Assessing Prerequisites and Processes of Self-, Co- and Shared Regulation During Collaborative Learning

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Abstract: To conceptualize regulation processes that may occur within groups, a differentiation between self-regulation (i.e., individual members regulate their own learning during collaboration), co-regulation (i.e., single learners regulate the learning of one or more of their learning partners), and shared regulation (i.e., the whole group regulates its learning) has been proposed. This symposium assembles four papers that offer various ways regarding the measurement of prerequisites and processes of such regulatory efforts during group learning. The presented methods range from Likert-scale self-report questionnaires over video case vignettes towards an analysis of real group processes by aid of logfiles and discourse coding schemes. These methods will be critically discussed, especially in terms of their transferability to studying collaborative learning in diverse educational contexts, both formal and informal. That way, the symposium will significantly expand previous methods for the assessment of self-, co- and shared regulation during collaborative learning.

The importance of regulation processes during collaborative learning

Collaborative learning is often described as an ideal context for individuals to engage in high-level cognitive processes that are closely related to knowledge acquisition. Examples for such high-level cognitive processes are asking and reacting to thought-provoking questions (King, 2007) or exchanging arguments and counterarguments with learning partners (Vogel et al., 2016). Activities like these occur almost naturally once students learn together. Not surprisingly, positive effects of collaborative learning on knowledge acquisition have been reported (Springer, Stanne & Donovan, 1999). However, research has also shown that learning in groups is not always superior to learning individually. For example, in a study by Weinberger, Stegmann and Fischer (2010), students were asked to analyze three problem cases by aid of a psychological theory. While some students worked individually on this task, others collaborated in groups of three. Results showed that – at least when groups were not appropriately scaffolded – students who had learned individually outperformed students who had learned in triads on a subsequent domain-specific knowledge test. As possible reasons for such suboptimal effects of collaborative learning, both motivational (e.g., social loafing effects; Karau & Williams, 1993) as well as (meta-)cognitive issues (e.g., a lack of cognitive and metacognitive learning strategies; Wang, Kollar & Stegmann, 2017) have been discussed. Thus, to make collaborative learning a successful endeavor, groups need to be able to effectively regulate such problematic processes.

Self-, co-, and shared regulation: Three levels of regulating collaborative learning

To conceptualize regulation processes within groups, Järvelä and her colleagues (e.g., Järvelä & Hadwin, 2013; Järvenoja, Järvelä, & Malmberg, 2015) suggested a theoretical model that distinguishes regulation processes at three social levels: First, at the "self"-level, individual group members may regulate their own learning, e.g., by setting goals for what they would like to learn by collaborating with their partners or by mentally monitoring their understanding of the subject matter during collaboration. Second, at the "co"-level, an individual group member may regulate the learning of one or more of her learning partners, e.g. by asking probing questions or by telling them what content to repeat for the following collaborative learning session. Third, "shared regulation" happens when the whole group more or less deliberately engages in regulation processes, e.g. by jointly discussing what content to learn and in what order or by setting up time plans for the whole group.

Goals and structure of the symposium

Whereas theoretical models on self-regulated learning are well established and validated by an abundance of empirical studies over the past decades, theorizing social forms of regulation has only recently gained momentum (Panadero & Järvelä, 2015). Previous studies in this respect are mainly focused on conceptually differentiating individual versus social forms of regulation and at identifying the latter in collaborative learners' (online) discussions. Empirically validating the theoretical constructs of self-, co- and shared regulation, however, unraveled methodological questions on how to assess social forms of regulation in an objective, reliable, valid, and economic way. Optimizing collaborative learners' regulation behavior furthermore demands for correlational studies unraveling facilitative conditions towards students' adoption of self-, co- and shared regulation. The symposium makes an important contribution to both aspects. First, it provides insights into the effects that different kinds of prerequisites have on the employment and selection of different strategies for self-, co- and shared regulation. In this realm, the paper by Williams, Seufert and Weinberger specifically looks at prerequisites *on the learners' side* (i.e., their competence to co-regulate learning processes) and reports on the development of a self-report questionnaire to measure learners' co-regulation competence. They also provide information on the validity of the instrument: co-regulation competence as assessed by aid of their CRCQ demonstrated to be predictive for achievement as well as learners' goal orientations. The paper by Melzner, Greisel, Kollar and Dresel investigates the effects of different characteristics of the *situation* (i.e., whether the group currently exhibits motivational or cognitive problems) on how individuals intend to engage in self-, co- and shared regulation processes during collaborative learning. Their results show that groups seem to react differently to different regulation problems, and that – at least when it comes to exam preparation – students put more emphasis on regulating their own learning than the learning of other group members or of the group as a whole. Second, the symposium offers insights into the methodological challenges and requirements when studying social forms of regulation, given that the different papers make use of different assessment methods, allowing for a critical methodological discussion. In this respect, the paper by Kielstra and Molenaar describes the development of an app that provides learners both with guidance on how to engage in task-oriented reading in individual and collaborative learning settings and with an automated way of measuring students' use of task-oriented reading strategies, based on logfile data. First results indicate that groups can successfully be scaffolded with the app, and that the app holds large promise for an in-depth assessment of regulation processes at the individual and the social level. The paper by De Backer, Van Keer and Valcke provides an in-depth look into time-bound evolutions in students' regulation behavior as well as in the quality (instead of only the kinds) of collaborative learners' regulation strategies. The results demonstrated that collaborative learning particularly evokes co-regulation but that truly sharing regulation is rather challenging for students. They need time and practice before they demonstrate sharing regulation. Findings further revealed qualitatively different types of shared regulation. Overall, all four papers offer valuable contributions especially regarding the question how to assess and manipulate (individual and situational) prerequisites and/or processes of self-, co- and shared regulation within groups. The availability of such assessment methods is of utter importance for the investigation of further research questions on self-, co- and shared regulation, especially regarding the effectiveness of self-, co- and shared regulation for successful collaborative learning and the question how to scaffold these social forms of regulation. Furthermore, the results of the four papers will spark further theoretical discussions and enable elaborating and refining current theoretical models on self-, co-, and shared regulation. From this perspective, the papers imply an important step forward in the emerging literature on self-, co-, and shared regulation. The papers will be critically discussed by Raija Hämäläinen, specifically also with regard to the limitations of the proposed instruments.

Are we closer? Measuring co-regulation competencies in collaborative learning environments

Christopher Williams, Tina Seufert, and Armin Weinberger

Regulation research has seen a shift of focus from an individual perspective of self-regulated learning (SRL) to more emphasis on social modes of regulation (Panadero, Kirschner, Järvelä, Malmberg & Järvenoja., 2015). In the literature, the two social modes of regulation often discussed are co-regulation and socially shared regulation. Hadwin, Järvelä and Miller (2011) claimed co-regulation is the temporary coordination of self-regulation amongst self and others" (p. 68). With the increased importance of investigating social modes of regulation like co-regulation, the question of how to properly measure this phenomenon also follows.

There are several self-evaluated learning strategies assessments, like Pintrich's (1991) *Motivated Strategies for Learning Questionnaire* (MSLQ), but there have been few attempts to measure co-regulation with questionnaires. Schoor, Narciss and Koerndle (2015) argued that even though researchers possess an in-depth understanding of methods to investigate self-regulation, co-regulation is a separate phenomenon and requires suitable method consideration. In our studies, the *Co-Regulation Competencies Questionnaire* (CRCQ) was developed and tested. The development of CRCQ aims to complement other qualitative methods. Moreover, the development of our multi-dimensional framework for coding co-regulation manifestations provides a specific approach to evaluate co-regulation.

Our research questions were: (1) Are we able to reliably measure co-regulation competencies and its sub-facets using a questionnaire? (2) Are co-regulation competencies measured with the CRCQ related to learning performance in a collaborative learning task? (3) Can the CRCQ be validated by qualitative measures of the learning process?

To answer our research questions, we conducted two studies. In the first descriptive study, the CRCQ was developed and analyzed with respect to the reliability of its subscales (N=212). Based on these results, we conducted a second study where 34 participants learned in a collaborative group setting. Their task was to understand biochemical concepts by integrating multiple representations learning materials that were distributed amongst the learners. The learning process required shared knowledge construction and hence, co-regulation. With this sample, we addressed the second research question and relate learners' co-regulation competencies – measured with the CRCQ – to their individual learning outcomes after the group learning process. Additionally, to answer the third research question, we analyzed group discourse by using our coding scheme to categorize actual co-regulation manifestations (up to now with N=9).

In the first study, the participants (N=212) were between 18 and 74 years old (M=35.88, SD=10.89). The CRCQ contains 84 items and aims to measure the learners' co-regulatory competencies by asking learners to assess the *sharedness* of their strategies: cognitive (e.g. rehearsal, organization, elaboration, critical thinking, collective efficacy), metacognitive (e.g. planning, monitoring, goal setting), and motivation (e.g. intrinsic/extrinsic motivation, task value, control beliefs). Participants rated statements, which assessed their learning strategies, by asking to what extent do they share their strategies either at all (e.g. self-regulation), with either one group member (e.g. co-regulation) and /or with the whole group (e.g. socially shared regulation). An example of a CRCQ survey statement assessing motivation strategies was "My expectations that we will do well with our group work". The study revealed, that 15 out of 17 CRCQ scales had an α > .72, which made us confident to use the questionnaire further on with slight amendments.

In the second study, participants (N=34) were between 20 and 43 years old (M=27.56, SD=6.00). A week before the learning activity, they completed several online questionnaires including the CRCQ and MSLQ. Before the learning activity, participants completed the CRCQ, and a biochemistry pre-test. In the learning phase, participants were presented with six different inter-linked representations in the domain of biochemistry. Each representation contributed vital information to understand the whole subject matter. After the learning activity, the participants completed a biochemistry post-test. Participants were encouraged to think aloud during the learning phase. They were also recorded and an observation protocol was implemented.

To answer RQ2, a regression analysis was applied for the biochemistry post-test (e.g. *performance*) as dependent variables with the following predictors: cognitive, motivational, and metacognitive competencies from the CRCQ and MSLQ. The regression model for co-regulation motivational competencies was significant (F(6, 27)=2.74, p=.05, adjusted R^2=.24). Co-regulation intrinsic goal orientation (β=.53, t(13)=2.82, p=.01) and co-regulation control belief (β=.62, t(13)=-2.05, p=.05) were significant predictors of performance. The cognitive and metacognitive predictors showed no significant influence on learning outcomes.

To answer RQ3, we coded up to now two groups based on our multi-dimensional framework for coding co-regulation. Participants (N = 9) were between 22 and 33 years old (M = 25.2, SD = 3.38), and were categorized as either 1) high (N = 3) or 2) low co-regulators (N = 6) based on a median split for their CRCQ score. The raters were trained (Vogel & Weinberger, in press) and obtained a significantly high level of agreement with a Kappa of above .95. The individual learner's co-regulation competency score was calculated by combining the raters' scores for each of the learners based on the 4 subcategories of the COPES model: operations, product, standards, and evaluation (Hadwin, Järvelä & Miller, 2011). The individual learner's total score was divided by the total maximum point available. The individual co-regulation score ranges from 0% (e.g. self-regulation) to 100% (e.g. socially shared regulation). A median split was conducted to create an independent categorical variable identified as *co-regulation score*. The dependent variables were (a) biochemistry post-test performance and the (b) co-regulation score. Concerning (a) the biochemistry post-test performance, we found differences between high and low-regulators (high: M = 9.75, SE = 1.75; low: M = 10.38, SE = 1.42). Regarding (b) the co-regulation score, we discovered no effect for metacognitive or cognitive learning strategies (metacognitive high: *M* = 30.89, *SE* = 24.19; low: *M* = 19.78, *SE* = 17.52; cognitive high: *M* = 28.92, *SE* = 6.05; low: *M* = 22.54, *SE* = 7.56), but we did find a meaningful difference for extrinsic goal orientation (high: *M* = 11.60, *SE* = 10.54; low: *M* = 27.37, *SE* = 6.17).

Considering the first research question, the CRCQ and sub-facets' alpha scores displayed a positive sign that the questionnaire has potential to reliably measure co-regulation competencies. The sharedness of one's motivations showed a positive effect on the learners' performance. Similar to the CRCQ initial study, the high inter-rater reliability with our multi-dimensional framework for coding co-regulation is another encouraging sign for future research and fairly validates the initial CRCQ results. Furthermore, the effects of high co-regulators on their external goal orientation is evidence that sharing one's motivations can have positive influences on performance but also is potentially a defining characteristic of high co-regulators.

How different regulation problems influence self-, co-, and shared regulation in student groups

Nadine Melzner, Martin Greisel, Ingo Kollar, and Markus Dresel

Research revealed that learning collaboratively may positively impact knowledge acquisition (Kyndt, Raes, Lismont, Timmers, Cascallar & Dochy, 2013). Therefore, it is not surprising that students often meet in groups voluntarily, for example when comes to preparing for important exams. Nevertheless, research has shown that groups often struggle during collaboration, especially when they experience motivational (e.g., a low interest in the learning material) and/or knowledge-related problems (e.g., little understanding of the subject matter at hand). To effectively regulate their learning when being faced with such problems, groups need to select and employ effective regulation strategies. Yet, an open question is how an adaptive choice of strategies would look like with respect to the social level on which these strategies operate. In this respect, Järvelä and Hadwin (2013) suggested to differentiate between strategies at (a) the self-level, at which group members regulate their own learning, (b) the co-level, at which they regulate the learning of other group members, and (c) the shared level, at which they jointly negotiate regulation processes within the group. In other words, it is unclear at what social level(s) groups mainly regulate motivational and knowledge-related problems that pop up during collaboration. By using a video-vignette paradigm together with open-ended questionnaires, this study therefore aims to elucidate the effects of present vs. absent motivational and/or knowledge problems in student groups (1) on the extent to which (individuals within) groups apply cognitive learning strategies and (2) on the extent at which they show these learning strategies at different social levels (self-, co-, and shared level).

Subjects were N=197 university students (M_{Age}=22.14, SD_{Age}=4.33) from educational science and from a pre-service teacher education program. On average, participants were in their 2nd semester of studies (M_{Study}=2.27, SD_{Study}=1.72). They watched four videos that presented groups preparing for an upcoming exam. Videos were shot from a first-person view perspective to increase the level of participants' immersion. Across the four videos, we varied the presence vs. absence of the two problem types (motivational and knowledge problems). Presentation sequence of the videos was randomized and balanced. After each video, participants were asked to write down what they would do in each situation to guarantee a high-quality learning process (separately for the self-, co-, and shared level). To that end, an open-answer format was used. First, all student answers were segmented into single idea units. Reliability of segmentation as the relative portion of two independent coders' overlapping sequences (Strijbos, Martens, Prins, & Jochems, 2006) was sufficient (82.2% vs. 85.1%, calculated from both coders' perspectives). Next, we coded the social level at which the mentioned strategy operated (Cohen' s κ = .78). After that, we applied a self-developed coding scheme to capture the kinds of strategies participants mentioned (six categories; Cohen's κ = .87). For the purpose of this paper, we only focus on cognitive strategies such as elaborating or organizing the learning material.

To answer our research questions, we ran a 2x2x3-factorial ANOVA with the within-subject factors 'motivational problems', 'knowledge problems', and 'social level' and the frequency of cognitive strategies as dependent variable. Regarding RQ1, we found a significant main effect for 'knowledge problems', $F(1,196)$ = 30.451, p < .01, η^2 = .134, and for 'motivational problems', $F(1,196)$ = 62.813, p < .01, η^2 = .243: With both problem types being present in the group, participants mentioned less cognitive learning strategies than when these problems were not present. The interaction between knowledge problems and motivational problems was not significant ($F(2,392)$ = 0.034, *n.s.*). Concerning RQ2, we found a significant main effect for 'social level', $F(2,392)$ = 21.851, p < .01, η^2 = .100. Bonferroni-corrected post-hoc comparisons revealed that participants mentioned significantly more strategies at the self- than at the co- and shared level (p = .00). The difference between strategy use at the co- and at the shared level was not significant (p = .42).

The results seem to indicate that once students experience any kind of problem (be it motivational or be it knowledge-related), they react with a reduction of their use of cognitive learning strategies. With motivational problems being present, a reason for this might be that the application of such strategies itself is dependent on students' motivation (as suggested for example by Boekaerts, 1997). Watching an unmotivated group and imagining being a member of that group might reduce one's own motivation as well and that way cause a lower use of cognitive learning strategies. In turn, when knowledge problems occur, students may switch the kinds of strategies they are currently using in the direction of applying more metacognitive strategies, in order to search for reasons for the current problems and to update the plans for the subsequent learning phase. Further analyses are necessary to test this assumption. Interestingly, at least when it comes to exam preparation, students seem to be mostly concerned with regulating their own learning (rather than the learning of other group members or the group as a whole). This may be specific to the particular situation we chose: Since exams typically are taken individually, students might regard a possible engagement in social regulation processes as an unnecessary burden. At least, students do not seem to expect to get a lot out of an engagement in such processes. This is unfortunate, given that prior research has particularly underscored the importance of socially shared regulation to promote individual learning outcomes (Järvelä, Volet, & Järvenoja, 2010). Future research should investigate to what extent these results can be transferred to other, possibly less externally-regulated learning situations.

An app to measure self- and shared regulation during task-oriented reading

Jolique Kielstra and Inge Molenaar

Task-oriented reading involves reading with the purpose of processing information for the execution of a specific task (Anmarkrud, McCrudden, Bråten, & Strømsø, 2013). Research shows that task-oriented reading is influenced by how students apply reading strategies (Vidal-Abarca, Mañá, & Gil, 2010). For example, Rouet, Vidal-Abarca, Erboul, and Millogo (2001) show that application of reading strategies during task execution explains differences in students' reading comprehension. Although this provides evidence for the importance of reading strategies during task-oriented reading, it does not inform us how students regulate during task-oriented reading. A number of elements are put forward as important. Prior to reading, a task can act to signal relevance, allowing readers to understand which sections of the text are relevant for a task (Anmarkrud et al., 2013). Thus, task representations play an important role in strategy application as they allow students to select a reading strategy that supports successful task accomplishment (Rouet, Britt & Durik, 2017). Also, proficient readers tend to use reading strategies more frequently compared to less proficient readers and also use more diverse strategies (De Milliano, van Gelderen & Sleegers, 2016). The above indicates the need for a more profound understanding of how less proficient readers regulate their task-oriented reading. Moreover, this group seems to need additional regulation support. We hypothesize that reciprocal peer tutoring can improve collaboration, students' understanding of a task and the usage of appropriate reading strategies (De Backer, van Keer, Moerkerke & Valcke, 2016) and that it can enhance less proficient readers' regulation of task-oriented reading.

To examine this hypothesis, we first need to develop a measurement instrument to assess how students regulate their task-oriented reading both in individual and collaborative settings. We performed a literature research to examine current methods to measure students' regulation of task-oriented reading. Current methods focus on task performance and strategy execution (Vidal-Abarca, Mañá, & Gil, 2010). As discussed above, we expect that a student's regulation is dependent on the students' task representation, their ability to select an appropriate strategy and to reflect on their strategy use. Therefore, we included these elements in a newly developed scaffolding and measurement app. Moreover, the app also has to be used to measure shared regulation in collaborative settings. We developed a macro script directed at supporting shared regulation on the specific elements of task-oriented reading during reciprocal peer tutoring. To the best of our knowledge, this app is the first measurement tool to measure self- and shared regulation in this way.

The app measures the interrelated aspects of task-oriented reading in individual and collaborative settings. Students' self-regulation of task-oriented reading is measured through a) the indicated task complexity, b) the selected reading strategy, c) the applied reading strategy, d) the execution of the task and, e) the reflection on the applied reading strategy. We trace a students' use of reading strategies with blurring. The text is masked except for the sentence the student deblurs, which allows us to capture the students' reading process. The log data from the app are used to measure self- regulation of task-oriented reading.

Students' shared regulation during reciprocal peer tutoring is scaffolded by including the five steps in a macro script to guide the groups' interaction around shared regulation of task-oriented reading. The groups' task representation, their strategy selection, their collaborative reflection on strategy execution as well as their individual reading, task performance and reading strategy awareness are included in the script. The script is designed to enhance group interaction by creating interdependency among the group members. Each member is provided with different information in the App which is necessary to fulfil the task. Students are assigned to different roles, i.e. tutor, task guard, text guard and writer. The tutor guides the shared regulation with a number of questions about task perception and reading strategies. The task guard has access to the task and explains the task to the group. The text guard has access to the text and describes layout of the text. The writer writes down the groups' answers to the questions. Under guidance of the tutor, the group discusses the task representation and the appropriate reading strategy. After this collaborative stage, each member continues to individually read the text and complete the task. Upon completion, each student indicates which reading strategy s/he applied. After all group members finish, the tutor again guides the collaborative discussion reflecting on the application of the reading strategies. The groups' answers are recorded in the logs as a measure of their shared regulation.

To validate the measurement instrument, audio recordings record the interaction between the group members. The dialogue is analysed to validate the app's measurements by aligning the logs with the groups' discussion of their shared task representation, strategy selection and reflection on their strategy use after task performance. Existing coding schemes from Molenaar, Sleegers and Van Boxtel (2014) will be used to analyse the groups' interactions.

Currently, 45 students in two classes of grade 4 in vocational secondary school are using the App. The students first completed 9 task-oriented reading tasks individually, after which they engaged in four reciprocal peer tutoring lessons in which they collaboratively engaged in 3 task-oriented reading tasks using the macro-script in the app. First results indicate great diversity in all elements of self-regulation of task-oriented reading. The macro script indeed supports reciprocal peer tutoring during the lessons and students indeed engage in shared regulation of their task-oriented reading.

Overall, this contribution introduces an App that is developed to measure how students regulate task-oriented reading both in individual and collaborative settings. In this way, we aim to better understand how shared regulation during reciprocal peer tutoring influences students' individual regulation during task oriented-reading. As such, the development of this tool is of essential importance to further our understanding how students enact regulation and how shared regulation can influence self-regulation.

A process-oriented analysis of peer tutoring participants' shared regulation behavior

Liesje De Backer, Hilde Van Keer, and Martin Valcke

The metacognition research recently shifted the focus from individual to social forms of regulation for there is consensus that collaborative learning not only encourages self-regulation, but shared regulation at interpersonal levels as well (Panadero & Järvelä, 2015). Socially shared metacognitive regulation (SSMR) refers to a joint engagement of multiple learners operating on each other's metacognitive contributions when regulating the group's cognition (De Backer, Van Keer, & Valcke, 2015; Iiskala, Volet, Lehtinen, & Vauras, 2015). Although SSMR is expected to advance collaborative learning, empirical evidence in this respect is limited and sometimes inconclusive (Panadero & Järvelä, 2015). This inconclusiveness raises theoretical questions regarding the existence of different types of SSMR, as well as methodological questions on how to measure utterances of shared regulation. It could be that not all of students' shared regulation benefits collaborative learning to the same extent and, consequently, that more fine-grained analyses are needed to enable the identification (and measurement) of these possibly different types of shared regulation. The present study investigates the existence of qualitatively different types of SSMR, demonstrated by higher education students collaborating in a peer tutoring context. Peer tutoring (PT) is a type of collaborative learning characterized by specific role taking: the more knowledgeable tutor supports the learning of less experienced tutees. The present study opts for a micro-level, process-oriented analysis of PT-participants' shared regulation. Its aims are twofold, directed at unravelling time-bound evolutions in students' SSMR and at identifying quality differences in the acts of SSMR demonstrated by the PT-participants.

A semester-long PT-intervention was implemented as part of the curriculum of freshmen in the Educational Sciences program. Sixty-four students weekly tutored one another in small groups of six. All PT-sessions of five randomly selected PT-groups were videotaped (70 hours of video recordings). The PT-intervention consisted of eight weekly face-to-face sessions (2 hours each). PT-interactions were structured by weekly session-specific tutor manuals. Students participated in a compulsory preliminary training to master tutoring skills and received ongoing support through interim feedback. During the PT-sessions, students worked on authentic assignments, demanding high levels of cognitive processing and directed at co-constructing domain-specific knowledge on "Instructional Sciences".

Students' shared regulation was assessed through systematic observation of the video data by means of literature-based coding instruments (De Backer et al., 2015), allowing process-oriented study of self-, co- and shared regulation. Coding the video data and analyzing PT-participants' shared regulation followed subsequent steps. First, statement coding was used to identify utterances of metacognitive regulation in students' verbalized interactions (n=14968). A statement referred to a single thematically consistent verbalization of a single metacognitive action by a single student. Second, metacognitive statements were reanalyzed through interaction coding to check the regulative agents involved and the reactions following the statement, aimed at identifying utterances of SSMR (*n*=397). A unit of SSMR encompassed interdependent regulative actions, represented by a sequence of reciprocal conversational turns reflecting a particular regulation skill, proceeding through at least three PT-participants' metacognitive statements. Third, mixed models for logistic regression allowing change points were run to unravel time-bound evolutions in PT-participants' adoption of SSMR. Fourth, all identified SSMR-units were analyzed in more detail to unravel possible quality differences. The latter were coded based on the following parameters: (a) the number of students' involved in a SSMR-unit (Iiskala et al., 2015); (b) level of (dis)agreement with peers' regulative thinking; and (c) the level of elaboration in the regulative reactions to peers' regulative contributions (Näykki, Järvenoja, Järvelä, & Kirschner, 2017). Fifth, a two-step cluster analysis was run to identify variations in the quality of segmented SSMR-units, based on the cluster variables (i.e. parameters a-c). Akaike's Information Criterion (AIC) was adopted as a measure of fit for the clustering, whereas Euclidian distance was adopted as a measure of similarity.

Despite a limited adoption of SSMR, the findings reveal an evolution towards increased SSMR from the starting (2.04%) to the closing PT-session (8.06%). During the second intervention half, SSMR is increasingly adopted during orientation and monitoring in particular. Whereas the odds of SSMR do not change during the first intervention half (p=.185), they increase 2.58 times (p<.001) during the second half. A significant change point was revealed at PT-session 5, implying a considerably larger evolution towards SSMR upon completion of the PT-intervention. It should be noted, however, PT-participants' engagement in SSMR is much more limited as compared to their involvement in self- (24.71%) and co-regulation (70.11%).

Further, results reveal the existence of variations in the quality of segmented SSMR units, based on the cluster parameters taken into account. More particularly, a two-cluster solution was revealed. After examination of the subscale means in both clusters, two types of quality were defined: surface-level SSMR (*n*=1489; 49.9%) and in-depth SSMR (*n*=1494; 50.1%). Surface-level SSMR, is characterized by the involvement of a rather limited number of students (M=4.03), who mainly react to each other's regulation with paraphrasing comments ($M_{level\ of\ elaboration}$=1.65) and who mainly confirm or only shortly discuss peers' regulative thinking, aimed at quick consensus-building ($M_{level\ of\ (dis)agreement}$=1.65). In-depth SSMR is characterized by the involvement of a large majority of students (M=4.93), who react to each other's regulation with elaborative comments ($M_{level\ of\ elaboration}$=2.55), and who mainly question and challenge peers' regulative thinking during SSMR ($M_{level\ of\ (dis)agreement}$=2.98).

The study's process-oriented scope on time-bound evolutions in SSMR enhances our theoretical understanding of SSMR but also provides instructors with input on when to scaffold SSMR. Acknowledging qualitative variations in SSMR further allows refining current theoretical models, as well as validating the differential impact of SSMR- acts on collaborative learners' outcomes in future studies.

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