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Teacher regulation of multiple computer-supported collaborating groups

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ABSTRACT

Teachers regulating groups of students during computer-supported collaborative learning (CSCL) face the challenge of orchestrating their guidance at student, group, and class level. During CSCL, teachers can monitor all student activity and interact with multiple groups at the same time. Not much is known about the way teachers diagnose student progress and decide upon appropriate interventions when they regulate multiple groups synchronously. This explorative study describes the strategies and experiences related to regulating the activities of seven groups of students, as reported by two teachers, and aimed to widen the framework for describing teacher regulation of CSCL settings that are characterized by synchronicity. Recurring themes included the high amount of information load teachers experienced while diagnosing students' needs, the focus and level of regulation, and the way the teachers used prior knowledge of students to decide on an intervention after diagnosis. Both teachers valued the ability to monitor student progress online, and mentioned the necessity of students being able to follow the teacher's activity as well. Theoretical implications are described in terms of understanding teacher regulation, synchronicity, and information load. Practical implications are described for lowering information load.

1. Introduction

Computer-supported collaborative learning (CSCL) denotes situations in which students collaborate using information and communication technologies. Collaboration between students is not always successful and it is known that collaborating groups may experience problems, for example when students differ in their motivations (Zhang, Ordóñez de Pablos, & Zhang, 2012) or when social conflicts arise (Kreijns, Kirschner, & Jochems, 2003). Partly, these problems may be reduced by technological support such as visualizations of group work (cf., Xi, Liu, & Ordóñez de Pablos, 2014) or scripting of student activities (Miller & Hadwin, 2015). Increasingly, the role of the teacher in regulating students' activities during CSCL is being recognized (a recent overview is given by Kaendler, Wiedmann, Rummel, & Spada, 2014; see also the Community of Inquiry framework, Garrison & Arbaugh, 2007). For example, teachers can play an important role in stimulating meaningful discussion between students. During CSCL, students often work on tasks that require in-depth discussion of task materials, which means students also construct meaning from the ideas developed during the discussion (Stahl, Koschmann, & Suthers, 2006). The effectiveness of teacher regulation increases when teachers adapt their support responsively to the understanding of the students (Van de Pol, Volman, & Beishuizen, 2010). To do so, one must first determine the students' current level of competence by using diagnostic strategies. When teachers have ascertained students' understanding of the task, they can adapt their intervention to the needs of the groups (Puntambekar & Hübscher, 2005), for example by providing additional explanations during the occurrence of misconceptions (Garrison & Arbaugh, 2007).

While the importance and complexity of teaching in a collaborative setting is recognized, there are still many aspects of the relationship between teaching and learning activities that need further investigation (Garrison, Anderson, & Archer, 2010). One such aspect is the *synchronicity* teachers are faced with when regulating CSCL that stems from the fact that multiple groups of student engage in multiple types of activities at the same time (see Doyle, 2006, for a description of the complexity of events in a classroom). It is known that increasing the size of face-to-face classrooms and increasing the size of collaborating groups (i.e., the number of group members) can negatively influence teaching quality (Blatchford, Baines, Kutnick, & Martin, 2001). However, not much is known about how synchronicity, in terms of the presence of *multiple groups*, affects teacher regulation of collaboration. Given the average class size in secondary education of 25 students, teachers often regulate at least 5 or 6 groups. Few studies have investigated the nature of diagnosis during CSCL and the possible relationship with teachers' interventions (Schwarz & Asterhan,

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2011). In particular, teachers' experiences with the possibility to regulate multiple groups at the same time and the resulting real-time decisions a teacher has to make, have not been extensively researched. The purpose of this study is to offer an exploration of the challenges a teacher may encounter when regulating multiple collaborating groups in order to enhance our understanding of teaching during CSCL. Descriptions of two teachers are presented to gain insight into teachers' reported strategies and experiences regarding diagnosis, the decision on an intervention after diagnosis, and the intervention itself.

1.1. Diagnosing student activities when regulating multiple groups

Teachers can use two strategies to diagnose students' level of understanding, namely by actively questioning students, and by observing students' activities (Van de Pol et al., 2010). In the present study, the computer-supported setting allows the teacher to communicate with students by means of a chat tool. The teacher may perform a diagnosis by directly asking students about cognitive or social aspects of their activities. In contrast to questioning, which requires teacher–student interaction, observing is a non-intrusive way of diagnosing in the sense no such intervening interaction is needed. Unique to a computer-supported setting is that the teacher can access students' activities and task output as it is being constructed. That is, CSCL environments can give the teacher access to the tools that students use to solve the task to diagnose the progress of the task *during* lessons as opposed to the teacher reading students' task output after or between lessons (termed "offline diagnosis" by Smit, Van Eerde, & Bakker, 2013). That is, when teacher and students are online simultaneously, the teacher can see the students' activities in real time, for example by continuous updates in written texts or changes in visual representations of students' arguments (see for example the Argunaut environment; Asterhan & Schwarz, 2010). The teacher can diagnose the way students collaborate by checking student communication in a chat or forum tool, which may provide clues as to how they are collaborating (for example, dividing tasks). This communication may also provide information about cognitive aspects, for example when students correctly apply or explain a concept to a peer.

Of course, the type of information available differs according to the nature of the task and the specific characteristics of the learning environment, but in general, in such settings there is a multitude of information available to the teacher. This *could* make it easier to diagnose the situation. Research in face-to-face settings has shown that it is difficult for teachers to acquire an accurate description of students' understanding (Myhill & Warren, 2005; Rodgers, 2004; Van de Pol et al., 2010). Additional information offered during CSCL settings may therefore be beneficial to the accuracy of teachers' diagnoses by complementing the teacher's observations, thereby helping the teacher to regulate students' learning processes (Cortez, Nussbaum, Woywood, & Aravena, 2009). However, there are two factors that can decrease this accuracy. First of all, the question is whether the teacher has the opportunity to read all the information available to him or her. On the one hand, a teacher could choose to delay answering a question and instead spend time on reading students' contributions. On the other hand, because student and teacher in synchronous settings are online at the same time, students will engage the teacher in conversations, which require immediate responses if the teacher is to make use of this moment (Schwarz & Asterhan, 2011). A consequence might be that teachers' responses to students are adjusted on the fly (Rodgers, 2004) instead of carefully prepared by reading the available information. The second factor is that when a teacher decides to diagnose by reading, the large amount of information could lead to an overload instead of being helpful (Dyckhoff, Zielke, Bültmann, Chatti, & Schroeder, 2012). Thus, the synchronicity in such settings means teachers are faced with a demanding task that requires them to decide how to divide their attention and which group(s) to monitor at a given time.

It is likely that both these concerns are related to the number of groups a teacher is regulating. After all, the presence of more groups means that there are more students who can ask for help, and that there is more information available. Several researchers argue that an increase of information load may prevent deliberate action, thereby possibly hindering conscious diagnosing of student performance (Elliott, 2009; Feldon, 2007). This may mean that in the case of high information load, instead of obtaining and using current information on students' understanding, teachers are more likely to use their existing knowledge about students to make decisions on the appropriate intervention (Feldon, 2007). Schwarz and Asterhan (2011) point out that the possibility to switch between multiple group conversations makes it more difficult to follow and diagnose the development of discussions in a particular group. Moreover, Brühwiler and Blatchford (2011) have shown that teachers more accurately diagnose students' achievement in smaller classes. It is therefore expected that a larger number of groups will lead to teachers reporting a higher information load and less adaptation to students' needs.

1.2. Teacher interventions when regulating multiple groups

It was already pointed out there is an intricate relation between diagnosis and intervention (Van de Pol et al., 2010): in order to be adaptive, an intervention should be based on the teacher's diagnosis of students' understanding. This relation would suggest that the difficulties associated with diagnosing, caused in part by the number of groups, also affect the teacher's interventions. Studies into face-to-face class size reduction have indicated that smaller classes lead to more frequent and individualized interaction between teacher and students (Blatchford, Bassett, & Brown, 2011; Smith & Glass, 1980). Teacher interventions were more frequent in small classes both for cognitive and for socially focused interventions. In larger classes, teachers focus more on cognitive activities, in particular activities concerned with planning (Blatchford, 2003).

The results in online settings regarding teacher interventions are not as straightforward as those for face-to-face settings. Russell and Curtis (2013) for example found quantity and quality of teacher interventions were limited in a large online course when compared to a smaller scaled one, while Orellana (2006) found no relationship between online courses' class sizes and the intensity of teacher–student interaction. Furthermore, there are few studies that focus on *collaborative* settings instead of individual student learning. Blatchford et al. (2001) state that smaller collaborating groups of students (i.e., a smaller number of students *per* group) provide the teacher with more opportunity to individualize help, but these authors do not consider the effect of the *number* of groups. The image that arises from studies of non-collaborative settings is that as class size increases, the teacher has less time to spend per student, resulting in less individualized help. This relationship is not as clear in collaborative situations, because students can also turn to each other for help. However, in this case the teacher gains the additional task of focusing on the groups' collaborative process in order to avoid collaborative problems (Kreijns et al., 2003). Thus arises a trade-off between intervening at individual versus small group level (and additionally, at class level). One might expect that larger classes would lead the teacher to intervene more at class or group level, as a solution to the difficulty of reaching every student (Blatchford, 2003). Contrary to this expectation, it was found that "teachers in large classes strive to maintain the same balance of individual, group and whole class teaching as their colleagues in small classes" (p. 589). Again, the question is whether this result is transferrable to an online setting.

1.3. Aim of the present study

Schwarz and Asterhan (2011) have given an elaborate description of the interplay between the teacher, students, and the CSCL environment. They were able to show that when regulating four groups the teacher is able to use teaching strategies effectively and to have an impact on students' learning processes. The authors hypothesize that a larger number of groups would be possible too, but that the associated complexity of this task would possibly hinder deliberate and effective regulation of the students. However, there is no research yet that has investigated teachers' strategies when regulating more than four groups. There is thus a lack of research concerning this question, especially in the field of CSCL, while on the other hand the importance and benefits of collaboration are increasingly recognized. The aim of this study is therefore to explore the diagnosis and intervention strategies used by two teachers during CSCL while they each regulate seven groups. The aspects of teacher regulation during CSCL discussed above, such as the possibility of information overload and the trade-off in intervening at individual or group level, are best investigated by studying teachers' reports about these topics. Therefore, in this study stimulated recall interviews are used to reveal teachers' intentions during specific events (De Smet, Van Keer, De Wever, & Valcke, 2010).

The following research question has been formulated: How do teachers regulate multiple computer-supported collaborating groups, in terms of diagnosing and intervening strategies?

2. Method

2.1. Participants

The data collection of this study was undertaken in 2012 and 2013. Two teachers and their classrooms, which were divided into seven groups of collaborating students, participated in this study. Following the guidelines by Onwuegbuzie and Leech (2007), the sample size in this study was chosen to be two teachers so that a deep, case-oriented analysis would be possible. The participating teachers in the study were chosen because they were interested and motivated to innovate their classroom practices by making use of new technologies. The teachers can be said to be representative of Dutch secondary school teachers, with average sized classes. The two male history teachers and their students in pre-university education worked on an assignment in a CSCL environment for respectively 8 and 3 lessons.

The two teachers were followed during the period to study their experiences concerning their strategies and faced challenges and opportunities while diagnosing and intervening during student collaboration. Teacher 1 was 43 years old and had 15 years of teaching experience. Teacher 2 was 35 years old and had 8 years of teaching experience. The classes consisted of respectively 21 and 30 students, which are common numbers for Dutch secondary school classrooms. All groups of students consisted of three, four, or five students, with a mean age of 14 years.

Neither teacher had any experience with teaching in a CSCL environment. All teachers and students received an introduction into the CSCL software. Although the number of lessons differed, all students worked on a similar kind of assignment concerning the Cold War. The task students worked on was an integral part of the obligatory History curriculum in secondary education and constituted a part of their grade for this subject. The teachers carefully prepared the assignment and students were aware that the completion of the assignment would occur fully through the online environment. The assignments were open-ended and required students to first read and discuss historical sources, to put the arguments they found in a diagram, and thereafter to write a short essay collaboratively about the question why the Cold War did not result in a Third World War.

2.2. CSCL environment

The classes of students and their teachers made use of the CSCL environment called Virtual Collaborative Research Institute (VCRI, see for example Janssen, Erkens, Kanselaar, & Jaspers, 2007). VCRI is a groupware program designed to support collaborative learning on inquiry tasks and research projects. All students had their own computer in the classroom, and synchronously communicated with their group members by means of a Chat-tool. The assignment involved exploring the topic of the project by reading historical sources in the Sources-tool. Students used the Debate-tool to construct a shared diagram of their arguments. Students used the Cowriter, a shared text processor, to write their essay.

This synchronous set-up within the same physical space has multiple advantages (Petrou & Dimitracopoulou, 2003). For example, in contrast to distance education, the classroom setting ensured that students did not need to spend time to get to know each other before starting on the assignment, because the class already had a common history and a set of behavioral norms (Asterhan & Schwarz, 2010). Students are required increasingly more often to collaborate on complex tasks. While working on these complex tasks, teachers are often not able to adequately monitor the collaborative process. Digital communication ensured that the teacher could constantly monitor each group's activities and lowered the chance of classroom disturbances or interruptions (Petrou & Dimitracopoulou, 2003). Digital communication through a Chat can also be argued to lead to more precise articulation because of the absence of non-verbal cues (Asterhan & Schwarz, 2010).

An alternative interface of the VCRI-program was available for the teacher, which allowed him to monitor the online discussions of the students in the Chat-tool in real-time and send messages to students. Messages can be sent by the teacher to a group, more than one group at a time, or the whole class. Teachers can examine the texts students are writing in the Cowriter or the diagrams they are making in the Debate-tool. The teacher could thus monitor multiple groups at a time by opening the tools the groups are working in, and could intervene by sending messages through the Chat-tool.

The program offered the teacher two additional tools. First of all, by a Statistics-tool the teacher could consult basic statistical information about students' activities in VCRI's tools (e.g., the number of keystrokes per student). Secondly, the teacher could check the relative activity of each group member in the Participation-tool, which in the form of spheres visualizes how much each group member contributed to the groups' activity (for more details, see Janssen et al., 2007). Fig. 1 displays an example configuration of the VCRI teacher interface, in which the Statistics-tool, two Chat-tools, and the Participation-tool of one group are opened.

2.3. Interviews

The aim of the study was to examine teachers' diagnosing and intervening strategies, the transition between diagnosis and intervention, and related aspects such as the possibility of information overload and the way teachers alternate or choose between regulating individual student or group level. Most of these aspects are not observable behavior. For example, when a teacher gives students a suggestion for solving the task, only this suggestion is visible as a written message in the Chat-tool. In previous studies, these interventions have been counted and coded by many

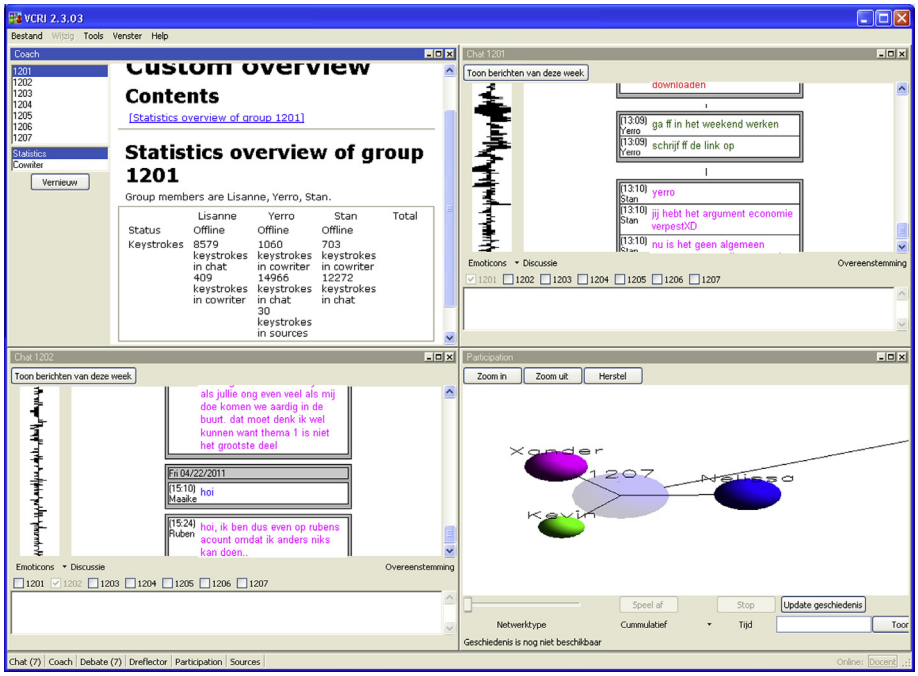

Fig. 1. An example of the configuration of the VCRI teacher interface. In this case, the teacher has opened the Statistics-tool (upper left), the Participation-tool (bottom right), and the Chat-tool for two of the groups.

researchers (Van Leeuwen, Janssen, Erkens, & Brekelmans, 2013). What remains invisible and has not been reported on in many studies, however, are the way the teacher diagnosed the students' task progress, how the teacher decided on an intervention, why the teacher focused on a particular type of student activity, and whether the teacher experienced any difficulties while doing so. Therefore, instead of the actual interventions, the primary object of study were teachers' reports about their *strategies* for diagnosing and intervening, and the associated challenges and opportunities. These reports were retrieved by means of interviews.

VCRI automatically logs all communication in the Chat-tool. Thus, for each lesson a protocol was available with the students' messages and teacher's interventions in the Chat-tool. The observable interventions were the starting point for the interviews. After each lesson, a number of fragments from the chat protocol which included teacher interventions were selected by the researcher and used in stimulated recall interviews with the teachers. The stimulated interviews were held at the same day or the morning after the corresponding lesson to ensure the teacher could clearly remember the selected fragments (Lyle, 2003). The fragments were selected in such a way that they would include an intervention in each of the groups the teacher regulated, as well as different types of interventions, for example fragments in which the teacher gave an explanation or in which the teacher gave an instruction. Both teachers were shown the selected fragments and asked to comment on how they monitored (i.e., diagnosed) this particular group and why they chose this particular message (i.e., intervention). Teachers were free to further elaborate on anything else they wanted to say about the fragments.

Because the number of lessons that the teachers worked with VCRI varied, so did the maximum number of possible stimulated recall interviews. It was made sure that at least two stimulated interviews were held with both teachers to ensure sufficient contact time between the researcher and each participant (Onwuegbuzie & Leech, 2007). Six stimulated recall interviews were held with T1, and two with T2. The stimulated interviews on average took 20 min per interview.

At the end of working with VCRI, an overarching semi-structured interview was held with each teacher. In these interviews the teachers were asked about the way they regulated students' activities in VCRI and how they used the various tools to do so. Questions were asked both about opportunities as well as possible difficulties. These interviews on average took 30 min.

2.4. Analysis

All interviews were transcribed and coded with the aim of extracting the most important themes that the teachers described. To code the transcribed interviews, the Atlas.ti software was used. A combined top-down and bottom-up approach was used, which meant a predefined set of themes was constructed that was further refined based on the actual findings. The aim of the coding procedure was to create a case-ordered matrix (Miles & Huberman, 1994) that would allow us to describe the teachers on each of the coded aspects. The initial coding scheme consisted of codes for (1) diagnosing strategies, (2) decisions to intervene, and (3) focus and recipient of interventions.

2.4.1. Diagnosing strategies

The first matter of interest was the strategies teachers employed to diagnose the progress and quality of students' activities, which can be divided in Observing and Questioning (Van de Pol et al., 2010). Subsequently, a teacher might report whether this strategy was efficient and whether he was able to retrieve all information about students he needed. Codes were created to analyze teacher utterances that specifically dealt with positive or negative aspects they encountered while diagnosing. Thus, concerning diagnosis, both strategies and associated experiences were coded.

2.4.2. Intervention decisions

Another important object of study was how a teacher decided to intervene. As explained, a hypothesized effect of the presence of multiple groups is that due to the vast amount of available information, decisions are not based on currently available information,

Table 1
Overview of results in the form of short summary phrases.

Theme	Strategy	Opportunities	Challenges
Diagnosing strategies	– Few instances of questioning	– Amount of available information	General: challenge to divide attention
	– Observing: all tools used. Look primarily for visual cues	– Participation tool for observing metasocial aspects	Observing – Would like more info on participation – High information load Questioning – Communication is less immediate – Absence of facial cues
Decision to intervene	Intervene whenever there is a question. Use previous knowledge of students		Low student awareness of teacher
Focus	Mostly metacognitive focus	Participation tool for observing metasocial aspects	– Adapting to groups when their progress diverges – Cognitive focus: punctuality of discussion
Recipient	Equal focus on student, group, and class level	– Ability to send class messages – Intimacy of group conversations	Communication is less immediate

but on prior knowledge (Feldon, 2007). Both of these possibilities were therefore identified as coding categories.

2.4.3. Focus and recipient of intervention

Two further characteristics of both diagnosing and intervening strategies were the *focus* and *recipient.* The *focus* of diagnosis or intervention denotes what type of student activity it was aimed at (Van Leeuwen et al., 2013). Commonly identified foci of teacher regulation are cognitive, metacognitive, social, and metasocial aspects of students' activities (Janssen et al., 2007). When the teachers reported their strategies and experiences, it was coded whether it concerned students' cognitive or social activities, or, on the regulative level, students' metacognitive or metasocial activities. The codes for *recipient* denote whether the object of the teacher's reports was an individual student, a collaborating group, or the whole class (Onrubia & Engel, 2012). Similar to the codes for diagnosing, the codes for focus and recipient also include a category for the associated teachers' experiences. For example, a teacher might report that he focused on cognitive activities, and state that he found this very easy to do.

After construction of the initial coding scheme, two researchers together coded both a stimulated interview and an overarching interview to serve as a test session. When needed, subcodes were added to the three main categories listed above. For example, concerning the Diagnosing Strategy 'Questioning', a subcode was added based on teacher reports about immediacy of communications. When disagreement occurred about the interpretation of a quote, the rules for coding were refined. After the test session, the remaining interviews were then coded by one of the researchers, leading to a total of 437 coded utterances.

In the final step, a cross table was made for participant × code (Miles & Huberman, 1994), resulting in an overview of the codes for both teachers. A list of quotes per participant was derived from the Atlas.ti software for each code. The results for the two teachers were compared and integrated into one overview. While the codes were straightforward and relatively coarse-grained, this step of summarizing and comparing resulted in rich and nuanced descriptions of each of the teachers (Boeije, 2010). The descriptions were translated to short summary phrases (Miles & Huberman, 1994) of the teachers' strategies and experiences.

3. Results

The overall results for each of the codes, in the form of short summary phrases, are presented in Table 1. For each theme, the teachers' strategies are summarized, as well as the opportunities and challenges they experienced. In the next subsections, the results are discussed for each theme. Fragments of teacher–student interactions, along with teacher comments, are given to illustrate the findings. In these fragments, student names are changed to preserve anonymity.

3.1. Diagnosing strategies

Both teachers acknowledged the opportunity to access more information about students' activities than is usually available during face-to-face collaboration in the classroom. The teachers were able to observe all student activity and thus see the process as it was happening. The most frequently reported strategy of diagnosing was Observing, and almost no instances of Questioning were mentioned. Teacher T1 mentioned as a disadvantage of Questioning that he sometimes felt he would have liked to have non-verbal signs to verify whether students understand a concept or not. Because both teacher and student can delay their response during a conversation, communication is not as immediate as it is face-to-face. All teachers missed this temporal immediacy. T2 remarks: "*There is a delay in the communication. I like immediate communication, which is there during regular teaching. It helps me to better estimate what help students need.*"

It seems that the function of Questioning was in part substituted by using Observing as a means to diagnose. Observing offered the teachers a multitude of information. The Chat-tool can for example show whether students are on-task or off-task, whether they use correct arguments, and how they divide tasks. The Cowriter and Debate-tool show real time task progress. The teachers expressed a disadvantage of Observing as well. While the Chat-tool makes a distinction between group members by name and text color, the Debate-tool and Cowriter do not. In these tools, it is not visible which student added which part. Teacher T1 mentioned he would have liked to have this information.

Although both teachers mentioned the advantage of having access to all student activity, they also struggled with keeping up with all this information. The teachers therefore divided their attention between the groups, often in the middle of a conversation. Table 2 illustrates how this resulted in perceived delayed communication between T2 and his groups. Table 3 illustrates T1's activity in multiple groups at the same time.

The teachers experienced a considerable amount of information load. This affected the way the teachers observed the students. Both teachers were prone to look for visual instead of semantic signs in the Chat-tool, for example the length of a student message

Table 2
Example of delayed interaction between T2 and his students, along with T2's comment.

Time	Message
10:08	Jane: I'm hungry
10:09	Mike: Later
10:09	Jane: Pizza
10:09	Mark: No I am thirsty [*smiley*]
10:09	Mike: What??
10:19	T2: You can use sources from all themes, as long as it supports your argumentation

T2 comment: "Normally, when a student asks a question you remain at their desk and the student will start writing, and later on you approach them again and you take a look and you know he got it. Or you ask about it again, you ask about the information you just provided, to see whether they understand. But this is different, it is harder. And divided. Because when I give an answer, I am simultaneously keeping an eye on the other groups.
You see, here I respond to something I read earlier in the chat. The communication is delayed, because you have to pay attention to so many things. They probably asked me a question in the beginning and I did not answer fast enough, and then they start talking about other things."

(see the example in Table 3), question marks to signal whether students had questions or the use of smileys to indicate possible off-task behavior.

3.2. Deciding on an intervention after diagnosis

The experiences associated with the diagnostic strategy of observing had consequences for the teachers' decision to intervene. In 65% of reported instances (of a total of 40 coded utterances about intervening decisions), the teachers intervened on the basis of specific visual signs (for example question marks) or their prior knowledge about students instead of on a thorough reading of the content of the students' conversations (35%).

Table 3
Example of interaction between T1 and multiple groups, along with T1's comment.

Time	Group 1	Group 2
12.36	John: Sir, where can we find the amount of victims and damage for completing the table?	
12.36	Bill: John, I put something in the table take a look	
12.36	John: Okay thanks	
12.37	John: Okay that looks good, right?	Lisa: I'm back
12.37	John: ?	Lisa: I was away for a minute
12.37	John: At least I think so	Lisa: The computer didn't work
12.38	Bill: Yes I think so as well	Terry: Sir, the links below the page, are those additional information or the original source?
12.38	T1. John, you can find that in the sources, in theme 1	
12.38	John: Okay	
12.39	John: What did they do to increase their power, let's take a look	T1: Terry, that is the original source, but you can use those links to look for further information
12.40	John: They both want to convince others of their way of reigning	T1: How is it going with the division of tasks in this group?
12.40		Terry: I think it's okay
12.41	T1: How did the US and the SU do that?	
12:42	John: They tried to increase their power by introducing the same political system (SU)	
12:42	T1: To everyone: I expect you to have an answer for the sub question in theme 1 today!	T1: To everyone: I expect you to have an answer for the sub question in theme 1 today!

T1 comment: "What I often did when I had all 7 chat windows opened, is check what is put below my message. When the students talk to each other, it is often one or two sentences. When the message is longer, it is usually a question. So when I see a longer text appearing, I first check that."

The ability to divide attention and switch between groups had a consequence for the teachers: students are not aware of what the teacher is doing. Students of course know that the teacher is able to see all groups' activity, but they do not know which group the teacher gives attention to at a given moment. T2: "*When I am asked a question, I sometimes do not respond immediately because I am reading something else. Of course this may happen in the classroom as well, but then you can say I'll be right with you or students can see what you are doing.*" It thus seemed that not only the teachers had a need to know what students were doing, but also the other way around: they felt a need for students to know what *they* were doing. The fact that students could not 'see' the teacher gave the teachers the feeling that students were waiting for their replies. Therefore, the teachers answered whenever they thought they were needed, and often did not stop to think whether intervention was necessary or whether students could work it out on their own (because a posed question could also be directed to and answered by another student). From the results reported here, it seems the decision whether or not to intervene requires time for teachers to perform a thorough diagnosis and enough space to reflect on the situation. Keeping up with multiple groups might cost too much resources to leave space for that reflection. As teacher T2 said, he had a demanding enough task of keeping up with the group discussions and the nature of students' questions.

Table 3 shows a fragment of a lesson in the class of T1, which illustrates how the teacher was active in multiple conversations at the same time, and developed a strategy for monitoring the discussions. It shows the speed of the conversations, and how the teacher tried to respond to every question, even when that question was already answered by another student (in Group 1, at time 12.38). In the corresponding comment by T1, he explains how he monitored the chat windows for questions from students (see also Section 3.1).

3.3. Diagnosis and intervention: Focus

The teachers often reported a focus on Metacognitive aspects (on average 56% of a total of 63 coded utterances about focus), more than on Cognitive aspects (on average 10%). Both teachers indeed indicated in the overarching interview that they would have liked to focus more on the task content or subject matter and to delve into deeper discussions with the groups. It was already discussed above that there was a high information load. This may have caused the teachers to have a less clear diagnosis of the groups' current understanding of the topic. In turn, this may have led to less cognitive focus. Furthermore, the Chat-tool required teachers to be more concise in their formulations. Teachers had to type their message instead of talk to students, which they said made their interventions more punctual (shorter in length). The teachers saw this as a disadvantage. They felt that especially when conversations delved deep into the subject matter, the Chat-tool made it difficult to give elaborate explanations, and to determine whether students grasped the teacher's feedback. Table 4 gives an illustration. The students need to collect evidence for why the Cold War did not result in World War III. A student has thought of a reason, and T2 tries to encourage her to think of whether this is an argument for or against war. This suggestion does not seem to get picked up by the students, and T2 reflects on this difficulty. Therefore, there sometimes were face-to-face conversations with groups during the lesson. Teacher T1 offers an additional remark. As the lessons continued, he noticed that groups started to diverge concerning their progress on the task.

Table 4
Example of interaction between T2 and his students, in which T2 doubted whether students grasped T2's meaning.

Time	Message
09:50	Vivian: After World War II Germany was split into four military zones
09:50	Vivian: Is that correct?
09:50	Vivian: Oh I got something
09:51	T2: Yes that's correct!
09:51	Vivian: Yeah
09:51	T2: Continue this line of reasoning and think of whether it is a counterargument or not
09:51	Vivian: Yes but would 'Tension between east and west' also be okay?
09:52	Vivian: And 'Shut down of transport into West-Berlin'
09:53	Lily: I wrote something down take a look at what I've got
09:53	Vivian: Oh yes I see, well done [*smiley*]
09:54	T2: Why is the marshall plan a cause for War?
09:55	Vivian: I also added one

T2 comment: "I have the impression that I sometimes do not have a clear idea of the nature of a student question. Then you quickly have to discover exactly what they mean and I find it hard to determine whether the answer is adequate, and to what extent it guides or stimulates them. You could say that students when necessary will indicate "that is no answer, where is the answer?" and at one point a student did. What I mean is whether they grasped the feedback, normally you can see that."

This made it harder to give specified help, and caused the teacher to focus more on planning and orchestrating the task (Metacognitive aspects).

The focus of the teachers' reported strategies and experiences was relatively often on Social and Metasocial aspects of collaboration (33%). They looked for information on collaborative aspects. T1 for example used the students' colors in the Chat-tool as an indication whether all group members were contributing equally. As was said, T1 would have liked this distinction between students in colors to be available in the Cowriter and Debate-tool as well to further focus on task division. The focus on Social and Metasocial aspects is closely related to the Recipient, which is further discussed in the section below.

Besides the Chat-tool, another source for observing Metasocial aspects were the Participation-tool and the Statistics-tool. During the stimulated interviews, the teachers mentioned using these tools for observing division of labor (a Metasocial aspect). The teachers were aware that these tools are based on a quantitative measure (the number of keystrokes) and that they do not say anything about the quality of student's input. Still, they used the tools as indicators for possible collaborative problems, and sometimes intervened or asked students questions based on their observation of the Participation or Statistics-tool.

3.4. Diagnosis and intervention: Recipient

T1 and T2 equally mentioned student, group, and class level. T1 specifically talked about the advantages of being able to communicate in small groups without the whole class noticing. As illustrated in Table 5, the teacher was able to interact with the group in a playful way, by giving them hints and letting them try to work it out for themselves. Normally, this kind of interaction might make students feel uncomfortable.

While both teachers reported struggling with maintaining an overview, at the same time they talked about the advantages of being able to switch between groups. In particular, a useful option available to them was to send messages to all groups simultaneously. When one of the small groups asked a question that was relevant for the whole class, it was easy for the teacher to send out the answer to all groups. Class messages could also be used for reminders of deadlines or to encourage students to finish a particular sub task. In Table 2, the teacher does so at time 12.42.

Table 5
Example of playful interaction between T1 and his students, along with T1's comment.

Time	Message
13:07	Ken: The Pacific Ocean?
13:07	T1: So where did they fight, which American soil?
13:07	Ken: Uhm
13:07	Tom: Cuba
13:07	Ken: Let's see
13:08	Tom: Korea... Vietnam... or Afghanistan
13:08	T1: American soil!!!
13:08	Tom: Hahaha [*smiley*]
13:08	Nelly: Haha
13:08	Tom: America...

T2 comment: "This is a good thing about the system. When you do this in a regular lesson and you interact with one student, the rest of the class is watching. And that can be unpleasant for a student, you have to consider who you will play such a game with. A student can feel awkward is he doesn't know the answer, but here it's not a problem. Because it's just 3 or 4 of you and nobody notices. So that is an advantage of doing it this way. And I have to say I enjoy it very much."

At class level, the teachers felt that there was sometimes a need to communicate with the students in a immediate, face-to-face manner. The teachers indicated they sometimes walked around the classroom to show their authority and make sure the students knew the teacher was monitoring them. This is related to the immediacy of communication mentioned earlier.

4. Discussion

This study aimed to contribute to the understanding of teacher regulation of CSCL by describing the strategies teachers use and the difficulties they encounter when regulating a relatively large number of groups.

4.1. Results and theoretical implications

Teacher regulation was investigated in a learning situation in which teachers regulate the activities of multiple groups within a digital learning environment. The context thus not only included the cognitive and social activities students engage in and which the teacher responds to by intervening, but also the way the learning environment offers affordances for teachers to monitor and diagnose those activities and the way teachers make sense of the multitude of information available to them. Ideally, the CSCL setting makes it possible that the teacher is constantly aware of the activities students are engaged in, thereby ensuring that the teacher can adapt the given support toward each group both in a proactive and a reactive way (a difference employed by for example De Lièvre, Depover, & Dillenbourg, 2006; Vlachopoulos & Cowan, 2010). Proactively, the teacher could initiate interaction with the students based on diagnosing the students' activities real-time. Reactively, the teacher could use the logged history of the collaboration to adapt their interventions to the students' request for support.

Indeed, the teachers in this study indicated they found the available information valuable and helpful. Teachers for example proactively looked for social aspects and valued the real-time information offered by the CSCL environment. Compared to other settings in which the collaborative process is not constantly observable, teachers could diagnose problems early on, which means for example free riding and resulting problems (Simms & Nichols, 2014) could be avoided. Diagnosing strategies thus consisted foremost of observing.

Another aspect of importance, both concerning diagnosing and intervening, was the way teachers shifted between individual, group and class level. Teachers continuously monitored and

diagnosed the students' activities, focusing their attention sometimes on the group level (by engaging in a conversation or observing a group's progress), and other times on the class level again to make an announcement or to see whether any group or student needed additional help (Looi & Song, 2013). Multiple groups could be observed simultaneously in order to compare their progress. When an issue was noticed that was relevant for the whole class, the teachers sent an announcement to all groups. Simultaneously, issues that were specific to one group could be dealt with without disrupting the whole class (Schwarz & Asterhan, 2011). Compared to a plenary discussion, this led to a more open way of communication between teachers and each of the groups, during which students were free to make mistakes. Each group therefore seemed to form a small community within the wider community of the classroom (Garrison & Arbaugh, 2007).

This shifting between levels is a complex demand on teachers. Teachers must continuously choose which group to monitor and how to divide their attention, whether to maintain an eye on every group or to engage in an in-depth discussion with one particular group. Furthermore, within each group conversation topics quickly succeed each other, requiring the teacher to monitor and shift attention both between and within groups (see the example in Section 3.2). As teachers shift their attention, they must process and maintain the information about students they encounter, making use of same limited attention resource (Barouillet & Camos, 2007). Interestingly, the question of 'orchestrating' different levels of activities has recently received more attention in CSCL research (Dillenbourg, Järvelä, & Fischer, 2009). It is recognized that there is an "interplay between different activities (e.g., how individual work is integrated in team work)" (p. 12). We certainly agree this is an important direction for future research, which may be aided by a cognitive approach to teacher regulation of CSCL in terms of demands placed on working memory (see examples of such an approach concerning student teachers; Moos & Pitton, 2014, teachers; Feldon, 2007, and students; Jacob & Parkinson, 2015).

Another cognitively demanding aspect for teachers as a result of synchronicity is that the available information about the groups caused high information load. Schwarz and Asterhan (2011) found that information about students' activities could help the teachers to adapt their interventions to the needs of each group. Part of this adaptivity is that teachers can take time before responding to a question (Vlachopoulos & Cowan, 2010) and choose *not* to intervene. As Schwarz and Asterhan (2011) describe, the teacher in their study explicitly pondered about whether intervention was necessary and if so, what type of intervention. However, in this study, with seven collaborating groups we found that as a result of high information load the teachers' priority was to detect students' needs and offer support where needed, rather than the question whether it was better to let students work it out themselves before intervening. The manageability of the available information decreased as a result of the number of groups, and the teachers were not always able to maintain an overview of all student activities. Thus, because of difficulties with diagnosing, intervening strategies were also partly hindered. In this respect, monitoring a large number of groups poses teachers for the same problems as managing large classes does in terms of less individualized support, as demonstrated by findings from large classes in face-to-face research (Blatchford, 2003).

To summarize, we have explored and made an attempt to widen the framework for describing teacher regulation of student activities in a CSCL setting characterized by synchronicity. Teacher regulation encompasses multiple facets, namely diagnosing and intervening strategies for proactively and reactively regulating collaboration, shifting between individual, group, and class level, and the extent to which the needs of each group can be met.

4.2. Practical implications

4.2.1. Lowering information load

As described in Section 4.1, synchronicity in the CSCL setting was accompanied by high information load, which in turn influenced teachers' diagnosing and intervening strategies. For example the decision whether to intervene or not requires teachers to have a good overview of the situation; i.e., a manageable information load. An obvious suggestion to limit information load would be to keep the number of groups relatively small. However, decreasing the number of groups during collaborative situations would result in *increasing* group size, i.e. the number of group members per group. For example, a class of 28 students might be divided over 7 groups of 4 students, or over 4 groups of 7 students. Increasing group size, in turn, may lead to additional collaborative problems: the risk of free-riders and the formation of "islands" within the group will be more likely (Kreijns et al., 2003). Thus, there is a trade-off between the manageability and information load caused by the number of groups, and the risk of problems brought on by increasing group size.

Another way to decrease information load is by the addition of teacher supporting tools, which are a form of learning analytics (Siemens & Gasevic, 2012; Van Leeuwen, Janssen, Erkens, & Brekelmans, 2014). That is, instead of or besides having access to the full discussions and group products, CSCL environments could show the teacher analyses of student activity in the form of visualizations or textual summaries, which can be automatically generated from log files of user activity (Siemens & Gasevic, 2012). Teacher supporting tools offer at-a-glance information, which could ensure that teachers have up-to-date information during lessons to be able to effectively regulate students' learning processes (Cortez et al., 2009). In this study, the teachers also had access to supporting tools: they could check basic statistics and visualizations thereof that showed each group member's relative contribution to the task. The findings showed that the teachers indeed used these tools as "indicators/markers": an uneven distribution within a group led them to further investigate whether that group needed support. A suggestion is that since the teachers focused less on cognitive aspects of collaboration, they may have a need for tools that analyze the texts students write and indicate weak or strong points. It is important that more research is conducted into the effects of teacher tools on teachers' strategies and experiences (Van Leeuwen et al., 2014).

4.2.2. Immediacy of communication

While communication such as in a Chat-tool more closely resembles face-to-face communication than asynchronous communication such as in a forum (Cress, Kimmerle, & Hesse, 2009), all teachers mentioned that they sometimes missed the temporal immediacy of face-to-face contact. There were two reasons for this. First of all, during communication teachers and students could delay their response. Students can for example engage in another task-related activity while the teacher sends them a message. This means that the immediacy of a face-to-face conversation, during which both conversation partners immediately respond to each other, is often never fully achieved during CSCL. It might be beneficial to add a feature to learning environments through which both teachers and students can request 'uninterrupted' communication.

The need for face-to-face contact was also partly based on students not being aware of what the teacher was doing, because they were unable to physically see which group is receiving help at a given moment, or if for example the teacher is reading students' texts. In other words, effective teacher regulation is not achieved solely by the teacher being online (Garrison & Arbaugh, 2007). Teaching presence may have been lacking because of what

Wengrowicz (2014) calls high pedagogical and communicational distance between teacher and students. It thus seems that students need information on the teacher's activities to know whether the teacher is present and has for example seen their question. Suggestions for this type of tool include showing each group a version of the Participation tool in which the teacher is also visible as a mark so that the students can see which group(s) the teacher is currently paying attention to, or a check button that the teachers can press to indicate he is reading or monitoring a groups' activities.

4.3. Limitations and future directions

Given the size of the study's sample, caution should be exerted in drawing general conclusions. Two case studies cannot provide generalizations or conclusions concerning the strategies teachers use nor the way the number of collaborating groups influences these strategies. However, as was stressed throughout this article, our aim has been to provide a qualitative exploration of the question at hand, because there is a lack of research that focuses on the often invisible yet important aspects related to teacher regulation of CSCL. The sample of this study was carefully chosen so as to ensure the right balance between being able to draw valid conclusions and the possibility for in-depth analysis (Onwuegbuzie & Leech, 2007). Follow-up studies on a larger scale could demonstrate whether the results can be replicated to show recurring patterns of how teachers diagnose and choose to intervene during CSCL. Furthermore, it should be kept in mind that the present study was conducted in history education, using tools that were designed to support learning tasks that that can be characterized as complex or wicked problems: there were no right or wrong solutions, and the task involved multiple views on the subject (Munneke, Andriessen, Kanselaar, & Kirschner, 2007). Had the students worked on a task for which clear solutions exist, monitoring the progress and quality of student activities might have been less difficult. The teachers' strategies and experiences and the possible influence of the presence of multiple collaborating groups may differ in this case.

Our goal was to more deeply explore issues related to teacher regulation of CSCL that have not been intensively researched yet, namely the employed diagnosing and intervening strategies and their possible relationship with synchronicity in terms of the presence of multiple collaborating groups. In previous sections we already gave some specific suggestions for future research. Two further directions for future research are highlighted here. First of all, explorative studies like these give rise to a need for larger, quantitative approaches to studying teacher regulation, including aspects such as the experienced information load and the way teachers use the tools that are provided to them. Furthermore, in Section 4.2.1 some suggestions were given for decreasing teachers' experienced information load, such as offering learning analytics to teachers (Van Leeuwen et al., 2014). Further research could point out whether teacher supporting tools can indeed serve this purpose and how such tools may best serve the learning process. Supporting tools may help to achieve the right balance between being informed and being overloaded with information. With the development of learning analytics (Siemens & Gasevic, 2012), teacher tools may move from purely quantitative measures to semantic markers that analyze the content of data. Also, tools should not only focus on providing the teacher with student data, but also on the best way students can be informed about the teacher's actions.

In general, research into class size has mostly focused on the size of the class as a whole, and not on the number of groups (see Section 1.2). Given the implications of the presence of multiple groups for the way the teachers in this study regulated their students' activities, it is important that this aspect of classroom organization receives more attention in CSCL research.

4.4. Concluding remarks

This study has given insights into the demanding task of regulating students' activities during CSCL, in particular concerning the way the presence of multiple groups of students offers challenges as well as opportunities for the teacher. While the synchronicity and associated challenges that teachers face while regulating collaborative learning also play a role during face-to-face education (Doyle, 2006), these challenges become especially clear during CSCL settings, when the possibility to monitor multiple groups simultaneously means there are new possibilities for diagnosing groups' needs and for intervening at both student, group, and class level. Our result indicate the importance of being aware of the balance between number of groups and group size, as each class constellation may have different consequences for both teachers and students. This explorative study made an attempt to widen the framework for describing teachers' strategies and experiences, and shows the need for further research to investigate the best way a learning environment can facilitate learning processes by assisting not only the students, but also the teacher.

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