Promoting socially shared regulation of learning in CSCL: Progress of socially shared regulation among high- and low-performing groups

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Abstract

Collaborative groups encounter many challenges in their learning. They need to recognize challenges that may hinder collaboration, and to develop appropriate strategies to strengthen collaboration. This study aims to explore how groups progress in their socially shared regulation of learning (SSRL) in the context of computer-supported collaborative learning (CSCL). Teacher education students (N = 103) collaborated in groups of three to four students during a two-month multimedia course. The groups used the Virtual Collaborative Research Institute (VCRI) learning environment along with regulation tools that prompted them to recognize challenges that might hinder their collaboration and to develop SSRL strategies to overcome these challenges. In the data analysis, the groups reported challenges, and the SSRL strategies they employed were analyzed to specify the focus and function of the SSRL. Process discovery was used to explore how groups progressed in their SSRL. The results indicated that depending on the phase of the course, the SSRL focus and function shifted from regulating external challenges towards regulating the cognitive and motivational aspects of their collaboration. However, the high-performing groups progressed in their SSRL in terms of evidencing temporal variety in challenges and SSRL strategies across time, which was not the case with low performing groups.
1. Introduction

Collaboration is increasingly required in today’s academic contexts and in working life. Although collaboration has the potential to promote learning, it is not easy. It requires groups to cope with various tasks while coordinating between multiple individuals with unique perspectives as they attempt to achieve a shared understanding in a joint task (Dillengbourg, 1999; Roschelle & Teasley, 1995). Research has shown that groups encounter a wide range of challenges during their collaboration (Kreijns, Kirschner, & Jochems, 2003; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011). In order to collaborate successfully, group members need to recognize the challenges that might hinder their collaboration and to develop appropriate strategies together to overcome these challenges through interaction with others. Typically, collaborative learning research is framed by intentions to explore cognitive aspects of the collaboration (e.g. Hmelo-Silver & Barrows 2008; Weinberger et al., 2007), including the social interaction (Kreijns, Kirschner & Jochems, 2003; Roschelle & Teasley, 1995). However, despite the importance of the interactive role of motivation and emotions in collaborative learning, these factors are often ignored (Järvelä & Hadwin, 2013; Järvelä et al., 2014). The research focusing on socially shared regulation of learning (SSRL) goes beyond cognitive aspects of the collaboration by acknowledging the important role of motivation and emotions in learning. To some extent, both of these research lines complement each other when building an understanding of socially shared regulation of learning in social interaction (Järvenoja, Järvelä & Malmberg, 2014). Socially shared regulation of learning emerges when individuals negotiate shared task perceptions, goals, plans, and strategies (Hadwin, Järvelä, & Miller, 2011), and maintain positive socio-emotional interaction during collaboration by listening and by taking each other’s opinions into consideration (Rogat & Linnenbrink-Garcia, 2011). Hadwin et al., (2011) conceptualized
SSRL as unfolding in four loosely sequenced and recursively linked feedback loops. During the first loop, groups negotiate and construct shared task perceptions based on internal and external representations of the current task (Winne & Hadwin, 1998). During the second loop, groups set shared goals for the task and make plans on how to approach the task together. During the third loop, groups coordinate their collaboration strategically and monitor their progress. Based on this monitoring activity, the groups can change their task perceptions, goals, plans, or strategies to elevate their collective activity towards the shared learning goal. In essence, when groups engage in SSRL, they extend their regulatory activity from the “I” to the “we” level in order to regulate their collective activity in agreement (Miller, Malmberg, Hadwin, & Järvelä, 2014; Hadwin & Oshige, 2011). We argue that it is exactly this “transfer in sharing” during SSRL that is essential for successful collaborative learning.

Contemporary models of regulated learning propose that social and contextual features affect SSRL, and therefore how it is shaped, are dependent on the learning situation (Hadwin et al., 2011; Winne & Hadwin, 1998). On that account, the learning situation has a mediating effect on how SSRL is constructed and shaped during collective activity. The key issue in SSRL is that it builds on and merges individual and social processes, and is not reducible to the individual. Rather, it is explained by the activity of the social entity in a learning situation, including situational affordances that provide opportunities for SSRL (Volet, Vauras, & Salonen, 2009). This means that learners need to perceive the relevant information from the environment, and to integrate that information to the previous knowledge of task, self and social context. Finally, learners need to be able to anticipate opportunities that might hinder collaborative learning. However, learners often fail to recognize the challenges that invite the development of strategies for socially shared regulation, which is a critical aspect of collaborative
learning. Learners need to be aware of where the group as a whole stands with respect to challenges, and to construct adaptive regulation strategies together when the opportunity arises (Järvelä et al., 2013). Therefore, we argue that challenges experienced by groups provide SSRL opportunities.

The issue of awareness has received much attention in the area of CSCL research (Gutwin & Greenberg, 2002; Kirschner & Erkens, 2013). The concept of awareness in CSCL can be divided into cognitive group awareness (i.e. information about other members’ knowledge) and social group awareness (i.e. information about other members’ participation and contributions to the collaboration process). Especially in the context of CSCL it is more difficult to be aware of what the group members are actually doing and thinking. Bodemer and Dehler (2011) argued that perceiving and processing perceptions of the social awareness of other group members is a prerequisite to progress in collaborative learning (Gutwin & Greenberg, 2002). If the group members do not process this information correctly, they may face the same problem many times and their collaboration may be less satisfying.

Emerging empirical evidence indicates that SSRL increases group performance in collaborative learning (see Panadero & Järvelä, 2015). In order to ensure successful collaboration, the group members need to realize the focus of their SSRL and accordingly regulate their cognition (i.e. strategy use, task perceptions), motivation and emotions (i.e. willingness to work according to task, maintaining the socio-emotional balance) and environment (e.g. taking advantage of the features of the learning environment). Especially in the context of CSCL, regulation of all these aspects in joint agreement is equally important (Järvelä & Hadwin, 2013). Building on the results of research into collaborative learning and theories of SSRL, we posit that in order to progress in socially shared regulation of learning, the collaborating groups must engage
in all of these forms of regulation. More specifically, this study aims to understand how collaborative groups progress in their socially shared regulation in computer-supported collaborative learning (CSCL).

1.1. Socially shared regulation of learning in the context of computer-supported collaborative learning

   Earlier research has shown that collaboration can result in cognitive, motivational, social, or environmental challenges (Järvelä et al., 2013; Van den Bossche, Segers, & Kirschner, 2006). Cognitive challenges may derive from difficulties in understanding the other’s thinking process or in negotiating multiple perspectives (Kirschner, Beers, Boshuizen, & Gijselaers, 2008; Miller et al., 2014, Mäkitalo, Häkkinen, Leinonen, & Järvelä, 2002). Motivational challenges, in turn, can emerge due to differences in group members’ emotional well-being, goals, priorities, and expectations (Rogat, Linnenbrink-Garcia, & DiDonato, 2013; Volet & Mansfield, 2006). By contrast, positive socio-emotional interactions, such as commitment and mutual trust, can support collaborative learning (Kreijns, Kirschner, & Vermeulen, 2013). However, negative interactions may also accumulate and result in a negative interaction loop (Linnenbrink-Garcia, Rogat, & Koskey, 2011). Especially CSCL contexts have been criticized as posing challenges for collaboration (Kreijns, Kirschner, & Vermeulen, 2013), mainly because they offer limited opportunities for social interaction: Group members might not be aware of each other’s task perceptions or goals and the group might have limited possibilities for socio-emotional interactions, which are crucial to facilitate cognitive aspects related to the group work. In other words, collaboration in the context of CSCL can pose environmental and social challenges. Therefore the concept of “sharing” becomes important in the context of CSCL.
To collaborate effectively, group members need to commit themselves to group work, establish a shared common ground, negotiate, and share their task perceptions, strategies, and goals to coordinate their collaboration (Hadwin, Oshige, Gress, & Winne, 2010). In addition, group members can also enhance their commitment to collaborative learning. For example, if the students perceive the situation as challenging because of individual differences or a lack of commitment, they can use strategies that can strengthen their feeling of togetherness and commitment by employing motivational regulation strategies (Järvenoja, Volet, & Järvelä, 2010). However, if these motivational challenges remain unsolved, the students might not be able to work according to the task demands unless the socio-emotional balance is restored between the group members (Näykki, Järvelä, Kirschner, & Järvenoja 2014). Especially in the context of CSCL, the students might confront challenges that become social challenges. To regulate these social challenges effectively, the students need to realize the actual source of these challenges. That is, whether the source of the challenges is because of different goals (motivation), incompatible strategies or task perceptions (cognitive), or due to external constraints, such as time (time management), they need to activate appropriate SSRL strategies to overcome these challenges (Järvenoja & Järvelä, 2009). Ultimately, whether or not the SSRL strategy is appropriate depends on how groups can build on their previous experiences and extend their repertoire of regulatory strategies in their future collaboration.

Recently, Järvelä and Hadwin (2013) argued that it is possible to tailor and modify tools to support SSRL. In this case, the support is provided by offering, for example, structured tools that prompt students to negotiate and share their goals, plans, and strategies, along with the possibility of being able to reflect on whether the goals were achieved, whether the plans were adequate, and how effective the strategies were
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

(Järvelä et al., 2014). Research following this line has evidenced that it is possible to tailor tools to promote SSRL (Järvelä, Järvenoja, Malmberg, & Hadwin, 2013). However, the results obtained from these studies have indicated that there are differences in the depth and quality of socially shared goals, plans, and strategies that groups report using. For example, Järvelä et al., (2013) identified “deep-” and “routine-level” strategies used by groups in a CSCL context. The focus of deep-level strategies was to overcome task-related challenges, whereas the focus of routine-level strategies was related to time management and environmental regulation. It can be argued that groups who used routine level strategies did not progress in their SSRL, despite being provided with the appropriate tools.

1.2. Capturing the process of socially shared regulation of learning in the context of computer-supported collaborative learning

It has been argued that the way in which students engage in self-regulated learning (and SSRL) is affected by previous learning experiences, and that these experiences influence each other between and within tasks (Molenaar & Chiu, 2013). Thus, when the focus of the analysis is on the events that characterize the SSRL in the context of CSCL, these events are not independent (Cress & Hesse, 2013). Therefore, there is a need to explore how events during SSRL evolve over time.

Methodological and technological advances in the field of CSCL have made it possible to investigate temporal and sequential characteristics of varying learning activities over longer periods of time by utilizing process-oriented methods (Cress & Hesse, 2013; Puntambekar, 2013). Theories of self-regulated learning (e.g. Zimmerman & Schunk, 2011) propose a general time-ordered description of phases (e.g. planning, monitoring and control, and reflection) in which students engage when performing a
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

task. However, there is no strong evidence concerning whether and how the phases are hierarchically or linearly structured such that earlier phases must occur before later phases (Bannert, Reimann, & Sonnenberg, 2013; Zimmerman, 2013). In order to advance in the field of self- and socially shared regulation of learning there is a need to understand SRL or SSRL as a process rather than as a static disposition. Thus, understanding of the regulated learning process has “the potential to transform contemporary conceptions of SRL” (Azevedo, 2014, p. 217).

The focus of process analysis is on the timing (temporality) and order (sequences) of the activities that learners use during their collaboration. Temporality can reflect, for example, theory-based dimensions of self-regulated learning (planning, goal setting, strategic enactment, and reflecting) that students engage in during their learning (e.g., Johnson, Azevedo, & D’Mello, 2011). Temporality can also be defined statistically by taking advantage of breakpoints that occur during collaboration by using statistical discourse analysis (Molenaar & Chiu, 2014), or by locating typical patterns that occur at different points in time by using educational data mining (Malmberg, Järvenoja, & Järvelä, 2013). In the field of self-regulated learning, the use of these process-oriented methods has evidenced the differences in the degree and quality of self-regulatory processes used by high- and low-achieving students (e.g., Bannert, Reimann, & Sonnenberg, 2013). Similar results have been obtained in the SSRL field, but research evidence is scarce (Järvelä, Malmberg, & Koivuniemi, 2015). We still have only limited understanding of how students’ progress in SSRL during longer timeframes, and how this progress affects their learning outcomes.

Hitherto, only a few studies have used process-mining techniques in the field of the self-regulation of learning and SSRL (e.g. Bannert, Reimann, & Sonnenberg, 2013; Bouchet, Harley, Trevors, & Azevedo, 2014; Schoor & Bannert, 2012). Process-mining
techniques are typically used in the business context, for example, to reveal product-management processes based on the actual flow of information. In this context, the advantage of investigating process models may be to reveal gaps or “bottlenecks” in the information flow (e.g. Paszkiewicz, 2013). Similarly, process mining can be adopted when investigating the processes of the self- and socially shared regulation of learning (Bannert et al., 2013). As a methodological approach, process mining is similar to educational data parsing and data mining (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007). Data mining allows for the investigation of detailed information about learner activities, such as which activities learners use, and when exactly these activities are used. Data parsing illustrates the sequences of the mined activities (Nesbit, Zhou, Xu, & Winne, 2007). Similarly, the process-mining technique reveals the most dominant processes that learners (or groups of learners) engage in when learning. Recently, Schoor and Bannert (2013) used a process-mining technique to investigate whether there were differences in SSRL processes between high- and low-achieving dyads. In their analytical approach, they identified 17 categories that were SSRL markers. In particular, they investigated how these 17 categories were present in the process models of their students’ collaboration during 90-minute task executions. In their analysis, Schoor and Bannert (2013) used the fuzzy miner, which stresses the most important paths between events (in their analysis, SSRL events), while the less important paths are abstracted from a process model (Günther & Van Der Aals, 2007).

The key aspect in the investigation of process models is to identify markers that characterize successful learning. This means information on how successful groups progress in the task in comparison to less successful groups. Hitherto, there is not much research available considering SSRL as a process. Therefore, an analysis of extreme groups allows better understanding of the key features of the progress in SSRL (c.f.
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL
Bannert, Reimann & Sonnenberg, 2014). Our hypothesis was that challenge episodes invite students to regulate their learning and that the way in which groups engage in SSRL is affected by previous learning experiences. Following these guidelines, we investigated how SSRL evolves over time and across multiple learning situations.

1.3. Aims

This study aims to elucidate how collaborative groups progress in their socially shared regulation in the context of computer-supported collaborative learning. The research questions are: 1) How do the groups regulate the challenges they have identified?; 2) How do the groups progress in their socially shared regulation of learning in the context of computer-supported collaborative learning?; and 3) Is there any difference in the progress of SSRL between low- and high-performing groups?

2. Methods

2.1. Participants and context

The first-year teacher-education students (N = 103, mean age 24.2 years) participated in a multimedia learning course that lasted for two months. The course was compulsory for the students and it was rated as either a pass or fail. The course consisted of nine collaborative face-to-face learning sessions lasting for 90 minutes each and nine following collaborative online learning sessions lasting for one week in which the students worked collaboratively in 30 groups of 3–4 members. The students were free to form the collaborative groups themselves. This study focuses on investigating online collaborative learning sessions in a VCRI learning environment (see below).

2.2. VCRI learning environment
In each collaborative online learning session, the students used the Virtual Collaborative Research Institute (VCRI) environment (Janssen, Erkens, & Kirschner, 2011). In this study, the VCRI environment was tailored to promote SSRL (for a more detailed review, see Järvelä et al., 2014). Within the VCRI, we used already existing features (Radar and Chat) and tailored another (Co-writer) in order to create two new ones (OurPlanner and OurEvaluator) to promote awareness of individual SRL and group SSRL and externalization and prompting of SSRL. The development of OurPlanner and OurEvaluator was based on the original idea of Personal Planning Tool (PPT) by Hadwin, Miller and Webster (2012).

Awareness of SSRL was promoted with the Radar diagram. This provides an anonymous visualization of group members’ social, cognitive and motivational ratings, and in turn, supports awareness of where the group stands as a whole in terms of the need to regulate social, cognitive or motivational aspects of their collaboration.

Externalization and prompting of SSRL was promoted via OurPlanner and OurEvaluator. The purpose of OurPlanner was to prompt students to plan their collaboration, whereas the purpose of OurEvaluator was to prompt them to reflect on their collaboration. Both of these tools invite externalizing aspects of SSRL by prompting groups to explicate their 1) Task understanding (“Describe your current task, What is the purpose of the current task?”), 2) Goal setting (“What is your goal for this task?”), 3) Planning (“Describe what you need to do to achieve that goal”), 4) Challenge (“What is the main challenge facing you as a group?”) and 5) SSRL strategy (“What are you going to do as a group to overcome this challenge?”). OurEvaluator had the same questions, expect they were formulated in the past tense. This study focuses on the groups’ responses to OurEvaluator focusing on challenges (“What was the main challenge your group confronted during your collaboration”) and following SSRL strategy (“What did your group do to overcome that challenge?”)
2.3. Procedure

During the collaborative on-line learning sessions, the groups used the VCRI environment to complete their collaborative task assignment, which was to write none brief essays on different topics. The purpose of this assignment was to make pedagogically relevant plans for the use of technology when teaching, for example, history, arts, or science, such as “Create scenarios on how you could integrate technology in chemistry lessons” or “How to use digital stories in the domain of history”. Altogether, each group wrote nine essays. The online tasks were considered relevant for the students with regard to their future work as teachers, because they encouraged student teachers to think about advances in technology in their teaching. First, the students were asked to read the collaborative task assignment. Second, they were asked to jointly fill in OurPlanner while using a chat tool that guided collaborative learning. Third, the students were asked to write an essay by utilizing the platform existing in the VCRI environment for collaborative writing. Fourth, after the learning task, the students were asked to jointly reflect their plans and collaboration by filling in OurEvaluator. This procedure was replicated nine times.

During the last collaborative online learning session, the groups were asked to write a summary considering “Threads and possibilities of technology in teaching and learning.” The purpose of the final essay was to collect and summarize the core ideas that the students had developed in their previous essays. The length of the final essays varied between one to two pages. In addition, the groups were asked to present their essays to the whole class.

2.4. Data collection

*OurEvaluator* was used to identify the challenges and socially shared regulation strategies that the student groups reported using during the nine collaborative tasks. The specific question that asked for challenges in OurEvaluator was “What was the main
challenge your group confronted during your collaboration?” The specific question that asked for the SSRL strategies that had been used was “What did your group do to overcome that challenge?” Both questions were designed to be answered collectively. Altogether, 30 groups responded to OurEvaluator 270 times.

*Learning results* were measured from the final collaborative essay written in the VCRI environment during the last collaborative online session. The task reflected the groups’ learning from the whole course.

3. Analysis

3.1. Qualitative content analysis

*The students’ identified challenges and socially shared regulation strategies* were coded through qualitative content analysis (Miles & Huberman, 1994) from the students’ responses from OurEvaluator ($F = 270$). In the analysis, each response with respect to challenges ($F = 270$) and activated regulation strategies ($F = 270$) was read through carefully. Despite the question in OurEvaluator asking for the “main challenge” and consecutive regulation, the groups reported one to three challenges in their SSRL strategies. This resulted in 391 reported challenges and 383 reported strategies for the SSRL.

Based on the students’ responses, the first and third author created a coding scheme based on the data, theory and our earlier empirical conceptions of socially shared regulation of learning (Hadwin et al., 2011; Järvelä, et al., 2014). To ensure a unified understanding of the categories and of the contents of those categories, the raters developed two coding schemes, one for the category “challenges” and one for the category “socially shared regulation of learning.”

For the “challenges” category, six sub-categories were found: “no challenge,” “cognitive,” “motivational,” “time-management,” “environment and technology,” and
“social” challenges. For the SSRL category, five sub-categories were found: “no strategy,” “cognitive regulation,” “motivation regulation,” “time management,” and “environmental structuring.” The categories, sub-categories, frequencies, and examples of the reported challenges and SSRL strategies are presented in Table 1. The Cohen’s kappa of inter-rater reliability between the two raters was calculated for both categories and it varied between .75 and .83, which can be considered as good agreement (Fleiss, 1981).

Table 1

Analysis scheme used to analyze the challenges and socially shared regulation strategies

<table>
<thead>
<tr>
<th>Code</th>
<th>Recognized Challenge</th>
<th>Socially Shared Regulation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>No challenge</td>
<td>25 No challenges.</td>
<td>No strategy</td>
</tr>
<tr>
<td>Cognitive</td>
<td>118 The concept of treatment is not clear for us.</td>
<td>Cognitive Each member will distribute their knowledge.</td>
</tr>
<tr>
<td>Motivational</td>
<td>58 To maintain interest toward the task.</td>
<td>Motivation It is good that there are three of us! Together we’ll beat the obstacles!</td>
</tr>
<tr>
<td>Time management</td>
<td>77 We don’t have enough time.</td>
<td>Time management We have set up the time when to do this task.</td>
</tr>
<tr>
<td>Environment and technology</td>
<td>82 New learning environment and new ways of learning.</td>
<td>Environmental structuring We utilized the possibilities of the environment.</td>
</tr>
<tr>
<td>Social</td>
<td>31 Understanding each other’s ideas, communication.</td>
<td></td>
</tr>
</tbody>
</table>

The students’ learning performance was coded from the last essay they composed during the course (f = 30). The topic of the essay was “Threads and possibilities of technology in teaching and learning.” The essays were evaluated according to three categories: First, how well the students had identified and elaborated on the threads and possibilities of technology. Second, how well the students had identified and elaborated on
the possibilities of technology in teaching and learning. The third category considered the integration and use of core concepts presented during the lectures within their essays. Each of the three categories was rated between zero and three (see Table 2).

Table 2

*Coding of collaborative essays*

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No examples of the category are mentioned</td>
</tr>
<tr>
<td>1</td>
<td>One to two relevant themes according to the category have been identified. Themes are listed rather than elaborated on.</td>
</tr>
<tr>
<td>2</td>
<td>Two to four relevant themes according to the category have been identified. Only one to two themes are elaborated on.</td>
</tr>
<tr>
<td>3</td>
<td>Five or more relevant themes according to the category have been identified. Three to five themes are elaborated on along with concrete examples.</td>
</tr>
</tbody>
</table>

First, the classroom teacher rated and provided a coding scheme for the essays and rated them according to the coding scheme. Second, the first and second authors rated 56% of the essays. However, the first and second author rated only two categories, namely the threads and possibilities of technology in teaching and learning. This was because the classroom teacher had exact information in terms of the content of the lectures and their themes. Kendall’s tau-b was used to measure correlations between the scores from the classroom teacher and from the two independent coders. The Kendall’s tau correlation between the raters was .731 ($p = .00$). Finally, after the negotiation of the categories and the codings, the classroom teachers’ ratings were used as a final and reliable measurement for students’ learning performance since the teacher was the expert in the content knowledge.

Based on the final score of each of the three categories in the essays, the students were divided into three categories; high- ($n = 8$), low- ($n = 14$), and moderate- ($n = 8$) performing groups. The students point varied from zero to nine, $M = 4.1$. In the category of high-performing groups, the students scored six to nine points ($M = 7.1$, $Std = 1.1$). In the category of low-performing student groups, the students scored zero to three points ($M = 2.1$, $Std =$
Finally, in the category of moderate-performing groups, the students scored four to five points ($M = 4.6$, $Std = .5$). For further analysis, we explored how all of the groups progressed in their SSRL; thus, the contrast between how high- and low-performing groups progressed in their SSRL during the two-month course was also examined.

### 3.2. Composing a process model from the coded “challenge–socially shared regulation of learning” pairs

When groups work together over some weeks, there is a need to consider both time and the order of activities that are present, especially in the context of CSCL (Reimann, 2009). The current study used a process-mining technique, first to reveal the most typical “challenge–SSRL” pairs, and second to investigate the interconnections between these pairs by employing a process-mining technique.

During the first phase of the analysis, we identified all the possible “challenge–SSRL” pairs that the groups reported using during the collaborative activity. In other words, each challenge ($f = 391$) was matched with the concomitant SSRL strategy ($f = 383$). This resulted in 27 different types of “challenge–SSRL” pairs. Each of these pairs emerged from 1 to 78 times ($Md_n = 11.2$).

During the second phase of the analysis, we developed a primary coding scheme for the identified “challenge–SSRL” pairs to explore the focus and function of the SSRL (Table 3). Thus, developing the primary coding scheme enabled us to investigate how the collaborative groups progressed in their socially shared regulation of learning in the context of CSCL without aggregating the data resulting from the original coding scheme created in a previous phase of the analysis. We identified four general primary codes that reflect the focus and function of the SSRL in a given situation based on the data and theory (Zimmerman & Schunk, 2011): (a) **Regulating cognitive and motivational challenges** refers
to forms of the SSRL where group members seek to maintain strategic motivation towards task completion, and where they focus strategically on the cognitive aspects of task completion (e.g. motivational challenge: “The challenge for us was to stay sharp until the end of the task” → cognitive regulation: “We thought thoroughly about how to express our ideas clearly to each other”). (b) Regulating external challenges refers to SSRL forms that focus on regulating the external constraints of the learning task, such as environment and time (e.g. environmental challenge: “Our challenge has remained the same: To get used to collaborating on-line” → motivation regulation: ”We are enthusiastic and ready to give everything to succeed in this task!”). Regulation of these external constraints does not relate directly to task completion, but rather they play a facilitative role. (c) Regulating social challenges refers to forms of socially shared regulation that aim to reinforce and sustain a positive socio-emotional interaction between the group members (e.g. social challenge: “The biggest challenge for us was to agree with each other” → motivation regulation “We decided to make a compromise between the different views in order to come up with a solution that satisfied everyone”. (d) No regulation refers to student groups not realizing or being reluctant to express a focus for the SSRL (e.g. motivational challenge: “We had no motivation” → no regulation: “…”).

In Table 3, each of the “challenge–SSRL” pairs that emerge in four categories are presented. How the “challenge–SSRL” pairs represent the focus and function of the situated SSRL strategy is determined based on its focus, except in the category of “no regulation.” In that category, each pair that starts with “no challenge” or ends with “no strategy” is coded in the category of “no regulation.”
### Table 3

**Primary coding scheme for the identified “challenge–SSRL” pairs**

<table>
<thead>
<tr>
<th>Focus and function of the socially shared regulation of learning</th>
<th>Regulating cognitive and motivational challenges ($f = 8$)</th>
<th>Regulating external challenges ($f = 7$)</th>
<th>Regulating social challenges ($f = 4$)</th>
<th>No regulation ($f = 8$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive → Cognitive</td>
<td>Environment → Motivation</td>
<td>Social → Motivation</td>
<td>No Challenge → No Strategy</td>
<td></td>
</tr>
<tr>
<td>Motivational → Motivation</td>
<td>Time Management → Time Management</td>
<td>Social → Cognitive</td>
<td>Time Management → No Strategy</td>
<td></td>
</tr>
<tr>
<td>Cognitive → Motivation</td>
<td>Time Management → Motivation</td>
<td>Social → Environment</td>
<td>Motivational → No Strategy</td>
<td></td>
</tr>
<tr>
<td>Motivational → Cognitive</td>
<td>Environment → Environment</td>
<td>Social → Time Management</td>
<td>Environment → No Strategy</td>
<td></td>
</tr>
<tr>
<td>Cognitive → Time Management</td>
<td>Environment → Cognitive</td>
<td>No Challenge → Motivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivational → Environment</td>
<td>Time Management → Cognitive</td>
<td>Social → No Strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivational → Time Management</td>
<td>Time Management → Environment</td>
<td>No Challenge → Cognitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive → Environment</td>
<td>Cognitive</td>
<td>No Strategy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

During the third phase of the analysis, we investigated how collaborative groups progress in their socially shared regulation in computer-supported collaborative-learning tasks. This was done by investigating how the identified “challenge–SSRL” pairs were temporally connected by utilizing a process-mining technique. The advantage of the use of process mining is that it provides a visual description of all possible connections between the events by taking the order and temporality of the events into account. In this case, process mining was used to provide a visual description of the “challenge–SSRL” pairs and the interconnections between these pairs.

The premise of process mining is that a set of pairs can be related to one or more pairs, or in other words, a set of observed pairs constitutes an instance of a process (Reimann, 2009). Process mining uses three types of metrics, such as unary significance metrics, binary significance metrics, and binary correlation metrics (Günther & Van Der Aals, 2007). Unary
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

significance metrics allow for the removal of less significant interconnections that exist in a process. They are based on frequency significance and routing significance that allow for the separating out of important interconnections from those that are less important. Binary significance metrics influence the selection of edges, which will be included in the simplified process model. Lastly, binary correlation metrics measure the distance of events (for a more detailed description, see Günther & Van Der Aals, 2007).

When the process discovery is used in the educational context, it is possible to capture a holistic view of how groups progress in their socially shared regulation at various points in time. In the current study, Fluxicon’s Disco analysis software (https://fluxicon.com/disco/) was used to visualize and investigate the “challenge–SSRL” pairs by utilizing process-mining protocols. However, the results from obtaining each pair and each connection can provide complex rather than simple illustrations (Bannert et al., 2013). Therefore, we selected to investigate process models that were the most noticeable, resulting in our being able to visualize and investigate 20% of the possible pairs and their interconnections. This means that the interconnections of the pairs are rather abstract than absolute, yet showing the strongest tendency of interconnectivity. This study thus focuses on investigating how groups regulate the challenges that they have identified and how they progress in their socially shared regulation. A holistic picture that illustrates how all the collaborative groups are engaged in SSRL is initially provided. We also compare how the low- and high-performing groups are engaged in the SSRL. By contrasting the low- and high-performing groups’ targets and focus SSRL, we can understand how the groups progressed in their SSRL and can clarify the specific aspects in the SSRL that low-performing groups might lack.

4. Results

4.1. How do the groups regulate the challenges that they have identified?
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

In order to provide a holistic picture of how the 30 groups engaged in the SSRL, the types of “challenge–SSRL” pairs to emerge during the collaborative tasks in terms of their focus and function were examined. In Table 4, all of the “challenge–SSRL” pairs ($n = 6$), which are also presented in a process model that characterizes how the collaborating groups progress in their SSRL, are presented. In addition, descriptive information about how many groups used the specific “challenge–SSRL” pair, the mean and standard deviation of how many times the specific pair emerged in each groups’ collaboration is also presented.

Altogether, 134 pairs (relative frequency 36%) were targeted at regulating the cognitive and motivational aspects of the task execution, whereas 74 pairs (relative frequency 20%) focused on regulating the external aspects of the task execution. Thus, the most used “challenge–SSRL” pairs focused on regulating cognitive and motivational aspects of the collaboration in the context of CSCL.
Table 4

Collaborative groups' focus and function of socially shared regulation

<table>
<thead>
<tr>
<th>Focus and Function of SSRL</th>
<th>Absolute f</th>
<th>Relative f (%)</th>
<th>Group M(SD)</th>
<th>Group f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulating cognitive and motivational challenges</td>
<td>60</td>
<td>36%</td>
<td>4.27(2.42)</td>
<td>30/30</td>
</tr>
<tr>
<td>Cognitive → Cognitive</td>
<td>26</td>
<td>21%</td>
<td>2.4 (2.11)</td>
<td>26/30</td>
</tr>
<tr>
<td>Motivational → Motivation</td>
<td>17</td>
<td>9%</td>
<td>1.03(1.27)</td>
<td>17/30</td>
</tr>
<tr>
<td>Cognitive → Motivation</td>
<td>17</td>
<td>6%</td>
<td>.80 (.81)</td>
<td>17/30</td>
</tr>
<tr>
<td>Regulating external challenges</td>
<td>74</td>
<td>20%</td>
<td>2.22(2.17)</td>
<td>24/30</td>
</tr>
<tr>
<td>Environment → Motivation</td>
<td>31</td>
<td>8%</td>
<td>.97(1.13)</td>
<td>19/30</td>
</tr>
<tr>
<td>Time Management → Time Management</td>
<td>26</td>
<td>7%</td>
<td>.77(1.01)</td>
<td>14/30</td>
</tr>
<tr>
<td>Time Management → Cognitive</td>
<td>17</td>
<td>5%</td>
<td>.47(.68)</td>
<td>14/30</td>
</tr>
</tbody>
</table>

4.2. How do the groups progress in their socially shared regulation of computer-supported collaborative-learning tasks?

To identify how the groups progressed in their socially shared regulation across the collaborative tasks, the “challenge–SSRL” pairs were used to compose a process model illustrating the most typical interconnections between the focus and function of the SSRL over time.
Figure 1 presents a process model that covers 20% of the complete process model composed from the “challenge–SSRL” pairs. The illustrated process model is an abstracted model from the reality, showing the tendency of the interconnections from the beginning to the end of the six-week collaborative group work.

The frequency with which a certain pair occurs in the process model is presented in squares. The arrows indicate what type of “challenge–SSRL” pairs followed each other in the progressive online learning sessions. The frequency of the occurrence of the connections between the “challenge–SSRL” pairs is presented next to each arrow. The dotted arrows indicate how often a particular “challenge–SSRL” pair was the initiator or finisher pair in the data.
Figure 1. Progressive “challenge–socially shared regulation of learning” process model in the context of computer-supported collaborative learning

Figure 1 shows that the “challenge–SSRL” pair “time management–cognitive”, representing regulation of external challenges, was the first pair 17 times. Since this pair occurred in the data 17 times, it was always reported as an initiator of the process model. The process model presented in Figure 1 indicates that the focus and function of the SSRL were firstly to overcome external challenges, such as the environment, and secondly to regulate the motivational and cognitive aspects of the collaboration. Thirdly, the focus and function of socially shared regulation were related to regulating external constraints, such as time management, but also to maintaining motivation towards task completion. To summarize, the process model presented above illustrates how collaborative groups typically progress in their SSRL in terms of temporal variety of the focus and function of SSRL.

4.3. Difference in the focus and function of the socially shared regulation of learning between low- and high-performing groups

The final phase of the analysis focused on investigating differences between the low- and high-performing collaborating groups. Firstly, we explored how these two groups regulated the challenges that they identified, and secondly, how they progressed in their SSRL over time. The results show that these groups differed in respect to what the focus and function of the SSRL were and in terms of how they progressed in their regulation across the collaborative tasks.

In Table 5 we present descriptive information about the low performing collaborating groups involving to the process model and all of the “challenge–SSRL” pairs ($n = 7$) that these groups used during their collaboration. The same is also presented in a process model
that characterizes how the low-performing collaborating groups progressed in their SSRL.

Altogether, 45 pairs (relative frequency 34%) were targeted at regulating the cognitive and motivational aspects of the task execution, whereas 41 pairs (relative frequency 31%) focused on regulating the external aspects of the task execution. In addition, 13 pairs (relative frequency 13%) had no focus or function during the SSRL. To summarize, the focus and function of low-performing groups during the SSRL were related to managing the cognitive, motivational, and external aspects of the collaboration. However, a relatively large number of pairs had no focus and function during the SSRL. This might indicate that the collaborating groups might confront challenges that require more sophisticated strategies for the SSRL.

Table 5

<table>
<thead>
<tr>
<th>Focus and Function of SSRL</th>
<th>Absolute f</th>
<th>Relative f (%)</th>
<th>Group M(SD)</th>
<th>Group f</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulating cognitive and motivational challenges</strong></td>
<td>45</td>
<td>34%</td>
<td>2.21(3)</td>
<td>13/13</td>
</tr>
<tr>
<td>Cognitive→Cognitive</td>
<td>34</td>
<td>23%</td>
<td>2.54(2.5)</td>
<td>10/13</td>
</tr>
<tr>
<td>Motivational→Motivation</td>
<td>11</td>
<td>11%</td>
<td>.77(0.92)</td>
<td>7/13</td>
</tr>
<tr>
<td><strong>Regulating external challenges</strong></td>
<td>46</td>
<td>31%</td>
<td>3.19(2.51)</td>
<td>12/13</td>
</tr>
<tr>
<td>Time Management→Time Management</td>
<td>15</td>
<td>10%</td>
<td>1.23/(1.09)</td>
<td>10/13</td>
</tr>
<tr>
<td>Time Management→Motivation</td>
<td>12</td>
<td>8%</td>
<td>.85(1.28)</td>
<td>10/13</td>
</tr>
<tr>
<td>Environment→Motivation</td>
<td>10</td>
<td>7%</td>
<td>.62(.76)</td>
<td>7/13</td>
</tr>
<tr>
<td>Time management→Cognitive</td>
<td>9</td>
<td>6%</td>
<td>.5(1.67)</td>
<td>6/13</td>
</tr>
<tr>
<td><strong>No regulation</strong></td>
<td>13</td>
<td>9%</td>
<td>.92(.95)</td>
<td>9/13</td>
</tr>
<tr>
<td>No Challenge→No Strategy</td>
<td>13</td>
<td>9%</td>
<td>.92(.95)</td>
<td>9/13</td>
</tr>
</tbody>
</table>
The process model presented in Figure 2 illustrates the interconnections between the “challenge–SSRL” pairs during the course as reported by low-performing groups. The model indicates that the focus and function of the SSRL were firstly to overcome external challenges, and secondly to regulate the cognitive aspects of the collaboration. Thirdly, the focus and function of SSRL were related to external aspects of the task, but were also to maintain motivation towards task completion. Despite the fact that the focus and function of SSRL shifted from the beginning towards regulating cognitive aspects of the collaboration, situations arose in which the low-performing groups were reluctant or unable to recognize the challenges in their collaboration. This information would have been a stimulus, which could eventually have led to regulation of motivational aspects and external constraints of the task execution.
Figure 2. Low-performing groups’ progressive “challenge–socially shared regulation of learning” process model

Table 6 presents the focus and function of the SSRL that occur during the course with high-performing groups. In addition, descriptive information about the high performing collaborating groups involving to the process model is also presented. In Table 6, all of the “challenge–SSRL” pairs \((n = 5)\), which are also presented in a process model characterizing how the high-performing collaborating groups progressed in their SSRL, are presented.

Altogether, 43 pairs (relative frequency 39%) were targeted at regulating the cognitive and motivational aspects of the task execution, whereas 13 pairs (relative frequency 12%) focused on regulating the external aspects of the task execution. In addition, six pairs (relative frequency 5%) focused on regulating the social aspects of the collaboration. To conclude, the focus and function of high-performing groups during the SSRL were mostly related to managing the cognitive and motivational aspects of the task execution. These groups also regulated not only the external aspects of the task execution, but also the social aspects of the collaboration.

Table 6

The most used “challenge–SSRL” pairs with high-performing student groups

<table>
<thead>
<tr>
<th>Focus and Function of SSRL</th>
<th>Absolute f</th>
<th>Relative f (%)</th>
<th>Group M(SD)</th>
<th>Group f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulating cognitive and motivational challenges</td>
<td>45</td>
<td>34%</td>
<td>4.5(3.02)</td>
<td>8/8</td>
</tr>
<tr>
<td>Cognitive ➔ Cognitive</td>
<td>25</td>
<td>22%</td>
<td>2(1.6)</td>
<td>7/8</td>
</tr>
<tr>
<td>Motivational ➔ Motivation</td>
<td>11</td>
<td>10%</td>
<td>1.5(1.69)</td>
<td>5/8</td>
</tr>
</tbody>
</table>
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

<table>
<thead>
<tr>
<th>Cognitive → Motivation</th>
<th>8</th>
<th>7%</th>
<th>1(.75)</th>
<th>6/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulating external challenges</td>
<td>46</td>
<td>31%</td>
<td>1.38(1.76)</td>
<td>4/8</td>
</tr>
<tr>
<td>Environment → Motivation</td>
<td>13</td>
<td>12%</td>
<td>1.38(1.76)</td>
<td>4/8</td>
</tr>
<tr>
<td>Regulating social challenges</td>
<td>6</td>
<td>5%</td>
<td>.75(.70)</td>
<td>5/8</td>
</tr>
<tr>
<td>Social → Cognitive</td>
<td>6</td>
<td>5%</td>
<td>.75(.70)</td>
<td>5/8</td>
</tr>
</tbody>
</table>

The process model presented in Figure 3 illustrates the interconnections between the five “challenge–SSRL” pairs during the course, as reported by the high-performing groups.

The model indicates that firstly, the focus and function of the SSRL were to overcome external challenges and to regulate the cognitive aspects of the collaboration. However, in the subsequent collaborative tasks, the focus shifted from regulating the cognitive aspects while recognizing the need to regulate the social aspects of the collaboration. In addition, the focus and function of the SSRL were also to maintain motivation towards task execution.

In sum, the high-performing student groups mainly focused their SSRL on the cognitive and motivational aspects of collaboration, but they also recognized the social challenges.
Figure 3. High-performing groups’ progressive “challenge–socially shared regulation of learning” process model

4.4. Summary of the findings

To summarize the findings, Figure 4 contrasts the focus and function of the SSRL between the low- and high-performing groups. Figure 4 illustrates the percentages with which a certain “challenge–SSRL” pair occurs with both of these groups. In the x axis is presented the focus and function of SSRL pairs whereas in the y axis presents the distribution of these pairs in percentages. Initially, the focus and function of the SSRL were related to the
cognitive aspects of the task execution (69%) with the high performing groups but the low-performing groups focused their regulation more often on external challenges (45%). The difference between the focus and function of the SSRL between these two groups is that the high-performing groups engaged in the SSRL throughout the tasks mostly focusing on regulating cognitive (69%), external (21%) and finally social challenges (10%), whereas the low-performing student groups did not. The low performing groups mostly focused on regulating external (45%), cognitive (43%) and no challenges (12%) during their collaboration.

Figure 4. Contrasting the focus and function of the SSRL between the low- and high-performing groups

In all, the results show that the focus and function of the SSRL were different across the collaborative tasks between the low- and high-performing groups. The composed process
models indicate that high performing groups progressed in their SSRL from the very beginning of their collaboration. At the beginning of the collaborative task, they managed to adapt their SSRL to regulate external challenges. In the later phases, the focus of SSRL varied between regulating cognitive, motivational and social challenges. In other words, there was temporal variety in challenges and SSRL strategies. However, the progress of SSRL is not clear among the low performing groups. In other words, they did not manage to regulate external challenges until later phases of their collaboration. Thus, they reported repeatedly the same types of challenges (e.g. environment, time management), indicating that they did not progress in their SSRL. Finally, the comparison of high – and low performing groups’ focus and function of SSRL indicate that these groups identified different challenges in their collaboration. The high performing groups mostly focused on regulating cognitive challenges whereas the low performing groups mostly focused on regulating external challenges. The high performing groups mostly focused on regulating cognitive challenges whereas the low performing groups mostly focused on regulating external challenges.

With respect to SSRL strategies, the results indicate that regardless of the challenge, socially shared regulation of motivation preceded recognition of cognitive challenge with both, high- and low-performing groups. Thus, socially shared regulation of motivation allowed groups to progress in their SSRL.

5. Discussion and Conclusion

The results indicate that despite challenges emerging due to the technology use or time-management problems, the groups were able to recognize these challenges and strategically regulate the cognitive and motivational aspects of the collaborative task execution. However, it was apparent that the focus and function of the SSRL were slightly different between the low- and high-performing groups. Mostly, the high-performing groups
progressed in their SSRL in terms of evidencing temporal variety in challenges and SSRL strategies across time, which was not the case with the low performing groups.

Our results support the earlier findings by Rogat and Linnenbrink-Garcia (2011) showing that a great deal of reported socially shared regulation is focused on superficial aspects of collaboration, such as environmental structuring and time management, especially during the early stages of collaboration. In addition, earlier findings by Järvelä et al., (2013) indicated that especially low-performing groups tended to report more “routine-level” strategies focusing on environmental structuring and time management, which was also the case in this study. It appears that either the low performing groups failed in their coordination of collaborative group work (e.g. time management) or they suffered from the lack of physical presence, resulting in confronting challenges due to the environment. This could be due to the fact that group members do not perceive and process properly other group members’ participation and social presence in the CSCL environment, an issue which has received much attention in the field of CSCL research (cf. Janssen & Bodemer, 2013). In addition, the term “mutual trust” is also used to describe the affective structure of the collaborating group. This line of research argues that at least some degree of mutual trust must exist before a group can progress in collaborative learning (Fransen, Kirschner, & Erkens, 2011). However, in this study both high- and low-performing groups were able to overcome challenges related to their environment, eventually by committing to socially shared motivation regulation. Similarly, Järvelä, Malmberg and Koivuniemi (2015) also found that in the context of CSCL, shared regulation of motivation afforded further opportunities to engage in cognitive regulation towards task execution. This finding adds a complementary view for collaborative learning research, indicating the importance of socially shared motivation regulation, especially in the early stages, as one condition required to guarantee successful collaboration.
A distinguishing feature between the high- and low-performing groups’ focus and function of the SSRL over time was that the high-performing groups recognized the social challenges as their collaboration progressed in time. Similarly, Järvelä, Järvenoja, and Veermans (2008) found that groups that recognized social challenges during their collaboration held more learning goals, which is favorable for learning performance (Lodewyk, Winne, & Jamieson-noel, 2009). Earlier studies in the field of collaborative learning have also indicated that positive interactions and feelings of trust can facilitate the cognitive and task-related aspects of collaboration (Kreijns, Kirschner, & Jochems, 2003). The results of our study show that recognizing the importance of the social aspects of collaboration and the successful regulation of these challenges were favorable for learning performance. To summarize, rather than focusing on external challenges such as the environment and time management, high-performing groups focused on regulating mainly the cognitive, motivational, and social aspects of their collaboration, which was not the case with the low-performing student groups.

The low-performing student groups mostly focused on activating superficial strategies for their SSRL. In addition, in many cases, they did not activate the SSRL at all. This is to say, this process was maladaptive to the learning situation (Boekaerts, 2011). It could be argued that perhaps it is somehow easier in the context of CSCL to point out challenges that focus on time management and the environment rather than recognizing the social challenges that might elicit negative forms of interaction among the group members.

With regard to the theoretical implications, the framework adapted from the field of self-regulation in learning and SSRL (Hadwin, Järvelä, & Miller, 2011; Zimmerman & Schunk, 2011) was applicable and suitable for the analysis in terms of revealing the focus and function of SSRL over time. Recently, Hadwin, Järvelä, and Miller (2011) advanced a theoretical framework of the self- and shared regulation of learning by advocating that
challenging learning situations create opportunities for targeted regulation. This is to say, challenges realized in a learning situation invite learners to contextualize their regulation strategies (Järvelä et al., 2013). Taking account of not only the focus and function of SSRL, but also of how SSRL evolved from situation to situation, enabled understanding of the congruence and dissimilarity between the SSRL of the high–and low-performing groups. Thus the results shed light on how SSRL is affected by previous learning experiences, and how these influence each other across tasks (Winne & Hadwin, 1998).

The main finding of this study is that in order to progress in socially shared regulation the group members need to adapt their SSRL to past learning experiences in a social contexts. That is, similarly to when students learn self-regulated learning skills (Winne & Hadwin, 1998), socially shared regulation of learning also needs to be adaptive based on past learning experiences. This becomes evident in terms of temporal variety in the focus and function of SSRL over time. If there is no temporal variety, the collaborating groups hardly progress in their SSRL. Here, too, more research is needed to provide evidence of whether or when a certain type of challenge is anticipated and what type of SSRL is needed to ensure successful collaboration. An important theoretical and methodological implication from this finding is that CSCL research needs to pay particular attention to the temporal aspects of the varying targets of SSRL.

To elucidate how student groups progress in their SSRL, the study took advantage of process-mining techniques and commercial software (https://fluxicon.com/disco/) to visualize the focus and function of the SSRL across the collaborative tasks. Currently, there has been a shift towards developing various process-oriented methods to better capture what is actually going on in a learning situation in the field of self-regulation and SSRL (e.g., Bannert, Reimann, & Sonnenberg, 2014; Järvelä, Malmberg, & Koivuniemi, 2015; Kapur, Voiklis, & Kinzer, 2008). Despite the lack of standard rules or metrics when examining the process of
regulated learning, research has repeatedly evidenced that successful and less successful students differ from each other with respect to their focus and function during regulated learning (Bannert, Reimann, & Sonnenberg, 2014; Järvelä, Malmberg, & Koivuniemi, 2015), and particularly when exactly these regulatory processes are used (Johnson, Azevedo, & D’Mello, 2011).

Bannert, Reimann, and Sonnenberg (2014) pointed out that process-mining techniques, such as process discovery, are a “tool for model and theory development rather than statistical testing.” This is mostly because by depending on the analytical framework, the result of the process mining can be too detailed and difficult to interpret. Therefore, rather than obtaining each event that signals regulated learning, there is a need to identify critical instances of what makes regulated learning successful based on the theory (e.g., Malmberg, Järvenoja, & Järvelä, 2013; Winne, 2014). Therefore, there is a need to be cautious when interpreting the results and drawing conclusions.

Currently, a number of researchers have applied process-oriented methods in the field of self-regulation and SSRL along with careful recommendations. First, if we aim to understand the self- and shared regulation of learning, we need to carefully define and specify the focus of what is being regulated (Azevedo, Johnson, Chauncey, & Burkett, 2010). Second, there is a need to aggregate the data to provide information about changes in the regulatory activities in order to identify adaptive and maladaptive forms of regulated learning (Järvelä, Malmberg, & Koivuniemi, 2015). For example, in the context of educational data mining, when learners perform a certain activity repeatedly (e.g. read a page), the obtained patterns may differ from each other in the number of repetitions of the pattern (Kinnebrew, Loretz, & Biswas, 2013). However, this does not clarify anything about the qualitative shifts or changes in terms of the activities, which might be more interesting.
SOCIALLY SHARED REGULATION OF LEARNING IN CSCL

With regard to practical implications, the findings illustrate how collaborative groups engage in SSRL in the context of CSCL. The findings could be used as an informative example when designing instructional technology (e.g. prompts or scripts) for group use in the CSCL context. For example, the process model indicates that student groups do tackle the external challenges during the early stages of their collaboration, and that groups need additional support for regulating social challenges during their collaboration. Recently, Kreijns, Kirschner, and Vermeulen (2013) argued that social interaction is the most severe barrier to collaboration perceived by online groups. This interaction needs to be stimulated, for example, by providing scripts (Morris et al., 2009). In practice, when designing scripts for CSCL instructions, instructional designers could benefit from process analyses, similar to those conducted in this study, to reveal what types of prompts or scripts could benefit individuals or groups of learners the most. Especially when designing massive open online courses (MOOCs), it would be important to recognize how to guarantee effective learning, since dropout rates are substantially higher in MOOCs when compared to traditional education (Clow, 2013).

Finally, our findings indicate an issue that needs to be investigated more extensively. The current study focused only on the focus and function of SSRL in various situations. This means that we are limited in terms of providing evidence for the quality and depth of the SSRL. Consequently, it will be important in the future to examine what the groups report doing as opposed to what they actually do. In addition, these issues mentioned above also shed some light on the limitations of our study. The analysis of socially shared regulation of learning was based on the students’ reported socially shared regulation of learning processes, not on what they actually did. For example, a study conducted by Miller et al., 2014 indicated that not all the group members engage to socially shared regulation of learning equally. This is to say, we are still limited in our understanding of how multiple individuals construct the
target for SSRL in a given situation, as earlier studies have also indicated (Rogat & Linnenbrink-Garcia, 2011; Miller et al., 2014).

References


SOCIALLY SHARED REGULATION OF LEARNING IN CSCL


SOCIALLY SHARED REGULATION OF LEARNING IN CSCL


SOCiALLY SHARED REGULATION OF LEARNING IN CSCL


SOCIALLY SHARED REGULATION OF LEARNING IN CSCL


SOCIALLY SHARED REGULATION OF LEARNING IN CSCL


