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Co-regulation of learning in computer-supported collaborative learning environments: a discussion

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Abstract This discussion paper for this special issue examines co-regulation of learning in computer-supported collaborative learning (CSCL) environments extending research on self-regulated learning in computerbased environments. The discussion employs a socio-cognitive perspective focusing on social and collective views of learning to examine how students co-regulate and collaborate in computer-supported inquiry. Following the review of the articles, theoretical, methodological and instructional implications are discussed: Future research directions include examining the theoretical nature of collective regulation and social metacognition in building models of co-regulated learning; expanding methodological approaches using trace data and multiple measures for convergence and construct validity; and conducting instructional experiments to test and to foster the development of co-regulated learning in computer-supported collaborative inquiry.

Keywords Co-regulation · Metacognition · Technology-enhanced inquiry · Computer-supported collaborative learning

Introduction

The pivotal role of self-regulation in learning has been widely accepted (Boekaerts et al. 2000; Pintrich 2000; Winne 2001; Zimmerman 2001). As computers are becoming ubiquitous in educational contexts, research on self-regulation in computer-based environments has attracted much attention (for a review, see Winters et al. 2008). Research has made important advances including models and processes of self-regulation (Azevedo 2005, 2007), measurements of self-regulation (Azevedo et al. 2010; Hadwin et al. 2007; Veenman 2007), effects of self-regulation on learning (Azevedo and Cromley 2004; Kramarski and Gutman 2005; Schraw 2007), and the role of technology on self-regulation and learning (Manlove et al. 2007). Whereas students may engage in solo work supported by technology such as learning from hypertexts and the Internet, computer-supported learning in schools often involves students working with others in groups in joint problem solving and collaborative inquiry on a shared task. For collaboration to be

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successful, students need to self-regulate their own learning, and co-regulate the learning of others in the group and of the group as a whole, and reciprocally, the work of group members influences students' own regulation and cognition. Conceptual and analytical frameworks for self-regulation need to be expanded to examine the nature of regulation in collaborative learning contexts, and to explore the potential of computer-supported environments in enhancing regulation for collaborative learning. With a shift in theoretical emphasis from cognitive to social views of learning (Brown et al. 1989), a major research field, computer-supported collaborative learning (CSCL) examines how groups of students develop shared meanings and co-construct knowledge when using computer-supported technologies (Koschman et al. 2002; Stahl 2006). The discussion of the articles in this special issue employs a socio-cognitive perspective focusing on social and collective views of learning in examining co-regulated learning supported by technology.

Learning collaboratively is now commonplace in schools and workplaces, and students increasingly need to learn how to solve problems and co-construct knowledge by working with others. Although collaboration in small groups and the use of computers are expected to enhance learning, simply putting students together does not automatically bring about collaboration and productive learning; students need to know how to regulate their learning and collaboration (Barron 2003; Chan 2001; Kreijns et al. 2003). Even if a student can self-regulate in a solo-learning situation, he or she may not be able to coordinate and co-regulate learning in a group. While collaborative inquiry using computers presents many challenges, it also provides fruitful environments to examine and to support the emergence and development of regulation. Self-regulation is difficult for students; typically, students do not set goals, monitor how well they have achieved the task goals, or ask themselves questions if they do not understand. However, in a group context, with distributed expertise, children can co-regulate each other as they work on a problem. For example, students can ask one another questions to clarify meaning, checking with others on the task and evaluating group progress. When students discuss different views and models, this may promote reflection that can have positive effects on their self-regulation. Computer-supported collaborative learning (CSCL) environments provide a rich context for research into co-regulated learning.

Seminal research in the field of CSCL has shown that successful collaboration is related to the group's coordinated and co-regulated engagement in joint problem sharing (Roschelle 1992). Successful collaboration requires students to self-regulate and co-regulate with other members both individually and as a whole. 'Self-regulation' refers to an active, constructive process in which students set goals, and monitor and evaluate their cognition, affects, and behaviour (Pintrich 2000). Co-regulation extends self-regulation encompassing cognitive and social dimensions. Volet et al. (2009) explain co-regulation in terms of individuals working together as multiple *self-regulating agents socially regulating* each others' learning; both depth of processing and social regulation are examined. de Jong et al. (2005) identify students' uses of strategies for seeking common ground when co-regulating others in a CSCL context. Manlove et al. (2006) examine co-regulated learning in terms of students' regulation of tasks and collaboration, and show how technologies such as chat tools provides a collaborative space for co-regulatory conversations. How technology can help to examine and promote co-regulation poses important areas of research.

Although much progress has been made on self-regulated learning in computer-based environments, research into co-regulated learning in computer-supported collaborative inquiry is a relatively new area. Some studies have investigated regulation among student dyads/groups, but focus on how students use strategies rather than the regulation of collaboration (Winters and Azevedo 2005). This special issue brings together papers examining co-regulation in CSCL environments in three domains of science, history and medical decision-making. These studies address several key questions including the following: How do students collaborate and regulate when they work in a computer-supported collaborative learning environment? What are the relations between regulation processes with learning outcomes? How can regulation in computer-supported learning environments be developed, and what is the role of technology in supporting regulation?

Overview of the papers

In the first paper, Saab et al. examine two kinds of regulation activities, task regulation and team regulation, and investigate their relationship with learning outcomes in the context of computer-supported collaborative learning. The study includes 48 dyads of 10th grade (15–17 year-old) students, who used a computer simulation (Collisions) and chat tools as part of carrying out collaborative inquiries. There were three conditions in the study. In the first condition, students received instruction on effective communication (RIDE) to scaffold team regulation, and in the second condition they received both RIDE instruction and a Collaborative Hypothesis Tool (CHT), which was designed to help students to formulate hypothesis in scientific inquiries. A control condition also was included. The results indicate that students employ more team regulation than task regulation; moreover, students who receive both RIDE and CHT engage in more team regulation, and team regulation activities are related to learning outcomes in the condition with both RIDE and CHT.

This study has two important findings. First, it demonstrates that regulation processes in computer-supported collaborative inquiry can be enhanced through instruction. Second, it shows that the use of regulation activities influences the learning outcomes. The study first differentiates between regulation activities focusing on the team and the task. For example, students have to check whether they understand the task and how they collaborate with others. The study effectively designs and incorporates cognitive and social scaffolds designed to support ill-structured and collaborative inquiry that is supported by technology. Students in the RIDE/CHT condition demonstrate more team and task regulation than do control students.

The second finding is that team regulation is related to learning in the RIDE/CHT condition; the study provides evidence of the role of co-regulation in collaborative inquiry and suggests that students who regulate more also learn more (Schraw 2007). It is useful to note that this relationship is only present in the RIDE/CHT condition, in which students also learn about scientific inquiry using hypotheses (but not in the condition when only RIDE rules are taught). The authors argue that students need to learn team regulation in addition to conceptual processing. It seems that team regulation processes are most effective when students not only learn team-processing regulation but also learn scientific inquiry and the conceptual processing of the domain. However, some questions can be raised about this study. Although the distinction of team regulation and task regulation is conceptually important, the coding scheme and examples provided are not very clear; it is not easy to see how the coding scheme may be applied or replicated. Further, no differences across conditions on the learning outcomes were found. How the RIDE results and hypotheses testing tools cohere with theories of regulation processes also need further investigation.

In the second paper, Janssen et al. examine how students regulate their learning in a CSCL environment, and how regulation affects performance. One hundred and one students—three students in each collaborating group—worked collaboratively on a historical inquiry task supported by a technology-enhanced environment (Virtual Collaborative Research Institute). Computer chat logs pooled from three studies were analysed. Four kinds of collaborative activities were identified: (a) task-related activities; (b) regulation of task-related activities; (c) social activities and (d) regulation of social activities. Students' computer logs were coded according to these key themes with related activities for each category. Learning outcomes were measured using group performance scores. The coded activities were examined employing factor analyses that load onto the four expected factors. The results indicate that students engage most often in regulation of task-related activities; and regulation of social activities predicts group performance while social activities are negatively related to group performance.

This study is important in that it examines the role and nature of regulation processes in collaborative inquiry, and how the identified regulatory processes are related to learning outcomes. Similar to the study of Saab et al., this study indicates that the regulation of social activities predicts group performance, and reveals the importance of co-regulation in collaborative inquiry. The important role of regulation of social activities rather than regulation of task processes in learning highlights why it is necessary to investigate social processes in co-regulation. Research in computer-supported collaborative learning emphasizes process but has given less attention to learning outcomes. The results showing the relations between regulation processes at group level and group learning outcomes provide a useful contribution to the literature.

Saab et al. and Janssen et al. also distinguish between task-related and team-related regulation, which they call social regulation. Of particular interest are the two by two dimensions of these processes, including social and cognitive dimensions on one hand, and basic and regulatory processes (e.g., planning, monitoring) on the other. Similar to how cognition and metacognition are related but different, the regulatory processes may constitute another layer of cognition in which students reflect on and regulate their task processing and social interactions. These four conceptual categories are supported by factor analyses and construct validations with the other measures of learning outcomes.

There are other interesting aspects of the Janssen et al. study. The authors have attempted to move beyond individual learning to group learning by, for example, aggregating individual students' regulating processes within the same group, and using group project for learning outcomes. Such analyses are better aligned with the emphasis of CSCL research emphasis on the collective rather than individuals. There are, however, some methodological questions such as the choice of units of analysis and how computer notes are parsed (van Aalst 2012). As well, while group scores are very important, it is unclear whether they constitute the most appropriate way to combine student data within the same group as aggregate scores. The examples of students' collaborative and regulation activities also seem rather commonplace and at times trivial and do not capture a fuller range of activities to illustrate productive collaboration and co-regulation. Nevertheless, the idea underlying this coding scheme is potentially useful and further work in this direction would be helpful.

In the third paper, Lajoie and Lu examine regulation in the context of medical decision-making and investigate how technology supports shared cognition and regulation. This study involved two samples of medical students, with 14 and 11 students respectively, who worked in groups of three on simulated events that involved medical decision-making. The first sample used traditional whiteboards to record and document arguments made by the participants during the simulation. The second sample used an interactive whiteboard, including a structured template for constructing and sharing arguments, to examine how collaborative decision-making may be enhanced. The results suggest that the sample using interactive whiteboards had deeper collaborative and regulatory discourse and better learning outcomes in patient management. The researchers conclude that developing shared understanding supported by technology can bring about more co-regulation and better outcomes in medical decision making.

This study is important because it illustrates how technology can provide scaffolds to support joint problem solving and co-regulation through visual representation of a team's shared understanding. The interactive white board supports the dynamic nature of decision-making, rendering it easier for others to monitor, evaluate and change the collaborative process. Visualization helps to externalize the groups' knowledge representation (individually and collectively), which can then become objects of inquiry, and enable students to develop their shared goals and understanding needed for emerging co-regulation activities. The study also demonstrates that, due to the technology-supported interplay between small groups and class community, the designs and annotations of one group become artefacts upon which the larger community can reflect. This study demonstrates how technology provides a metacognitive tool for facilitating co-regulated processes through developing common ground and shared cognition.

The study also illustrates the temporal dimensions of co-regulation, identifying differences in co-regulation activities in the two samples' early, middle and later phases. Groups using the interactive whiteboard initially engage in prolonged planning to establish shared goal and common ground, thus facilitate co-regulation and collaboration in later phases. There are useful implications for examining the temporal dimensions of co-regulating for model building: Examining the nature of co-regulation goes beyond identifying the different kinds of strategies; it is also about when and how these strategies can be used. While the analysis of the strategies are quite detailed, it would be useful to explain further the rationale of this coding scheme and in what ways these activities are considered metacognitive or regulatory; Lajoie and Lu seem to use these two terms interchangeably. Another issue is that while the authors assert that regulation activities are related to patient management and learning outcomes, the study does not provide empirical evidence of the relationship.

Theoretical, instructional and methodological implications

The articles in this special issue raise important issues surrounding the examination of co-regulated learning supported by technology. While the studies have different goals, all three raise questions concerning how students co-regulate to learn collaboratively. From a *theoretical* standpoint, what is the nature of co-regulated learning in computer-supported collaborative inquiry? How is it similar to and different from self-regulation? How is it related to such concepts as metacognition? All three papers have analysed co-regulated learning, utilizing, to varying degrees, dimensions of self-regulation strategies (e.g., planning, monitoring, and evaluation). Extending the current analyses focusing on tasks and strategies, Saab et al. and Janssen et al. both consider the need to examine social regulation, distinguishing it from task regulation. This approach has important implications for research into co-regulated learning including a social and group dimension. However, although the distinctions are fruitful, the coding schemes in both studies are brief and examples are not clearly illustrative of high-level regulation strategies; variable patterns are found between regulation activities and learning outcomes (i.e., negative correlations). These observations suggest that, although these analyses are useful, there is a need to refine the coding schemes and develop conceptual and methodological models for examining co-regulation. These studies provide a very good start for further research in this area: This section discusses two issues pertaining to the dialectics of individual and group, as well as the nature of co-regulation and social meta-cognition.

The first issue pertains to examining "individuals" and "group as an entity" in which co-regulated learning takes place. Co-regulation, while encompassing self-regulation, differs from it in that individuals interact with one another in a situated context. As mentioned in the introduction, regulation in collaborative learning involves students regulating themselves and other group members, while they work jointly as a group influencing each other. One recently-advanced framework for regulation in computer-supported collaborative learning distinguishes between “self-regulation”, “co-regulation”, and “shared regulation” based on how they pertain to different processes such as monitoring, standards, control; self, task and strategy knowledge (Winne et al. 2012). Further to self-regulation and co-regulating group member(s)’ processing, shared regulation emphasizes the shared goals and joint understanding of the team as a whole. In this case, regulation occurs at different levels including self, member(s) and the group.

The studies of Saab et al. and Janssen et al. both allude to team processing such as students checking if the other group member understands, or how they co-regulate another by asking questions. Lajoie and Lu discuss shared understanding for co-regulated learning. These analyses highlight the importance of coordinated perspectives and common ground that may be extended to *collective regulation* with students focusing on the group-team as a collective entity. Research in CSCL emphasizes examining group cognition beyond just individual processing to understand how learning takes places (Stahl 2006). Co-regulated learning emerges in the situated group context; it does not belong to one person but is the joint efforts of the group. Similarly, the CSCL model of knowledge building and Knowledge Forum emphasizes collective agency and regulation when students work towards the collective progress of a community (Scardamalia and Bereiter 2006). These researchers use the term “rise-above” or “meta-discourse” that signals students co-regulating at a high-level for the collective advances of the community (see Chan 2012 for a review of knowledge building). Technology-support in Knowledge Forum includes scaffolds supporting collective regulation such as ‘putting our knowledge together’ (e.g., Let’s put our ideas together) and meta-discourse (Where are we heading next in our discussion?). The emphasis here is that co-regulation processes may be examined as collective regulation, involving student efforts to advance the whole team (i.e., ‘I’ to ‘We’ perspectives). Although the analyses of Saab et al. and Janssen et al. papers do not differentiate the levels, nor have they focused on the collective, both show the roles of team regulation (compared to task regulation) on learning performance that may point to these ideas. These different models of shared regulation and collective regulation, as with others, need further examination developing analytic schemes and instructional experiments to see how they can examine the complex nature of co-regulated learning.

A second issue pertains to the tensions and relations between regulation and metacognition. There is much controversy and confusion about these two constructs (Kaplan 2008; Lajoie 2008). Briefly, metacognition refers to one’s knowledge about one’s cognition (White and Fredericksen 2005), while regulation is about the strategic control of one’s knowledge and learning; the current view is that metacognitive knowledge can be a kind of regulatory competency (Azevedo 2007; Veenman 2007). Lajoie and Lu use the terms metacognition and regulation interchangeably, while it is not clear how the other two studies illuminate the concept of metacognition. However, models of co-regulation, like models of self-regulation, need to include elements of metacognitive knowledge. Self-regulation models include phases such as goal setting, awareness, monitoring, control, reflection (Azevedo 2005; Pintrich 2000); and awareness may pertain to students’ metacognitive knowledge about what they know and do not know, both individually and collectively. In collaborative learning in small groups, students need to go beyond developing metacognitive awareness about their own knowledge gaps, to developing metacognitive awareness of their *team’s* state of knowledge. It is only when students perceive gaps in the group’s knowledge that they may exert regulatory strategies to monitor and improve their task processing. Just as students can use strategies to *co-regulate* others’ learning, working in groups may help students develop *social metacognition* and become more aware of what they do not understand. All three studies were conducted in rich knowledge domains; however, while the current emphasis was placed on the *frequencies* of strategies, it is also necessary to consider the *quality* of strategies and depth of conceptual processing (Volet et al. 2009) in light of students' metacognitive knowledge. The relationships between regulation and metacognition need to be addressed in collaborative context: knowledge about both one's own and one's group cognition is needed if one is to know *when, why* and *how* to employ co-regulatory strategies.

A related point pertains to the differences between interactive-collaborative and co-regulation processes, which are somewhat analogous to cognition and metacognition. Most coding schemes do not differentiate between collaboration and regulating activities; Janssen et al. employ two levels to capture the differences between task processes and regulation of task processes, although the coding and analyses need to be elaborated. When students ask a question in a group, it indicates communication but depending on context and quality, it can be a low-level interaction; on the other hand, it can indicate a meta-cognitive awareness that they are having problems meeting the team learning goals and need to execute co-regulatory strategies to overcome the impasse. These are subtle but important differences that need to be captured and examined more closely in situated contexts. The investigation into co-regulation in collaborative learning may raise new questions about the relationship between metacognition and regulation.

There also are important *instructional* implications to be drawn from these studies. All three studies discuss the relationship between regulation and learning outcomes with some evidence that students engaging in more team regulation achieve better learning outcomes. These results support the theme that more regulated students are better learners and highlight the importance of developing regulatory instructions (Schraw 2007). Another implication is that the nature and context of co-regulation processes influences learning. Lajoie and Lu's study reveals the temporal dimensions of co-regulation and suggests providing more time for orientation and goal setting and developing a shared/collective understanding of the problem. Saab et al. and Janssen et al. show that team regulation is correlated to learning outcomes, alluding to the importance of emphasizing social dynamics and the 'group' (community) as an entity in classroom instruction. As discussed earlier, the study of Saab *et al* shows that students' use of team regulation is effective only when students are also provided support in the form of CHT; this suggests many fruitful areas for future research with classroom implications, such as the effect of social regulation situated in context with rich domain instruction.

Another implication pertains to the development of co-regulation supported by technology. Overall, these papers suggest that regulatory processes can be enhanced in computer-supported collaborative learning environments. Specifically, Lajoie and Lu show that technologically-supported instruction supports more regulation processes than does tradition instruction, and suggests ways in which technology and visualization can be used to facilitate shared understanding for co-regulation. Such implications are supported by other research. For example, Knowledge Forum provides a collaborative space in which students can record and reflect upon ideas through collective inquiry and regulation (Scardamalia and Bereiter 2006). Specifically, when students can make their ideas explicit in a communal space, supported by technology, they may be better able to regulate, monitor and reflect on their thoughts, both individually and collectively. The implication for classrooms is that making students' ideas public with opportunities for shared and revised understanding may in turn prompt more co-regulation.

Saab et al. study illustrating the effects of RIDE on regulation can be extended using technology. Currently it is common to provide sentence openers, one kind of scaffold, for knowledge construction in CSCL environments. Extending that approach, it would be useful to develop technology that can embed regulatory processes, such as RIDE, and more complex ones directed at one's self, other group members and/or the group as a whole. There are some concerns that technology-enhanced instruction may increase cognitive loads and affect learning efficiency; as such, the use of technology to develop co-regulation needs to be embedded within a rich pedagogy, much as Lajoie and Lu do when they use an interactive whiteboard in a rich, simulated role-play of medical decision-making context. Instruction and scaffolds for regulation need to be linked to models that examine the nature and processes of co-regulation and its effects on learning.

From the *methodological* perspective, these studies raise different issues on how to broaden the methods to research into co-regulation in collaborative contexts. All three studies discussed here generally used utterances/computer entries (speaker turns) as units of analysis for coding and analysis. This approach is important as the categories reflecting the different regulation processes can be examined for their relations with learning outcomes for individuals. Current CSCL methods include a variety of approaches; and as group learning emerges in its own context, researchers have examined different methods and units of analysis for examining group cognition (Puntambekar et al. 2011). Co-regulated processes, similar to group learning, may not pertain to individuals, as they are jointly constructed by and for the group. Researchers have increasingly employed episodes and connected discourse as a basis for coding co-regulation for more contextual meaning (Manlove et al. 2006). Furthermore, while the common approach is to code each utterance (or part of the utterance) within the episode for some process, it may be fruitful to consider coding co-regulation processes for connected discourse; for example, certain higher-level co-regulatory processes that are hard to identify through a single utterance may be more easily discerned across a number of utterances (Volet et al. 2009). These possibilities point to the need to consider more varied approaches that examine not just individuals, but also groups as entities. There can be multiple levels of analyses and construct validity is needed to examine how group-level processing scores may be related to individual processes and performance. Multiple methods are needed to broaden methodology to test conceptual models.

Additional methodological issues raised in these studies include the need for convergence and construct validity (Veenman 2007). The analysis of processes mainly relies on the coding utterances for comparison with other sources of data. There can be wider use of log server and trace data (Hadwin et al. 2007) to illustrate how students are working in the computer-based environment as it relates to other activities. For example, research has examined students' participation patterns based on server logs in relation to student metacognition (e.g., social network analyses, Hurme et al. 2006). These studies employ chat logs and transcripts of face-to-face discussions; however, although they yield interesting patterns, it may be difficult for students to engage in high-level co-regulated learning because there is limited time for reflection during such discussions. Co-regulated learning should be examined in varied contexts and drawing from multiple data sources for construct validity. Another methodological problem is that statistical analysis is done at the level of the individual student, although the students work in groups. Some researchers have suggested the use of more sophisticated statistical techniques, such as multi-level modelling, to explain the relationships between individuals nesting under groups in collaborative learning (de Wever et al. 2007).

Future research directions

This set of papers has raised important implications and issues for advancing our understanding of co-regulation in computer-supported collaborative inquiry. First, there is a need to develop *conceptual models and frameworks* that explicate more clearly the nature and processes of co-regulation. Social regulation is important and what it encompasses needs to be investigated further. The model advanced by Winne et al. (2012), which differentiates between self-regulation, co-regulation and shared regulation, and CSCL models emphasizing collective regulation are fruitful areas of inquiry. Another interesting area is the relationship between regulation and metacognition; how students develop social metacognition with more understanding/awareness of their own and group knowledge gaps, and how this inter-relates with co-regulation can be examined. Regulation encompasses motivation-affective elements that have not been considered much in co-regulation but can be examined. More detailed taxonomy and fine-grained analysis of co-regulatory and meta-cognitive processes are needed to develop theories and process models; different conceptual models and schemes can be integrated to examine the nature and dynamics of co-regulation.

Second, research is needed to further the development of *analytic methods* that can broaden the methodology used to examine group processes in situated context. Co-regulation is often examined on the assumption of the individuals 'owning' the strategy/process; it may be useful also to consider that these processes emerge jointly among the dyads and groups in their interaction. More research on different coding schemes, analytic approaches, units of analyses for group processes is needed that align with theoretical shifts and conceptual models. To tap into situated co-regulation processes, research may examine coding that goes beyond single utterances including *uptake* among adjacent pairs of utterances, and the flow of the entire discourse in episodic tracts, in order to identify the nature and emergence of co-regulation. Multiple methods can be considered, such as examining ways to combine aggregate scores and approaching co-regulation as a group phenomenon, to widen the theoretical perspective. As mentioned previously, research using technology to examine co-regulation using trace data and server log data need to be developed. Multiple measures are needed for convergence and construct validity. Different methodological approaches examining individual and group processes as well as their interaction are important. Primarily further research is needed for expanding research methods, analytic tools, and fine-grained analyses that can support the development of theories and models.

A third research area is to examine *developmental issues* related to the growth of co-regulation. While these papers show that regulatory processes improve with instruction, more research is needed into what kinds of regulatory strategies to develop and how to design instruction to support those strategies and outcomes. Students may not often show high-level regulation; theoretical analyses of co-regulation can be enhanced through instructional experiments that help students develop high-level co-regulation processes such as reflecting on collective group goals and progress; these experiments can be used to test theories and to suggest how co-regulatory processes could be fostered. Research can also be conducted into the design of technology to embed and to scaffold co-regulation processes – how students understand why, when and how certain strategies and scaffolds are used so they can be internalized need to be investigated. Technology can support students to reflect on their own regulatory processes, based on criteria (standards) suggested by the researcher and tracked by technology and mirroring tools. The relationship between co-regulation and learning outcome needs to be examined for educational implications.

These suggested areas are related and point to further necessary work; research on co-regulation models and the nature of co-regulation can have theoretical implications for classroom practice, while instructional experiments can help formulate better co-regulation models. Research into this area may help to broaden methodological approaches and enable researchers to focus not only on individuals, but also on group processes and collective regulation. This special issue suggests that examining the social nature of co-regulation may enrich the field of regulation and metacognition, and highlights the need to help students learn how to co-regulate for more productive collaborative learning.

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