for the phenomenon.

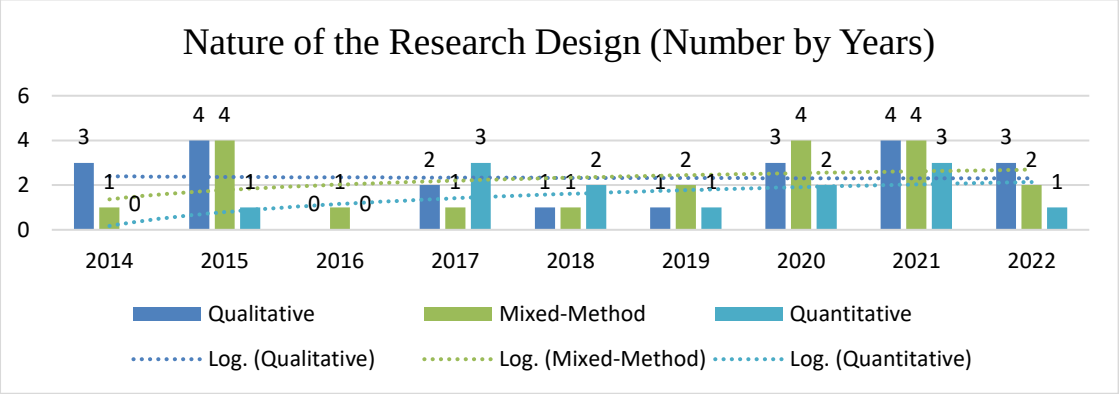

Figure 3. Distribution of the nature of the research design by years

Distribution of the Studies Regarding the Nature of the Research Design

Figure 4 shows that case studies (n=21) were frequently conducted for qualitative and mixed-method studies, whereas the experimental research design was generally used for mixed-method and quantitative studies. Due to the unknown nature of the group metacognition within the face-to-face and online learning environments, case studies were (the primary source of the data) mainly used.

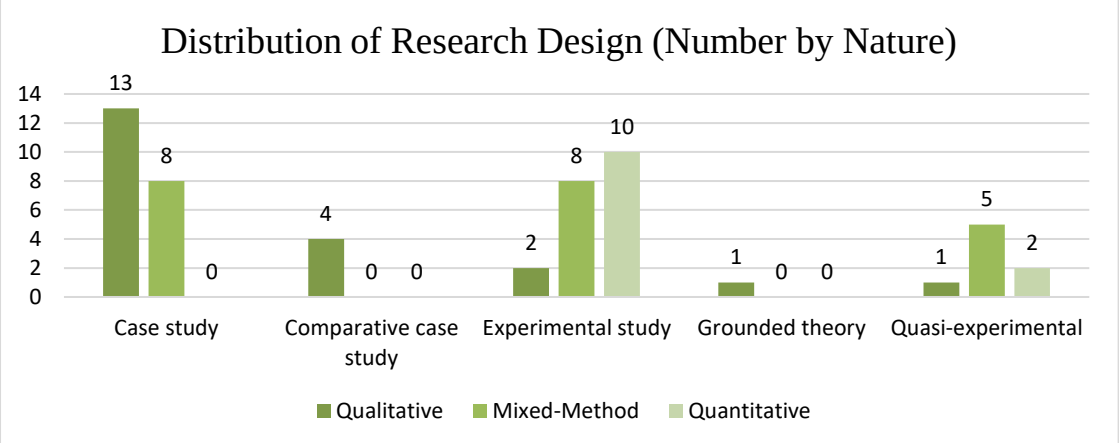

Figure 4. Distribution of the research design by nature of research

Distribution of the Studies Regarding the Way of Conductance

Face-to-face, online or both ways were used for the studies. Figure 5 illustrates that group metacognition studies are predominantly utilized in online learning environments as opposed to face-to-face learning environments. This might be due to the shift from traditional learning settings to online environments, as well as the need for a metacognitive regulatory tool that may replace the teacher presence.

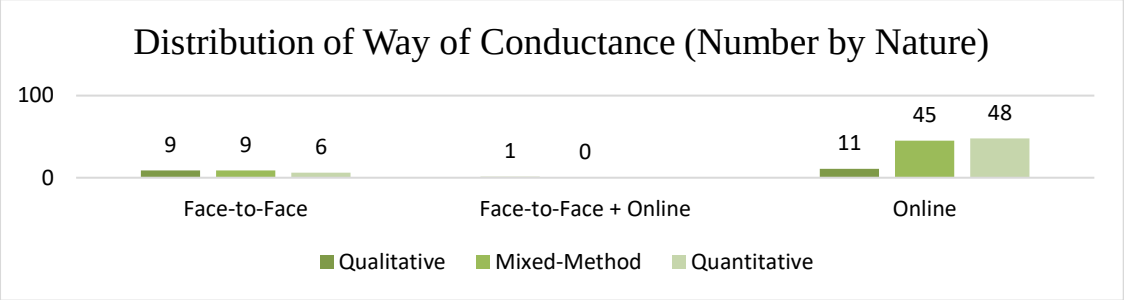

Figure 5. Distribution of way of conductance by nature

Distribution of Target Population by Study Duration

Figure 6 presents a summary of the data on the distribution of the target population by study duration. It seems that the majority of the selected studies targeted undergraduate and graduate students, which may be a result of the convenience sampling method used in the selection process." Moreover, longitudinal studies were mainly used for the selected studies. This might be caused by the integration of metacognitive-oriented activities in the lectures throughout the semester.

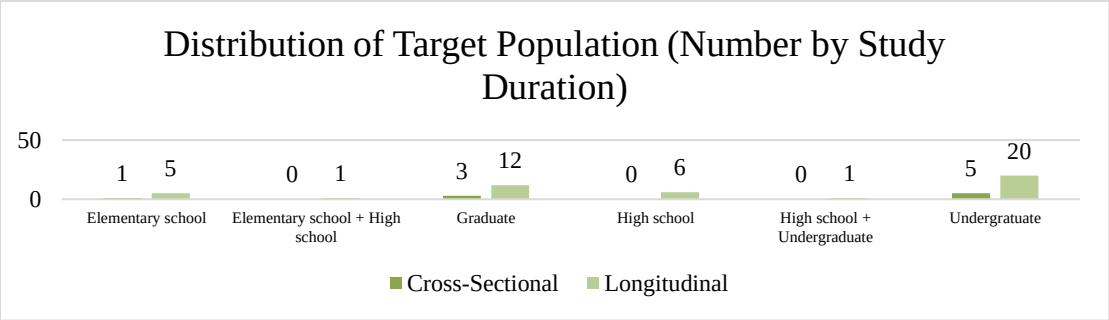

Figure 6. Distribution of target population by study duration

Distribution of Group Size Among All Studies

Figure 7 compares the results obtained for the use of group size in the studies investigating group metacognition. It seems that many studies prefer to use three to five people in one group. This might be because of the need for controlling instructional design among identified sample and trying to define the conducive environment for activities that support group metacognition over a specific group size.

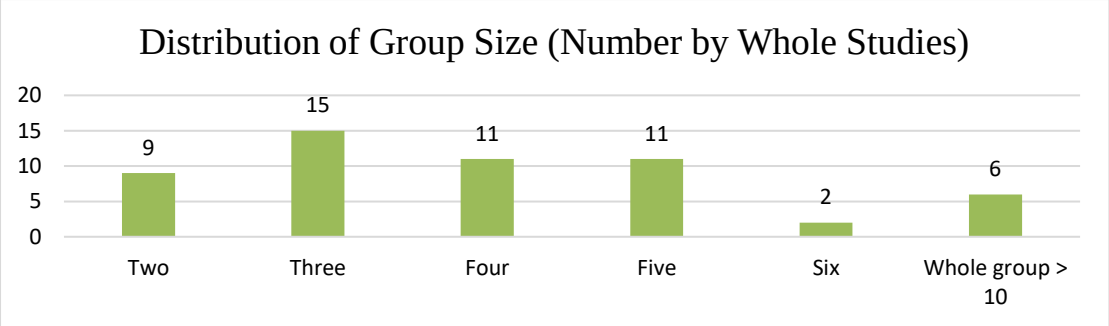

Figure 7. Distribution of group size among all studies

Fostering Group Metacognition (RESULTS FOR RQ3)

Insights for Fostering Group Metacognition (Social-related, Self-related and Other Variables)

Group metacognition is significantly influenced by various social factors. These factors include group composition, interpersonal communication, shared goals, shared beliefs, group norms, group roles and group dynamics. Group composition takes into account

age, gender, cultural background, educational level and level of expertise, while interpersonal communication includes communication patterns and reflective discussions. Furthermore, when group members align their goals and beliefs for a common understanding, this can affect their motivation, engagement and coordination.

Second, it is also important to consider various self-related factors that influence individual and collective metacognitive processes within a group. These factors include individual metacognitive skills, self-efficacy, self-regulated learning strategies, individual cognitive abilities, motivation and interest, self-perception and social comparison, and metacognitive knowledge and beliefs. First of all, individual metacognitive skills, such as self-awareness and self-regulation, play a role in group metacognition. Self-efficacy, or the belief in one's capabilities, can impact motivation and task engagement within the group. Individuals' use of self-regulated learning strategies, including goal setting and self-monitoring, can contribute to collective metacognition as well. Cognitive abilities also influence individuals' metacognitive processes, and motivation and interest affect their engagement in metacognitive strategies. Self-perception and social comparison processes influence metacognitive judgements, and individuals' metacognitive knowledge and beliefs shape their understanding and use of metacognition. Considering these self-related factors in group metacognition research allows researchers to understand how individual differences in metacognitive skills, beliefs, and motivations contribute to collective metacognition.

Third, it is important to consider various variables beyond social-related and self-related factors. These variables include task characteristics, group size, time pressure, external support and tools, group training and experience, cultural and contextual factors, and feedback and evaluation processes. Understanding how these variables interact with group metacognitive provides insights into the impact of task features, group dynamics, environmental factors, and feedback mechanism on the groups' monitoring, evaluation and regulation of cognitive processes. By considering these social, self and other related factors in group metacognition research, one can better understand how group metacognition is shaped.

When considering social, self, and other-related factors, the aforementioned 54 studies have been categorized into six distinct domains: cognition, context, motivation, metacognition, learning outcome, and interaction. First of all, it appears that 37 out of the 55 studies have utilized the *learning outcome* within their investigations. These studies may pertain to factors associated with either social or self-related aspects. Moreover, the predominant focus seems to be on research endeavors that assess either individual (*n*=18) or group (collective) performance (*n*=15).

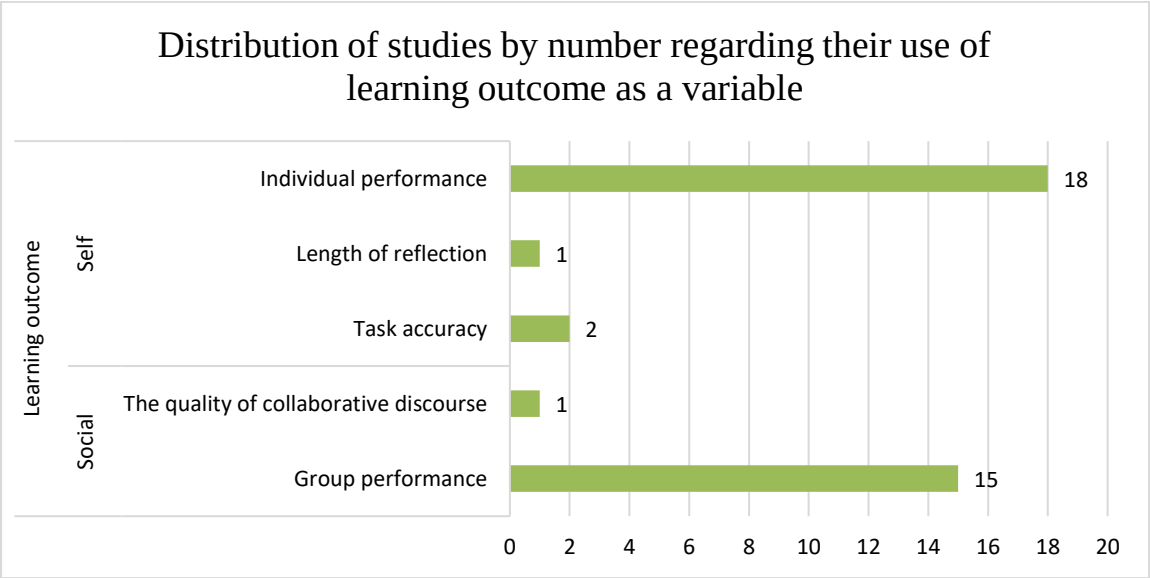

Figure 8. Distribution of use of learning outcome as a variable

Second, 53 out of 54 studies used variables associated with metacognition. Metacognitive regulation, collaborative knowledge construction, and socially shared metacognitive regulation have often appeared as variables or conceptual definitions that are attempted to be understood. This situation can be interpreted in relation to how group metacognition is defined. It has also been observed that researchers prefer to focus on individuals' processes during group performance measured in collaborative learning environments (see Figure 9).

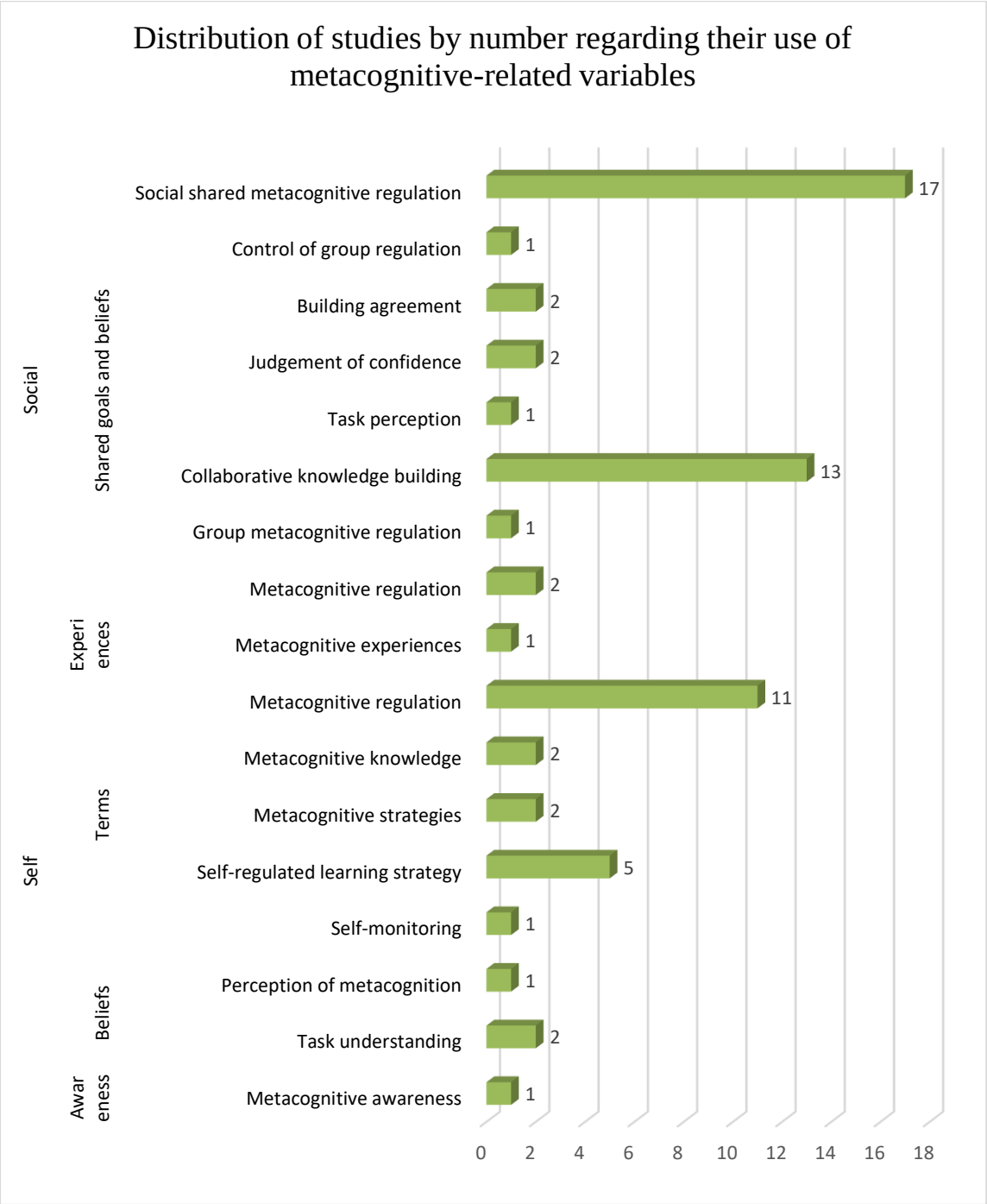

Figure 9. Distribution of use of metacognitive-related variables

Third, we can observe that studies associated with the context encompass various social and other variables. Particularly noteworthy within these investigations is the emphasis placed on constructing research designs by considering external support (*n*=14) and the type of collaboration (*n*=8). In addition, it is evident that the studies delineate the attributes of tasks. Among these attributes, the predominant focus lies in establishing settings that can evoke group metacognition, contingent upon the complexity (*n*=4) or difficulty (*n*=6) posed by the tasks (see Figure 10).

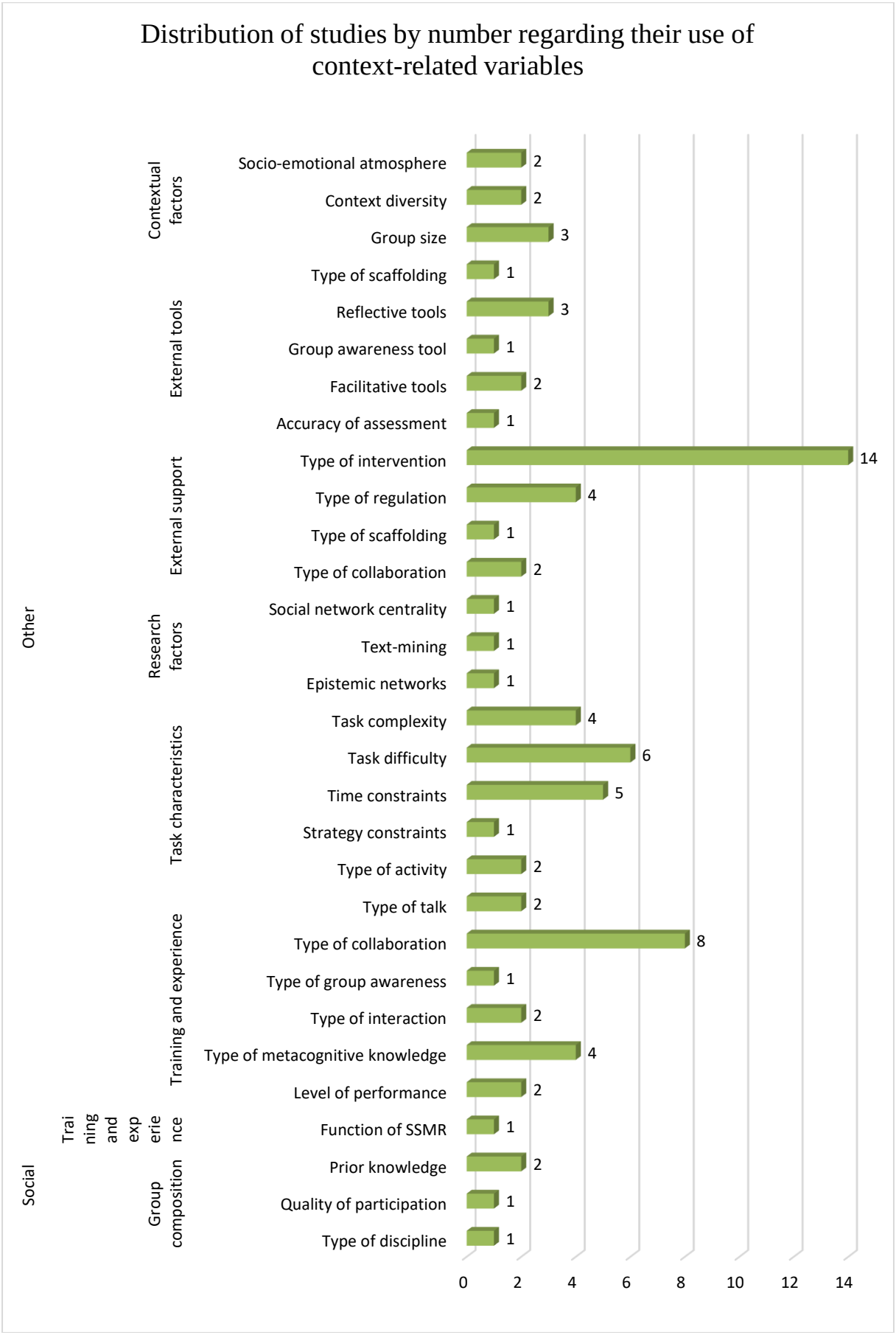

Figure 10. Distribution of use of context-related variables

Fourth, in group metacognition studies, variables associated with cognition have also been incorporated. Among the variables frequently encountered in these studies, a focus on the level of comprehension of the subject matter is observed. Here, rather than

the overall comprehension level of the group, the individual comprehension level of each member within the group is emphasized. Furthermore, it is evident that other notable variables include working memory and cognitive load. Exploring the idea that the underpinning of a group's metacognitive processes relies on the working memory capacity and cognitive loads of individuals within the group can potentially create a significant breakthrough in this field (see Figure 11).

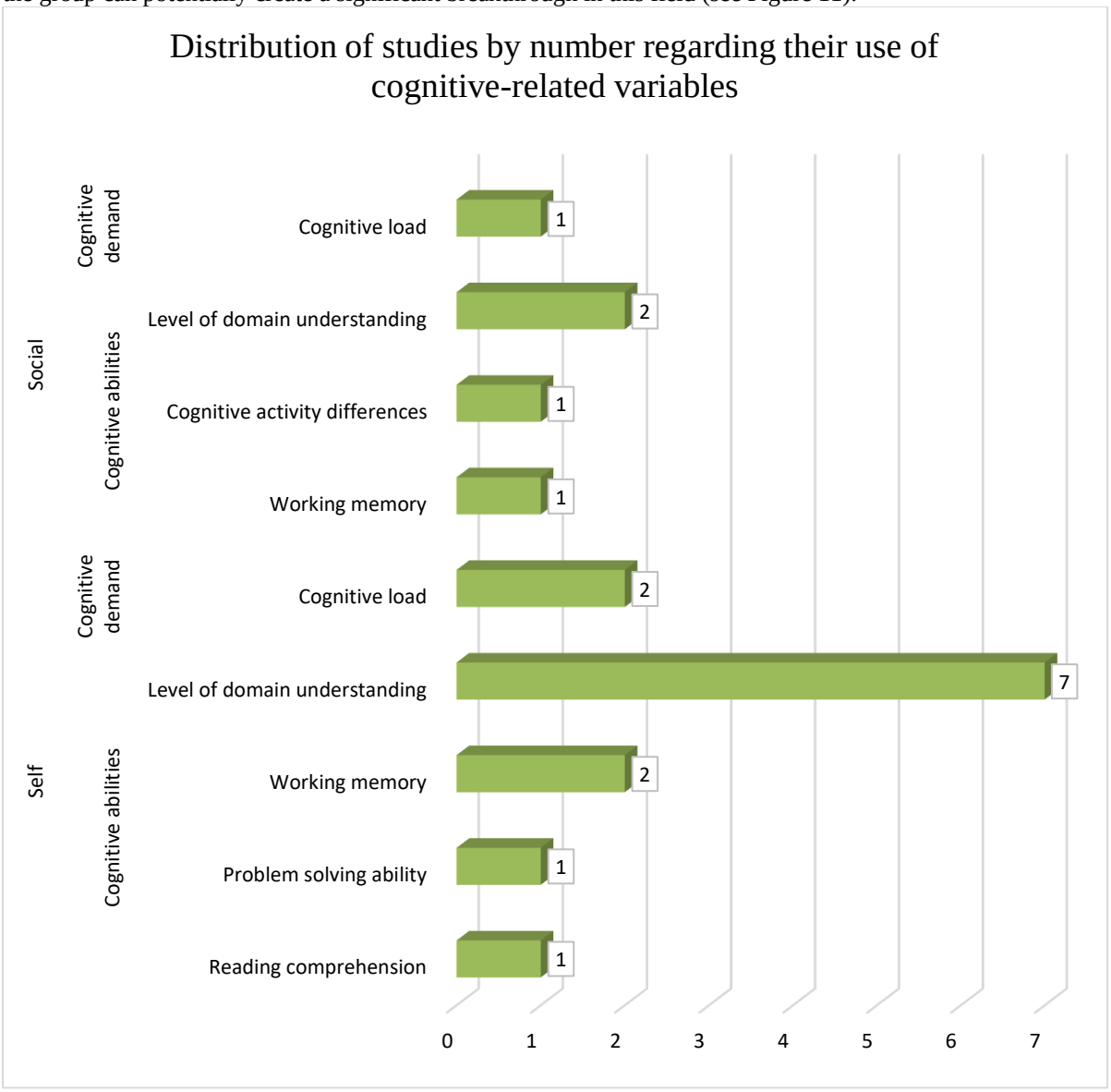

Figure 11. Distribution of use of cognitive-related variables

Finally, when examining motivation-related variables, it is evident that studies particularly assess the level of individuals' participation in activities within the group. It was not observed a significant emphasis on the collective motivation and participation of the group in these studies. Accordingly, for motivational processes, the independent motivation of individuals within group metacognition can be investigated to determine whether it affects group performance or individual performance.

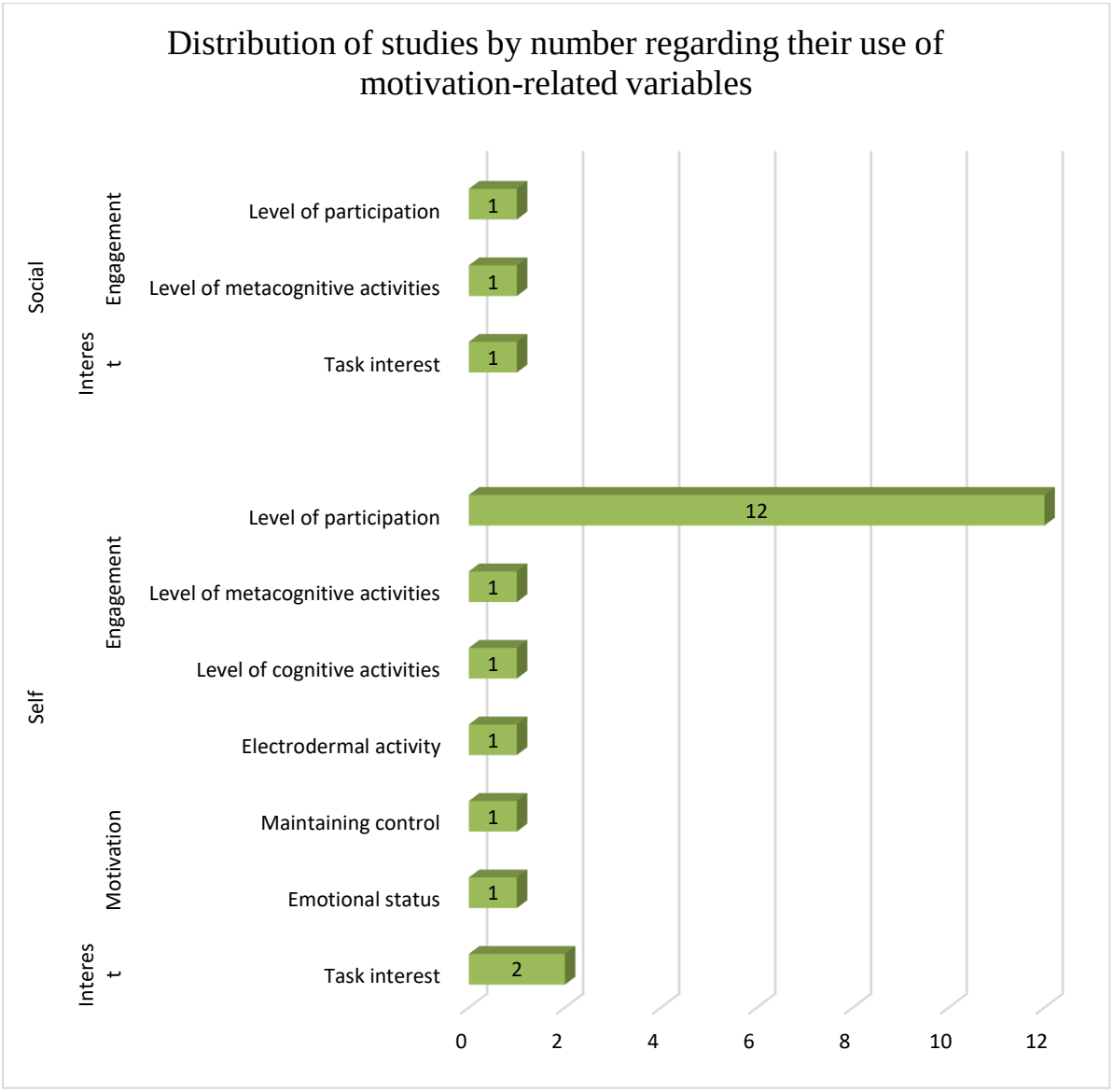

Figure 12. Distribution of use of motivation-related variables

Insights for Fostering Group Metacognition (Potential Impact of Quality of Collaboration)

In accordance with the insights gleaned from the outcomes of the selected studies, it is conceivable that the quality of collaboration might exert an influence on the facilitation of group metacognition, bearing both positive and negative implications. This potential impact is informed by multifaceted considerations encompassing individual, social, and contextual factors, encompassing various dimensions spanning the realms of contextual, cognitive, metacognitive, motivational, and outcome-based perspectives. The subsequent compilation enumerates findings derived from the empirical and observational investigations from the reviewed studies:

1. Using collaborative tools effectively, especially in ways that engage metacognition, significantly affects the quality of collaborative work. How these tools are used directly influences how deeply the group thinks about metacognition and how well they perform overall.
2. Providing technical support to enhance collaboration not only improves the quality and quantity of ideas but also creates an environment for productive discussions, promoting a richer social metacognitive atmosphere among the group.
3. Reducing mental effort enhances group performance in collaborative tasks, allowing more mental resources to be allocated to thinking about metacognition.
4. Exploring metacognitive contributions in more depth encourages more active interactions, leading to more intricate metacognitive exchanges among group members.
5. Being overly confident in collaborative skills, as seen in higher confidence levels, could shape perceptions of individual and collective metacognitive abilities, potentially impacting group-level metacognition.
6. Fostering high-quality social interactions around metacognition within the group helps create an environment conducive to effective group metacognition.
7. There can be a direct connection between a deeper understanding of concepts and a higher level of group metacognition in collaborative contexts.

8. Making substantial contributions by actively overseeing and adjusting metacognitive strategies, especially through proactive monitoring and adjustment, plays a critical role in promoting collective metacognition and, consequently, enhancing collaborative outcomes.
9. Addressing challenges related to planning can lead to smoother execution of metacognitive processes, potentially resulting in improved group metacognition.
10. Approaching problem-solving processes with a deliberate, gradual pace, whether positively perceived or as part of a shift in collaborative learning, can encourage more thoughtful metacognitive reflection, ultimately enhancing the group's metacognition.
11. Deliberately slowing down problem-solving, regardless of the evaluation or its impact on the direction of collaborative learning, has the potential to affect group-level metacognition and reshape collaborative dynamics.
12. Cultivating a positive social and emotional environment contributes to a stronger shared understanding among group members, nurturing a collective metacognitive mindset.
13. Elevated group performance and improved coordination are directly connected to effective group metacognition, underscoring the importance of metacognitive processes in achieving collaborative success.
14. Engaging in advanced cognitive and metacognitive activities heightens group metacognition, highlighting the value of intellectual participation in collaborative settings.
15. While higher confidence levels might not directly affect learning gains, they can still influence group-level metacognition and collaborative interactions.
16. Actively cultivating a positive social and emotional atmosphere leads to higher satisfaction within the group and positively impacts the group's metacognitive processes.
17. Increased participation acts as a catalyst, leading to positive outcomes in behavior, motivation, learning, and metacognitive processes, underscoring the essential role of active engagement in nurturing group metacognition.
18. Improving working memory capacity has the potential to boost the group's ability to tackle complex metacognitive tasks, thereby enhancing effective group metacognition.

DISCUSSION AND CONCLUSION

This study aimed to conduct a systematic review of studies associated with group metacognition conducted in either face-to-face or online environments. A total of 54 studies included in the review were evaluated in terms of diversity of definitions, research methods, and it has been assessed to identify and systematically present various variables associated with group metacognition. According to the study findings, the term "socially shared metacognitive regulation" emerged as the most frequently used term. However, the *absence of a common terminology* or *universally accepted definition* for group metacognition is noteworthy. In a parallel vein, the clarification of terms pertaining to groups or organizations stands out as a noteworthy concern spanning various academic disciplines. The distinction and exposition of notions like collaboration, coordination, and solidarity within organizational contexts—underscoring their nuances and discerning differences—have the potential to enhance the enduring effectiveness of outcomes produced within organizational frameworks (Castañer & Oliveira, 2020). According to their assertion, collaboration entails voluntary actions aimed at contributing to the realization of public or private goals. In the context of this study, terms employed, such as collaboration, shared, cooperation, and group, appear to convey a similar orientation and aimed at achieving common goals. This alignment may support the notion that the concept of group metacognition encompasses regulatory processes, wherein emotional, cognitive, and contextual factors are intertwined and mutually influential. Subsequent investigations are warranted to establish a more coherent definition and conceptual framework for group metacognition.

Furthermore, a variety of research designs, data collection techniques, target audiences, and group sizes have been identified in the studies. The nature of research design is observed to be structured through qualitative, quantitative, and mixed methods, with identified research designs including case studies, comparative case studies, experimental studies, grounded theory, and quasi-experimental research. Particularly, an increased frequency of studies on group metacognition is noted in the years 2020, 2021, and 2022. This finding suggests a heightened response to the need for studies on group metacognition over the past four years. Future research suggests that individual metacognition within a group may have different dynamics emerging from within the group's metacognitive processes (Chiu & Kuo, 2009; Halmo et al., 2022). The exploration of these dynamics and establishing connections with individual metacognition are crucial. Therefore, the recent surge in these studies holds significant importance for understanding the dynamics of group metacognition and conducting replicable research in the coming years.

Furthermore, the research has considered various group sizes, ranging from two to more than ten participants. These diverse findings underscore the use of different research methods in investigating group metacognition, emphasizing the need for further exploration and standardization of research approaches. Additionally, initiatives to improve collaboration among students facing academic challenges, such as low self-awareness (Samsonovich et al., 2008), limited working memory capacity (Komori, 2016), high cognitive load, reduced social interaction, or unfavorable educational contexts, are suggested to reinforce group-level metacognitive mechanisms. These endeavors are anticipated to lead to individual academic advancements. Furthermore, there is an anticipation that rotating responsibilities among group members could enhance collaborative proficiency and collectively enhance the metacognitive structure.

In addition, insights gained from the conducted survey to support group metacognition reveal that various variables in the categories of social-related, self-related, and others are employed in research. These variables have been examined across four categories, encompassing metacognitive-related, context-related, motivation-related, cognitive-related, and learning outcome-related aspects. One of the most noteworthy findings is that studies commonly employ measurement tools to assess both individual and group performance. Although there are studies that include learning outcomes such as the length of the read texts, duration, or task accuracy, it has been observed that these are in the minority. This situation directs us to the problem of measuring metacognition both at the individual and group levels. Findings have been reported in many studies suggesting that metacognition predicts student performance (Moores et al., 2006; Dindar et al., 2020; Puente-Diaz et al., 2023). In the current studies, awareness, belief, and indicator frequencies are often reported in tools aimed at measuring metacognition. This leads us to the lack of standardized measurement tools and variables.

When we look at variables related to the cognitive domain, it is evident that the level of understanding of the subject area (which refers to the level of domain understanding) of the applied course is prominent in self-related cognitive domain variables. It is anticipated that an individual with advanced metacognitive skills will have effective regulation, a more efficient learning process, and a higher level of understanding (Rivers et al., 2020; Sercenia et al., 2023). While it would be valuable for repeated studies in different research designs to support each other in reaching this finding, it is crucial to evaluate the relationship between variables such as working memory and cognitive load, especially with group metacognition. However, in the conducted review, it is observed that variables in this cognitive dimension are rarely addressed in studies. Nevertheless, studies suggesting that the relationship between cognitive load and group metacognition is dynamic and that high and low cognitive loads can be either supportive or inhibitory factors for group collaboration and metacognition are available (Scott & Schwartz, 2007; Costley, 2021). For instance, Costley (2021) reported findings indicating that germane cognitive load contributing to meaningful learning could increase group metacognition when the distribution of roles among group members is appropriately managed. Studies in this field are limited, and for researchers in the long term, it will be important to focus on studies addressing both the intrinsic, extraneous, and germane dimensions of cognitive load and questions about how working memory affects group metacognition.

In the social dimension of metacognitive-related variables, collaborative knowledge building and the social regulation of learning are frequently observed. Identifying the relationships among these variables poses a challenge in educational research processes. Additionally, one of the less frequently used variables is metacognitive experiences. In exploring the impact of collaborative metacognitive activities on shared motivated metacognitive experiences, a social network analysis of successful and unsuccessful collaborations revealed a higher impact of collaborative metacognition on successful groups (Fabelico, 2020). Other variables that are not commonly addressed in studies include decision-making, task perception, and confidence assessment. While many studies aim to establish a general framework in educational research, focusing on specific variables such as confidence assessment can be an important method when attempting to understand group metacognition.

When looking at variables related to the environment, although most studies utilize applications in both online and offline settings, it may not be possible to claim that every study incorporates supportive systems for these applications. Group awareness tools, supportive, and reflective tools seem to be present in six out of 54 studies. This suggests not only the integration of metacognitive interventions into the methods used in the studies but also the limited observation of metacognitive activities in students resulting from the use of these tools. Finally, in the examined studies, various measurement instruments were employed to assess group metacognition, and relevant independent and dependent variables were reported. However, *the absence of standardized measurement tools and variables* has been observed, underscoring the need for more consistent and reliable assessment instruments in this domain. Additionally, in certain studies, the *potential impact of the quality of collaboration on group metacognition* has been investigated, with both positive and negative effects reported. This highlights the connection between collaboration and group metacognition, demonstrating that the quality of collaboration can influence the development and effectiveness of group metacognitive processes. For example, during the use of applications, the finding that collaborative brainstorming and providing technical support can enhance collaboration not only in terms of the quantity of ideas but also in terms of quality is valuable (Zion et al., 2015; Leinonen et al., 2017). This insight suggests that students engaging in productive discussions is crucial, emphasizing the importance of valuable findings.

IMPLICATIONS

- When evaluating learning outcomes, individual and group performance has been extensively examined. It is advisable to incorporate and replicate other variables such as task accuracy, the number of error detection, or the number of error correction. The utilization of task-specific numerical variables might facilitate observing the distribution of tasks within the group and could present a replicable study design.
- Despite the limited number of studies, considering the sub-dimensions of the relationship between cognitive load and group metacognition can be essential due to the significant findings it presents.
- Few of reviewed studies suggest that fostering a positive social and emotional environment plays a crucial role in developing a shared understanding among group members, nurturing a group metacognitive mindset. Therefore, creating a positive social and emotional atmosphere is vital for cultivating group metacognition, potentially leading to a higher level of understanding in the knowledge domain.

- While only a few studies have addressed working memory capacity, enhancing the working memory capacity of individuals appears to have the potential to enhance the group's ability to manage complex metacognitive tasks, thus improving overall group metacognition.
- Additionally, a higher level of confidence among group members may impact the learning gains of the groups. Therefore, implementing self-efficacy enhancement programs or promoting well-being could be beneficial in fostering confidence among group members.
- In online learning environments, incorporating facilitative tools may address these issues and enhance the quality of collaboration. Researchers might consider using social network analysis within and between group members to identify cliques, patterns related to performance scores, and matched frequency in metacognitive activities among students.

Limitations

In this study, emphasis has been placed on the ERIC database due to its production of relevant results compared to other databases. Researchers intending to replicate the systematic literature review are advised to also utilize other databases. Furthermore, studies included in thematic coding were identified by considering factors in the measurement instrument developed by Biasutti and Frate (2018). However, in addition to this, the systematic review of the research was completed by considering the distribution of publication years, learning outcomes, the quality of collaboration, and potential relationships during qualitative coding. While other researchers can replicate the systematic review using these indicators, they can also enhance the review by incorporating different indicators. Lastly, despite the absence of a consensus on the perspective of group metacognition, an attempt has been made to enumerate the similarities and differences in the definitions of the included studies. Nevertheless, future researchers are encouraged to comprehensively examine how individual and group metacognition are conceptualized in studies with different scales.

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* The asterisk indicates the references taken into consideration in the systematic review.

Appendix I

Table 2. Focused Definition of Group Metacognition in Publications between 2013 and 2022 (mid-year)

Used term or process name	Common Definition(s)	Reference(s)
Socially shared metacognitive experiences	• collective metacognitive experiences that are shared, externalized, or co-constructed among group members	(Lobczowski et al., 2021)
Socially shared metacognitive regulation	• jointly monitoring and controlling learning among group members during collaborative learning • maintaining coordinated and mutual engagement in regulating the group's problem solving • metacognitive regulatory processes are genuinely shared among members • shared metacognitive awareness and egalitarian, interdependent adoption of regulation skills to wards joint learning objectives in groups operating as genuine social entities • metacognitive regulation at the interpersonal level	(De Backer et al., 2015a, 2020; De Backer et al., 2021; Khosa & Volet, 2014; Kielstra et al., 2022; Zheng et al., 2021; Näykki et al., 2017; Tang et al., 2022; Volet et al., 2017)
Metacognitive group coordination		(Leng et al., 2021)
Social metacognitive interaction	• a phenomenon can be affected by different types of scaffolds	(Molenaar et al., 2014)
Socially shared regulation	• the processes groups use to regulate their joint work on a task • having two dimensions as a social regulation dimension and a content-processing dimension. • the interplay between students' metacognition • collective regulation and adaption of cognition, metacognition, behavior and motivation.	(De Backer et al., 2017; Hogenkamp et al., 2021; Malmberg et al., 2019; Ouyang et al., 2022; Rogat & Adams-Wiggins, 2014; Sobocinski et al., 2017; Zhang & Hsu, 2021)
Socially shared metacognition	• metacognition is linked to social in nature rather than linked to individual learners.	(Leinonen et al., 2017)
Help-seeking		(Lai & Liu, 2018)
Group metacognitive strategies for modelling competencies		(Vorhölter, 2021)
Social metacognition		(Borge et al., 2022; Siqin et al., 2016)
Metacognitive experiences in collaboration	• manifestations of metacognitive monitoring in collaboration	(Dindar et al., 2020; Siqin et al., 2016)
Metacognition in social context		(Çini et al., 2020; F. Teng, 2020; M. F. Teng & Huang, 2021b; Wu et al., 2020; Yang et al., 2020; Zheng et al., 2021)
Shared group planning		(Hadwin et al., 2018)
Shared regulation		(Ucan & Webb, 2015)
Meta-level discourse on group process		(Kuhn et al., 2020)
Metacognitive regulation in collaboration		(Borge et al., 2018; De Backer et al., 2015a; De Backer et al., 2016; Iiskala et al., 2021; Kolić-Vehovec et al., 2022; Malmberg et al., 2021)
Metacognitive monitoring in collaboration		(Haataja et al., 2022)
Social annotation		(Li et al., 2015)
Group awareness		(Erkens & Bodemer, 2019; Pifarré et al., 2014; Schnaubert & Bodemer, 2019)
Socio-emotional aspects of collaboration		(Bakhtiar et al., 2018; Isohätälä et al., 2020)

Appendix II

Table 3. Conductance Procedure, Assessment Scenario and Topic of Group Metacognition Researches in Publications between 2013 and 2022 (mid-year)

Conductance Procedure						
Platform	**Name**	**Instructional Design**	**Assessment Scenario**	**Topic**	**Used term or process name**	**Reference(s)**
Collaboration app	Collabucate CREATE	Project-based learning Ill-structure problem solving	Collective knowledge construction Collaborative performance	Pharmacy Information Science and Technology	Socially shared metacognitive awareness Social metacognition	(Borge et al., 2022; Lobczowski et al., 2021b)
Online collaborative learning platform	Wiki Y-read? Virtual science laboratory Diigo Text-based	Project-based learning Group script writing Well-structured problem solving	Collective knowledge construction Collective conceptual understanding	Computer networks Educational technology Environmental sustainability Electronics	Socially shared metacognitive regulation Metacognitive group coordination Social annotation	(Çini et al., 2020; Dindar et al., 2020; Erkens & Bodemer, 2019; Hayashi, 2020; Iiskala et al., 2021; Lai & Liu, 2018;

	KnowCat DingTalk Discussion forum Knowledge forum Virtual class Tailorship simulation CASSIS	Inquiry-based learning Ill-structured problem solving Scaffolded learning Group concept mapping Complex problem solving	Collective knowledge seeking Individual performance Perceived group performance and perceived individual performance Collective knowledge construction and individual performance	Learning processes and strategies Psycho-pedagogical intervention in developmental disorders English proficiency Educational research methods Advance general science Human language processing Climate chage Physics Multimedia technology and website making Visual arts Pyschological theory task	Socio-emotional aspects of collaboration Group awareness Help-seeking Metacognitive regulation in collaboration Social awareness Metacognition in social context Socially shared metacognition Socially shared regulation Shared regulation Metacognitive experiences in collaboration	Ouyang et al., 2022b; Siqin et al., 2016a, 2016b; Wang et al., 2017b; Zheng et al., 2021b)
Electronic learning platform	Ontdeknet Markstrat Desktop computer Multi-touch table top computer	Group script writing Scaffolded learning Well-structured problem solving Ill-structured problem solving	Collective knowledge construction Group performance Group knowledge result	Country cultures Learning strategies Market strategy Applied Cognitive and Media Science	Social metacognitive interaction Meta-level discourse on group process Shared group planning Group awareness	(Hadwin et al., 2018b; Kuhn et al., 2020; Molenaar et al., 2014; Schnaubert & Bodemer, 2019)
Face-to-face learning platform	Transparent glass work-board	Group concept mapping	Collective conceptual understanding	Veterinary medicine	Socially-shared metacognitive regulation	(Khosa & Volet, 2014)
Face-to-face learning	Running records No electronic platform	Inquiry-based learning Ill-structured problem solving Project-based learning Group script writing Well-structured problem solving Concept figuring Group concept mapping Reflective learning	Collective knowledge construction Collective model construction Group performance Individual performance Individual and collective conceptual understanding Collective knowledge construction and individual performance Collaborative performance Collective conceptual understanding Individual performance by peer and self-reported reflections	Instructional sciences Educational technology Elementary science Business Veterinary medicine Coastline management Physics English English writing Mathematics didactics Language Advanced physics Operant conditioning Human learning Mathematical task Mathematical modelling Blood circulation Human body systems Cells	Socially shared regulation Shared regulation Socially shared metacognitive regulation Socially shared process Cognitive collaboration Group metacognitive strategies Cognitive and socio-emotional aspects of collaboration Social interdependence and metacognition Metacognitive regulation in collaboration Social regulation in collaboration Metacognition in social context Metacognitive monitoring in collaboration	(Daniel & Jordan, 2017; De Backer et al., 2015a, 2015b; De Backer et al., 2016, 2017; De Backer et al., 2020; De Backer et al., 2021; Haataja et al., 2022; Hogenkamp et al., 2021; Isohätälä et al., 2020; Kolić-Vehovec et al., 2022; Lee et al., 2015; Leinonen et al., 2017; Malmberg et al., 2019, 2021; Näykki et al., 2017; Rogat & Adams-Wiggins, 2014; Schünemann et al., 2017; Sobocinski et al., 2017; F. Teng, 2020; M. F. Teng, 2022; M. F. Teng & Huang, 2021b; Ucan & Webb, 2015; Volet et al., 2017; Vorhölter, 2021; Wu et al., 2020; Zhang & Hsu, 2021)