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Contemporary Perspectives of Regulated Learning in Collaboration

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Introduction: Self-Regulated Learning Covers a Set of Critical 21st-Century Skills

Successful students actively engage in numerous activities, including planning their learning, utilizing effective strategies, monitoring their progress, and handling the difficulties and challenges associated with their learning tasks (e.g., Zimmerman, 2000). In today's knowledge-based society, the importance of 21st-century skills for learning, creative and critical thinking, collaboration, and strategic use of information and communication technology (ICT) are essential (Beetham & Sharpe, 2013). Knowing how to learn and improve one's learning skills are the keys to individuals' and society's well-being. Decades of self-regulated learning (SRL) research success in solo and collaborative learning tasks requires the development of regulatory learning skills and strategies for working individually or collaboratively (Hadwin, Järvelä, & Miller, 2017). Being able to strategically regulate one's own learning and that of others has great potential for optimizing cognitive, motivational, and emotional behavior throughout life and work. (Zimmerman & Schunk, 2011).

Unfortunately, research consistently shows that learners often fail to plan adequately, use adaptive learning strategies, or leverage technologies for learning, collaborating, and problem solving (cf. Järvelä & Hadwin, 2013; Kirschner & Van Merriënboer, 2013). Regulation of one's own learning is not easy and often needs to be both learned and supported with self-regulation tools and/or environments (e.g., Hadwin, Oshige, Gress, & Winne, 2010). Learners may lack skills or knowledge to direct their own learning, or the motivation to enact successful strategies and processes. Additionally, difficulties regulating at the individual level (self-regulation), are compounded when interacting with peers and teams, (co-regulation and shared regulation). Socially shared regulation is especially critical as many of today's and tomorrow's problems are dependent on teams that can solve complex tasks together. In short, properly planning and strategically adapting one's learning to the challenges encountered during the learning process requires the ability to strategically regulate oneself (i.e., SRL), socio-cultural situations and people (i.e., co-regulated learning; CoRL), and the group collectively (i.e., socially shared regulation of learning; SSRL) (Hadwin et al., 2017). This chapter introduces these concepts and discusses their contribution to the learning sciences. We also describe the design principles and technologies that support regulated learning.

SRL Development During the Past Decades

Early ideas about SRL emphasized the individual, particularly cognitive-constructive aspects of regulation such as cognition, behavior, and motivation (e.g., Winne, 1997). SRL stressed the importance of students taking charge of their own learning (e.g., Zimmerman, 1989). Socio-cognitive perspectives of SRL emphasized triadic reciprocity, whereby cognitive and personal factors, environments, and behaviors interacted in reciprocal ways (Schunk & Zimmerman, 1997). However, the emergence of situated perspectives of learning in the early 1990s (Greeno, 2006) began to challenge the limitations of socio-cognitive models of SRL to explain regulation in highly interactive and dynamically changing learning situations.

Learning situations are increasingly social and interactive, and enriched with various technologies. Regulated learning has therefore come increasingly under consideration in social and collaborative situations, often in computer-supported collaborative learning contexts (Järvelä & Hadwin, 2013; Järvenoja, Järvelä, & Malmberg, 2015). In recent years, researchers have begun exploring where the social and self meet in strategic learning regulation. We ourselves have been striving to define and conceptualize the three forms of regulation (self-regulation, co-regulation, and shared regulation) as central processes in highly interactive and collaborative learning contexts (Hadwin et al., 2017).

Defining the Concepts of SRL, CoRL, and SSRL, and Their Contributions to the Learning Sciences

Three regulation modes are central to collaborative learning: self-regulated learning, socially shared learning regulation, and co-regulated learning. Given the proliferation of these constructs over the past five years, it is important to clarify the meaning of each. To do so, we rely heavily on our most recent review of the field (Hadwin et al., 2017).

Self-regulated learning (SRL) refers to an individual's deliberate and strategic planning, enactment, reflection, and adaptation when engaged in any task in which learning occurs. Individuals self-regulate learning when they learn or refine sports skills, complete academic work such as studying, learn new parenting skills as children develop, or adjust to a new workplace. In SRL, metacognitive monitoring and evaluation drive adaptation, and personal goals and standards set the stage for learner agency. The resulting SRL processes are iterative and recursive, adapting continuously as new metacognitive feedback is generated. Importantly, these metacognitive, adaptive, and agentic processes extend beyond controlling cognition to behavior, motivation, and emotions. This perspective recognizes that metacognitive knowledge and awareness are critical for adaptively responding to a complex set of challenges contributing to learner success. Individual SRL in the service of a group task is necessary for optimal productive collaboration to occur. In other words, evidence of SRL during collaboration is complementary rather than antagonistic to the emergence of shared regulation.

Co-regulated learning (CoRL) in collaboration broadly refers to the processes through which appropriation of strategic planning, enactment, reflection, and adaptation are stimulated or constrained. Co-regulatory affordances and constraints exist in actions and interactions, environmental features, task design, regulation tools or resources, and cultural beliefs and practices that either support or thwart productive regulation. Interpersonal interactions and exchanges may play a role in stimulating this type of transitional, flexible regulation, but other aspects of situation and task may also contribute. This definition of CoRL acknowledges the role of co-regulation in shifting groups toward more productive shared regulation, not just individuals toward self-regulation. Co-regulation also generates affordances and constraints that shape potential for shared regulation, which is why co-regulatory prompts are often found to be embedded within shared regulation episodes (e.g., Grau & Whitebread, 2012). Co-regulation involves group members developing awareness of each other's goals and beliefs and temporarily transferring regulatory support to one another or to technologies and tools that support regulation. The regulator can initiate co-regulation, such as when regulatory

support is requested (e.g., asking someone to clarify the task criteria). Alternatively, regulation can be prompted by a peer or group member (e.g., prompting a strategy: "maybe you should review your notes"). Finally, co-regulation can be supported by tools and technologies, such as a digital reminder to check the time, or a goal-setting scaffold embedded in a learning system.

Two important points should be made regarding co-regulation. First, co-regulation is more than merely promoting a regulatory action. It is a temporary shifting or internalization of a regulatory process that enables uptake by the "co-regulated" (Hadwin, Wozney, & Pontin, 2005). Second, CoRL emerges from distributed regulatory expertise across several individuals; it is strategically invoked when necessary, by and for whom it is appropriate. Co-regulation can be difficult to distinguish from shared regulation because consistent and productive co-regulation is likely a necessary condition for shared regulation to emerge.

Socially shared regulation of learning (SSRL) in collaboration refers to a group's deliberate, strategic, and transactive planning, task enactment, reflection, and adaptation. It involves collectively taking control of cognitive, behavioral, motivational, and emotional conditions through negotiation and continual adaptation. Transactivity implies that multiple individual perspectives contribute to the emergence of joint metacognitive, cognitive, behavioral, and motivational states, with meta cognition being central to shared regulation. Metacognitive processes that fuel regulation (monitoring and evaluation) shared among group members, thereby driving negotiated changes, are referred to as large- or small-scale adaptations. Individual SRL provides a critical foundation for collective agency; collective agency depends upon the emergence of joint goals and standards that may be informed by individual goals but do not always replace them. Finally, shared regulation is sociohistorically and contextually situated in both individual and collective beliefs and experiences that together inform joint task engagement and are changed as a result of collaboration.

What Is Regulation in Learning, and What Is It Not?

Over the past 10 years, interest in regulatory constructs, as well as their application to research and practice, has burgeoned well beyond their origins in educational psychology. Increased interest in the topic signals the relevance of regulated learning for understanding the complex, multifaceted processes associated with learning and engagement. However, the construct's emerging uses and elaborations have often been divorced from their psychological underpinnings, leading to inconsistent interpretations, definitions, and operationalization of the constructs, as well as their misuse.

Forms of SRL and social regulation have been studied in educational psychology for more than two decades. This chapter draws from a base of theoretical and empirical research, beginning with early conceptions of SRL (cf. Schunk & Zimmerman, 1997), to emphasize the cognitive, motivational, and metacognitive foundations from which the constructs of self-regulated, co-regulated, and shared regulation of learning originate. We present six guiding themes for conceptualizing all forms of regulation.

First, learning is more than metacognitive control or executive functioning. While metacognitive monitoring, evaluation, and control fuel regulated learning, they should not be treated as the same construct. For researchers adopting a multifaceted view of regulated learning, this means collecting data about the interplay between motivation, behavior, metacognition, and cognition during regulated learning, not just attending to a single facet.

Second, regulation (SRL, CoRL, and SSRL) arises because human beings exercise agency in striving toward goals as part of learning and collaboration. Self-set and collectively generated goals, whether transparent or not, contextualize engagement, strategic action, and interaction. For researchers, this means that data about learner and group intent need to be examined as well as the degree to which that intent matches the task goal or objectives. Without knowledge of learner intent, inferences about observed strategies, behaviors, motivation, or emotions are limited at best.

Third, regulation develops over time and across tasks. This notion of regulation as an adaptive process, rather than a state, is central to both Zimmerman and Schunk's (2011) macro-level phases (forethought, performance or volitional control, and self-reflection) and Winne and Hadwin's (1998) regulation model micro-level COPES architecture (Conditions, Operations, Products, Evaluations, and Standards), which inform phases of SRL. For researchers, this means collecting data about regulation as it temporally unfolds, emerging from and continuing to shape future beliefs, knowledge, and experiences.

Fourth, regulation is situated in personal history. New learning situations are always informed by knowledge, beliefs, and mental models of self, task, domain, and teams and based on past experiences. Learners start from what they know and feel about learning and collaborating, not just their prior knowledge about the domain. As a result, strategic task engagement is always heavily personalized—rooted in past individual and collective experiences. For researchers, this means that data about personal and collective conditions that situated regulation must be collected and observed over time.

Fifth, the mark of regulation is intent or purposeful action in response to situations such as challenges. For example, learners engage in positive self-talk when negative self-efficacy lowers task engagement or performance, or when a situation is anticipated to have lower efficacy. Learners overtly articulate goals when task persistence wanes. The proficiency with which people toggle regulation on and off creates cognitive capacity for complex processing (Hadwin et al., 2017). For researchers, this means that regulation cannot be observed spontaneously at just any time or place. Rather, data collection should be carefully timed to capture situated responses to overt and tacit challenges or situations that simulate self-monitoring and action.

Finally, regulation emerges when learners engage with real learning activities and situations that have personal meaning and create opportunities for them to connect past knowledge and experiences to the situation at hand. It is in these situations that cultural milieu and relationships, as well as interactions, context, and activities, give rise to self-regulation, co-regulation, and shared regulation of learning. We specifically draw from Winne and Hadwin's COPES model of SRL because it models the unfolding of updates to internal, external, and shared conditions within and across task work phases. By so doing, this model acknowledges regulation's situated nature, as well as the ways different modes of regulation (self-, co-, and shared) interact with one another. For researchers, this means being extremely cautious about inferences and interpretations drawn from studies during which learners complete learning or collaboration tasks solely to satisfy the requirements of a research study.

Prompting Metacognitive Awareness with Technologies

Over the past decade, researchers have designed and introduced technologies that support SRL and metacognitive awareness (Azevedo, 2015; Bannert, Reimann, & Sonnenberg, 2014). These technologies offer learning environments guided by the theories of how people typically learn and behave in such environments. For example, MetaTutor (Azevedo, 2015) is a state-of-the-art software that is grounded in SRL theory. MetaTutor gives learners prompts to promote metacognitive awareness based on learners' activities in the environment (Johnson, Azevedo, & D'Mello, 2011). The prompts involve a learning goal (e.g., a science topic to master), learning session sub-goals, and the possibility of communicating with the learning environment (e.g., animated pedagogical agents fostering metacognitive awareness).

Similarly, Bannert, Reimann, and Sonnenberg (2014) developed metacognitive prompts in order to support orientation, planning, goal specification, searching information, monitoring, and evaluation. They prompted learners to exercise metacognitive awareness aiming at supporting regulated learning processes and the learning product. Findings revealed a systematic difference between the occurrence of loops comprising cognitive and metacognitive learning activities in which students received or did not receive prompts.

New technology is often developed and tested under the assumption that students already possess sufficient self-regulatory skills, but are not metacognitively aware of when to spontaneously recall or execute regulated learning (Bannert & Reimann, 2012). Technology has the potential to automatically identify moments in which there is a need to promote metacognitive awareness by prompting cognitive and metacognitive processes. Contemporary research has begun to explore sequential and temporal associations between metacognitive and regulatory processes (Malmberg, Järvelä, & Järvenoja, 2017). However, further research is needed in authentic learning and collaboration contexts.

Why Regulation of Learning Is Relevant to Learning Sciences

The learning sciences are concerned with deep learning that occurs in complex social and technological environments (Sawyer, 2014). Studying and learning in these physical and social contexts introduces new demands for learning. Although the importance of collaboration for deep learning is well established in the learning sciences (e.g., O'Donnell & Hmelo-Silver, 2013), researching and supporting social and collaborative learning requires considering complex interactions between cognitive, social, emotional, motivational, and contextual variables (Thompson & Fine, 1999). To illustrate, Lajoie et al. (2015) examined socio-emotional processes contributing to metacognition and co-regulation used by medical students learning to how to deliver bad news. By coding for metacognitive processes, positive expression of emotions, and negative socio-emotional interactions, they revealed the dynamic relationships between emotions and metacognition in a distributed online problem-based learning environment.

We posit that regulation of learning is the quintessential skill for successful 21st-century learning (Hadwin et al., 2017). However, empirical research consistently indicates that group learning and sharing mental processes in the context of social interaction are challenging. Even when group activity is carefully designed pedagogically, groups can encounter numerous difficulties, including cognitive and socio-emotional challenges (Van den Bossche, Gijselaers, Segers, & Kirschner, 2006). Cognitive challenges can derive from difficulties in understanding each other's thinking or from negotiating multiple perspectives (Kirschner, Beers, Boshuizen, & Gijselaers, 2008). Motivational problems can emerge due to differences in group members' goals, priorities, and expectations (Blumenfeld, Marx, Soloway, & Krajcik, 1996). Addressing these challenges means moving beyond supporting knowledge construction and collaborative interactions alone. Working together means co-constructing shared task representations, goals, and strategies. It also means regulating learning through shared metacognitive monitoring and control of motivation, cognition, and behavior.

Previous studies indicate that students (a) construct shared task perceptions, negotiate their plans and goals together by building upon each other's thinking (Malmberg, Järvelä, Järvenoja, & Panadero, 2015), and (b) equally share their strategic engagement with the task and collectively monitor their learning progress toward their shared goals (Malmberg et al., 2017). For example, Järvelä, Järvenoja, Malmberg, Isohätälä, and Sobocinski (2016) examined groups' cognitive and socio-emotional interactions with respect to three phases of regulation (forethought, performance, and reflection). They studied how self- and shared regulation activities are used in collaboration, as well as whether they are useful for collaborative learning outcomes. Their findings indicated that collaborative planning of regulatory activities became shared in practice. Furthermore, groups that achieved good learning results used several regulatory processes to support their learning, in addition to engaging in shared regulation.

It has also become clear that the tasks used to study and support SRL must be difficult enough to require students to engage in monitoring and control their learning. Hadwin, Järvelä, and Miller (2017) explain that challenging learning situations create SRL opportunities. That is, challenges invite learners to contextualize their regulation strategies in a situation and to put them into practice

in order to test whether their SRL processes are conscious or not. When the learning process is effortless, conscious SRL ceases and will not emerge again until a challenge activates the need.

It is our belief that situations designed according to the principles of learning sciences aiming for active learning provide opportunities for training regulation. Furthermore, SRL can be facilitated or constrained by task characteristics (Lodewyk, Winne, & Jamieson-Noel, 2009) or domain (Wolters & Pintrich, 1998). For example, over the last two decades, Perry has examined the quality of classroom contexts that support elementary school children's SRL. In their studies (Perry & VandeKamp, 2000), Perry used classroom observations of teachers and students, work samples, and student interviews to identify factors that encouraged and constrained SRL. The findings revealed that students engage in SRL most often in classrooms where they: (a) have the opportunity to engage in complex, meaningful tasks across multiple sessions; (b) have the opportunity to exercise choice about the task, who to work with, and where to work; (c) can control how challenging the task is; and (d) participate in defining criteria for evaluation, as well as reviewing and reflecting on learning.

Designing collaborative learning tasks with optimal levels of challenge and student responsibility is central for activating students' regulated learning (Malmberg et al., 2015). Collaborative learning research shows that it takes time to progress to productive collaboration (Fransen, Weinberger, & Kirschner, 2013), as it takes time to progress in regulating learning. Malmberg et al.'s (2015) findings indicate that when collaborating groups work on open tasks, the focus of groups' shared regulatory activities shifts over time. At the beginning of the collaboration, groups may focus on regulating external aspects of collaboration (such as time management and environment), whereas in the later stages the focus shifts to cognitive-oriented and motivational issues. In short, groups must be given abundant opportunities to collaborate with each other, complemented by guided opportunities to systematically plan for and reflect on their collaborative progress and challenges.

Learners bring different beliefs and interests to their activity, resulting in varied motivation and engagement, efficacy for success, and the types of support needed for learning (Järvelä & Renninger, 2014). Researchers have identified motivating features of group work, such as the integration of challenging tasks for supporting interest (Järvelä & Renninger, 2014) or individual accountability and interdependence (Cohen, 1994). Others have studied motivational challenges related to group members' different goals, priorities, and expectations toward group activities. Findings in motivation and emotional regulation indicate that, in successful groups, members are aware of socio-emotional challenges and are able to activate socially shared motivation regulation (Järvenoja et al., 2015). As suggested by Järvelä and Renninger (2014), educators could anticipate differences in learners' interest, motivation, and engagement, and include project or problem features in their designs that increase the likelihood that one or another of these features will feel possible to the learner, triggering interest, enabling motivation, and supporting learning regulation. In summary, it appears that design principles for learning must account for differences of interest, motivation, and engagement, and they must do so by (a) supporting content-informed interactions, (b) providing the learners with scaffolding for thinking and working with the content, and (c) providing regulatory support.

Design Principles and Technological Tools for Supporting Regulated Learning

Increasingly, technologies have been used in learning sciences to provide new ways for prompting and supporting learning. For example, computer-supported collaborative learning environments (CSCL) offer learners opportunities to guide and support their own learning, and allow researchers to study the different forms of regulation.

Technology has been used in five ways to support regulation. First, technological tools and environments have been developed for sharing information and co-constructing knowledge as solutions to joint problems (e.g., Scardamalia & Bereiter, 1994). Research has examined the quality and

efficiency of the knowledge construction processes and outcomes within these knowledge-building environments (e.g., Fischer, Kollar, Stegmann, & Wecker, 2013).

Second, group awareness and sociability have been supported with the goal of positively affecting social and cognitive performance (Kirschner, Strijbos, Kreijns, & Beers, 2004). Three core CSCL elements (sociability, social space, and social presence; Kreijns, Kirschner, & Vermeulen, 2013), along with their relationships with group members' mental models, social affordances, and learning outcomes, have been implemented in tools and widgets (e.g., Janssen, Erkens, & Kirschner, 2011; see also Bodemer, Janssen, & Schnaubert, this volume).

Third, adaptive tools and agents have been developed to support SRL and metacognitive processes (cf. Azevedo & Hadwin, 2005). Computer-based pedagogical tools are designed to support learners to activate existing SRL skills as needed. Adaptive systems have the potential to react "on the fly" to learner activity, providing tailored and targeted SRL support (Azevedo, Johnson, Chauncey, & Graesser, 2011). Pedagogical tools can vary from being relatively short-term reminders to goal-setting planning tools that depend on the learning phase (Bannert & Reimann, 2012).

Fourth, developing awareness and understanding of self and other when working together on a task over a period of time has been supported with awareness and visualization tools (Kreijns, Kirschner, & Jochems, 2002). Derived from computer-supported collaborative work (CSCW) (e.g., Dourish & Bellotti, 1992), these tools focus on achieving optimal coordination between and within loose- and tightly knit group activities, both between and within collaboration. In CSCL, tools applied ideas of history awareness and group awareness (Kreijns, Kirschner, & Jochems, 2002). Mirroring tools collect, aggregate, and reflect data back to the users about individual and collective interaction and engagement (Buder & Bodemer, 2008).

Finally, SSRL processes have been promoted and sustained by developing regulatory planning, enacting, and monitoring supports (Järvelä, Kirschner, Hadwin, et al., 2016). These supports are grounded in findings that learners seldom recognize opportunities for socially shared regulation and often require support in order to enact these processes (Järvelä, Järvenoja, Malmberg, & Hadwin, 2013). For example, individual and group planning tools have been integrated directly into complex collaborative tasks (Miller & Hadwin, 2015). Comparisons of levels of support (individual vs. group, high vs. low) indicate that, regardless of the individual support level, a high level of group support promotes transactive planning discussions; these, in turn, lead to the construction of more accurate shared task perceptions that capitalize on individuals' task perceptions.

Future Trends and Developments

Despite theoretical and conceptual progress regarding the social aspects of SRL theory, future research may focus on the development of tools that make the intangible mental regulation processes and their accompanying social and contextual reactions more concrete for researchers and learners. Self-reports and subjective coding of video and/or verbal protocols alone are not sufficient to examine how regulation develops and adapts over time. Self-reports are based on students' perceptions of how they would or did enact certain processes; these perceptions often do not align with what actually occurs during learning (Zimmerman, 2000). Subjective coding of observation data is also weak due to the coders' interpretations of observed behaviors. The results lack generalizability, as they are content-specific, time-dependent, and individualistic.

A current trend in research about regulated learning includes (a) collecting rich multimodal data, (b) using data-driven analytical techniques (e.g., learning analytics), and (c) aggregating these data sources to guide learners to strategically regulate individual and group cognition, motivation, and emotion (Roll & Winne, 2015). *Multimodal data* comprises objective and subjective data from different channels, simultaneously tracing a range of cognitive and non-cognitive processes (Reimann, Markauskaite, & Bannert, 2014). While multimodal data collection in SRL research is in its early

stages, multichannel data triangulation can provide a fundamentally new approach that captures critical SRL phases as they occur in challenging learning situations.

The progress of SRL research benefits learning scientists who are actively designing and implementing innovative methods for teaching and learning in various contexts, as well as testing their interventions in design-based research (Sawyer, 2014). Researchers and instructors can inspect the extent to which their interventions change the learning processes, in addition to the material that is learned and learners' motivational and affective states. However, in reality, this is seldom the case. Interventions do not determine how learners engage with tasks. Rather, interventions are affordances that agentic learners absorb along with other elements in the learning context, as they perceive it, to regulate learning (Roll & Winne, 2015). Focusing on the online learning processes and collecting data about learning traces can make these complex regulatory processes visible and contribute to better learning design. Multidisciplinary collaboration in the SRL field is promising for producing more efficient tools and models for the learning sciences.

Further Readings

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This book chapter provides the most recent overview of the definitions and mechanisms of the three modes of regulated learning.

Järvelä, S., Malmberg, J., & Koivuniemi, M. (2016). Recognizing socially shared regulation by using the temporal sequences of online chat and logs in CSCL. *Learning and Instruction, 42*, 1–11. doi:10.1016/j.learninstruc.2015.10.006

This article provides empirical evidence for how self- and shared regulation activities are used and whether they are useful for collaborative learning outcomes.

Miller, M., & Hadwin, A. (2015). Scripting and awareness tools for regulating collaborative learning: Changing the landscape of support in CSCL. *Computers in Human Behavior, 52*, 573–588. doi:10.1016/j.chb.2015.01.050

This paper addresses the need to apply a theoretical framework of self-regulation, co-regulation, and socially shared regulation to design tools for supporting regulation in CSCL.

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This chapter explains the basic principles of metacognition and its role in productive self-regulation.

NAPLeS Resources

Järvelä, S., *Shared regulation in CSCL* [Webinar]. In *NAPLeS video series*. Retrieved October 19, 2017, from http://isls-naples.psy.lmu.de/intro/all-webinars/jaervelae/index.html

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