It's all about metacognitive activities: computerized scaffolding of self-regulated learning

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6  Metacognitive Activities Embedded in Interaction

Abstract In this article we investigate how metacognitive activities are embedded in the interaction between the group members during collaborative learning. Research indicates that the quality of cognitive activities is positively influenced by transactive interaction in which group members relate to and engage in each other’s contributions. We examine if metacognitive activities embedded in different types of interaction are more likely to facilitate the group process. Moreover, we inspect the provisional role of shared attention on interaction. We analyzed 996 metacognitive episodes embedded in the interaction of 6 triads collaborating on a research task in a computer-based learning environment. We found that metacognitive activities can be ignored, accepted, shared and co-constructed among the group members. Shared attention indeed supported more transactive interaction. Moreover, metacognitive activities embedded in more transactive interaction were more likely to facilitate the group process than those embedded in less transactive interaction. These findings confirm that interaction between the group members can positively influence the quality of metacognitive activities and that in collaborative settings it is important to look how metacognitive activities are embedded in interaction.

Keywords  ·  Metacognition  ·  social systems  ·  Collaborative learning  ·  Elementary Education  ·  discourse analysis

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Introduction

In the learning sciences there is a strong focus on computer-supported collaborative learning (Stahl, Koschmann & Suthers, 2006). Many studies aim to explain under which circumstances collaboration among students facilitates learning (Dillenbourgh, Jarvala & Fischer, 2009). A central issue is how learning activities are embedded in the group’s interaction (Chi, 2009; Weinberger & Fischer, 2006). Group members elaborating on each other’s contributions, such as providing feedback, giving critical comments and engaging in arguments, fosters learning (Barron, 2003, Webb, 2009). Yet, this research so far has focused mostly on content-related activities, the cognitive activities. From self-regulated learning research, we know that successful learners not only employ cognitive activities, but also control and monitor their learning with metacognitive activities (Azevedo, Moos, Greene, Winters & Cromley, 2008; Zimmerman, 2002). Successful learners orientate on the learning assignment to set clear learning goals and consequently plan, monitor and evaluate their cognitive activities during learning (Veenman, 2011). Until now, metacognitive activities have received little attention in computer-support collaborative learning as explanatory factor for learning (Dillenbourgh, Jarvala & Fischer, 2009).

Moreover, the discussion of metacognition in the literature does not adequately attended to the social nature of collaborative learning (Hadwin & Oshige, 2011; Iiskalla, Vauras, Lehtinen & Salonen, 2011). There is little research that explores how metacognitive activities are embedded in interaction between the group members. Some studies did find that interaction between the group members positively influences metacognitive activities (Goos, Galbraith & Renshaw, 2002; Iiskala et al, 2011; Lin & Sullivan, 2008). However, these studies focused on full reciprocal interaction among the group members, which is fairly rare in collaborative learning (Dillenbourgh, 1999). Therefore the goal of this article is to further enlarge our understanding how metacognitive activities are embedded in interaction during collaborative learning. This article contributes to our current understanding by differentiating between different types of interaction in which metacognitive activities are embedded. Additionally, we investigate how these metacognitive activities embedded in different types of interaction facilitate the group process and what the provisional role of shared attention is. We analyzed 996 episodes of social metacognitive activities from 6 groups that collaboratively worked on a research task in a computer-based learning environment. First, we introduce the construct of metacognition and elaborate on how it facilitates collaborative learning. Then we argue that analyzing metacognitive activities in small groups needs to consider how these activities are embedded in the groups’ interaction.

Metacognitive activities in social settings

The construct of metacognition originates from cognitive information processing theory (Flavell, 1979). It was originally defined as “cognition over cognition” or “knowledge about knowing”, which a learner needs to control and monitor his learning. A distinction is made between metacognitive knowledge, i.e. the knowledge students have about the
interaction between person, task and strategy characteristics (Flavell, 1979) and metacognitive skills, i.e. the skills to apply metacognitive activities to control and monitor cognitive activities (Veenman, 2005). In order to distinguish clearly between cognitive and metacognitive activities Nelson (1996) defined the object- and the meta-level of learning. Cognitive activities are those activities dealing with the content of the task (the object-level) and metacognitive activities are those activities dealing with controlling and monitoring cognitive activities (the meta-level), such as orientation, planning, monitoring, evaluation and reflection activities (Meijer, Veenman, Van Hout-Wolters, 2006). In educational psychology, students’ ability to regulate their learning is considered important for learning in complex computer-based learning environments (Azevedo & Greene, 2010; Winne & Hadwin, 2011; Zimmerman, 2002). Moreover, the literature emphasizes that metacognitive activities facilitate learning and students that use more metacognitive activities gain higher learning achievements (Veenman, 2005; 2011). However, it is important to acknowledge that metacognitive activities can also be inappropriately used and become ineffective when over used (Moos, 2010). Metacognitive activities facilitate learning when they support develop, activate or confirm cognitive activities that consequently help the student to achieve his/her learning goals (Iiskala et al., 2011). However, metacognitive activities can also not facilitate the student when they stop appropriate cognitive activities or slow cognitive activities eliciting inappropriate conceptualizations or representation (Iiskalla et al., 2011).

In small groups learners also need to control and monitor their group’s learning (Hadwin & Oshige, 2007). This entails that groups need to use the appropriate cognitive activities to attain their learning goals and use metacognitive activities to control and monitor their learning (Hadwin & Oshige, 2011, Iiskalla et al, 2011; Volet, Vauras & Salonen, 2009). For example, group members orientate on their learning assignment, plan the group’s activities, monitor the group’s actions and evaluate the correctness of the group’s learning and finally reflect on the learning strategies followed by the group. In group settings it has been proposed that different forms of metacognitive activities occur at various points along the social spectrum, namely individual, other and social metacognitive activities (Iskala, Vauras & Lehtinen, 2004, Iiskala et al., 2011; Hadwin & Oshige, 2011). Individual metacognitive activities occur when a student controls or monitors his/her own cognitive activities (Volet et al, 2009). For example, a student evaluates whether the answer he calculated is correct. Other metacognitive activities are transitional activities between two group members, when one student controls or monitors another student’s cognitive activity (Iiskala et al., 2011; Volet et al., 2009). For example, a group member evaluates the answer a group member calculated, supporting the evaluation of the cognitive activity of that group member. Finally, social metacognitive activities occur when one or more group members control or monitor the group’s collaborative cognitive activities (Volet, et al, 2009). For example, a group member evaluates whether the answer the group calculated is correct, supporting the evaluation of the cognitive activity of the group.
In this chapter, we focus on social metacognitive activities. As indicated in the introduction an important issue is the way social metacognitive activities are embedded in the interaction among the group members. Collaborative learning research consequently found that cognitive activities embedded in more intensive interaction between the group members had higher quality and supported learning more (Teasley, 1997; Roschelle, 1996; Stahl, 2005; Suthers, Dwyer, Medina & Vatrapu, 2010). In small groups learning activities are formed through reciprocal activities between the students in which they exchange, share and co-construct activities (Volet et al, 2009). Consequently, students influence each other in a spiral-like fashion; students contribute activities to the social system, which can elicit new activities from the group members (Salomon, 1993). This mechanism is likely to also affect metacognitive activities, for example, one student monitors the groups learning activity by stating that he thinks the calculation the group is performing is wrong. Another group member can ask the student why the calculation is wrong, asking the first student to further elaborate on his monitoring. Hence when the group members engage in intensive interaction around metacognitive activities, this is likely to alter metacognitive activities. Goos, Galbraith and Renshaw (2002) highlight the significance of intensive interaction in contributing to productive metacognitive decisions by the group.

However, previous research only looked at instances of so-called socially shared metacognitive activities. These were embedded in fully reciprocal interaction between group members (Iiskala et al. 2011). From collaborative learning research we know cognitive activities can be embedded in different ways in the group member’s interaction and that fully reciprocal interaction happens relatively infrequently (Weinberger & Fischer, 2006). Therefore, it is important to consider how metacognitive activities are embedded in the interaction between the group members beyond the most intensive type of interaction. In the next section we discuss different types of interaction and how metacognitive activities can be embedded this interaction.

**Metacognitive activities embedded in interaction**

Research clearly shows that the advantage of the group’s interaction on learning depends on the quality of students’ interaction and their discussions (Webb, 2009). Different types of interaction are distinguished in collaborative learning theory. In individual dialogue group members externalize their own knowledge without reference to other students’ activities or engage in disputational talk that is characterized by disagreements, short exchanges and assertions (Chi, 2009; Mercer, 1996; Weinberger & Fischer, 2006). In joint dialogue group members do respond to each others contributions in different ways. Students can elicit activities from other group members through asking questions or explanations (Weinberger & Fischer, 2006). Moreover in cumulative talk they exchange and share existing knowledge making substantive contributions to the same topic (Chi, 2009; Hatano, 1993; Mercer, 1996, Webb, 2009). However, students are not always critical to each other’s contributions. Often they do not disagree with each other or demand for justifications, therefore this type of interaction is also referred to as quick consensus.
building (Clark & Brennan, 1991; Fischer et al., 2002; Weinberger, 2003). In conflict-oriented consensus building students do challenge each other’s ideas through disagreement (Fischer et al., 2002, Weinberger & Fischer, 2006). Whereas integrated-orientated consensus building (Fischer et al., 2002, Weinberger & Fischer, 2006) or explorative talk (Mercer, 1996, Webb, 2009) refers to students that built on each other’s activities collaboratively constructing new knowledge. Students share each other’s knowledge and additionally explain and question each other’s thinking and provide feedback one and other. Co-construction among group members often leads to knowledge that individual group members are unlikely to generate by themselves (van Boxtel, van der Linden, Roelofs & Erkens, 2002; Damon, 1984).

In these different descriptions of interaction, the constructs “relate to” and “engage in” are very important. Students relate to a group member’s previous contribution when they are referring to the same topic in their next contribution (Barron, 2000; 2003). They engage in a group member’s contribution when they are responding, discussing and elaborating on the previous contribution (Barron, 2000; 2003). During collaborative learning the extent to which students relate to and engage in on each other’s contributions is called transactivity. It has been shown that more transactive interaction supports groups to benefit from their collaboration, gaining more knowledge and better learning (Weinberger & Fischer, 2006). Transactivity varies in different types of interaction (Weinberger & Fischer, 2006; Fischer et al., 2002). Until now this construct is mostly used to analyze how students’ cognitive activities are embedded in interaction, but can also be applied to analyze metacognitive activities embedded in interaction.

Based on the above, we make a distinction between 4 different types of interaction that describe how metacognitive activities can be embedded in groups’ interaction (see figure 13). First, when metacognitive activities are not related to nor engaged in, we call them ignored metacognitive activities. These activities occur when a group member attempts to control or monitor the group’s learning activities, but the other group members ignore this effort. For example, a student evaluates the answer of the group calculated commenting that he thinks the answer is wrong and the other group members do not react.

Second, when metacognitive activities are engaged in but not related to, we call them accepted metacognitive activities. They occur when a group member engages in a metacognitive contribution within a cognitive activity that applies the controlling or monitoring activity suggested. For example, a student evaluates the answer the group calculated commenting that he thinks the answer is wrong. Another group member starts to re-calculate the answer. This indicates that the evaluation activity is noticed and followed up in the calculation.
Third, another form of metacognitive activities embedded in interaction are shared metacognitive activities. They occur when a group member monitors or controls the group’s learning activity and another group member relates to this activity with a metacognitive activity. The students share existing metacognitive knowledge, but do not engage in discussion, elaboration or revision of the metacognitive activities. For example, a student evaluates the answer the group calculated commenting that he thinks the answer is wrong. Another group member comments that he believes the answer might be wrong too.

Fourth, students can co-construct metacognitive activities. This occurs when group members relate to and engage in each other’s metacognitive activities. The metacognitive contributions become object of discussion, revision or elaboration by the group members. Group members build on each other’s metacognitive activities regulating the group’s cognitive activities co-constructing metacognitive activities. For example, a student evaluates the answer of the group calculated commenting that he thinks the answer is wrong. Another group member comments that he believes the answer might be right and justifies this comment. The third student evaluates the comments of the previous two.

To summarize the above, we expect metacognitive activities to be embedded in different types of interaction; ignored, accepted, shared or co-constructed metacognitive activities. In ignored metacognitive activities there is no transactivity. We speak of medium transactivity as group members relate to or engage in each other’s contributions. Finally, high transactivity is occurring when members relate to and engage in each other’s contributions. Moreover groups that are successful at collaborative problem solving are better able to regain shared attention focusing the collaborative group effort. These students relate to each other’s contributions sharing perspectives on a similar topic and engage in each other’s questions, discussions and explanations (Barron, 2000, 2003). On the other hand, groups that are less successful at problem solving often show relational
issues such as competitive and self-focused interactions (Barron, 2000). Group members ignore each other’s contributions and externalize their own thoughts without refereeing to their group members ideas. Thus differences between succesful and unsuccesful groups can be explained by the type of interaction between the group members. Moreover, shared attention among the group members seems provisional to create reciprocal and symmetric interaction to which all group members contribute (Barron, 2003; Sfard & Kieran, 2001).

**This study**

The purpose of this study is to understand how metacognitive activities are embedded in students’ interaction. Group members could engage in ignored, accepted, shared or co-constructed metacognitive activities which are accompanied with no transactivity to high transactivity. One factor associated in the literature with transactive interaction is the group’s shared attention. We expect that shared attention among the group members positively affects the transactivity in the interaction. Moreover, transactive interaction is found to support the quality of the activities. Therefore we expect that metacognitive activities embedded in more transactive interaction are more likely to facilitate the group’s process. We will analyze 996 social metacognitive episodes of 6 groups to answer the following research questions:

1. How are metacognitive activities embedded in the group’s interaction, i.e., to what extent do ignored, accepted, shared and co-constructed metacognitive activities occur?
2. Does shared attention among the group members support transactive interaction?
3. Are metacognitive activities embedded in more transactive interaction more likely to facilitate the group process?

The data were taken from 6 groups that work face to face in a computer-based learning environment on a writing task.

**Method**

**Participants**

For this study, we used the discourse from 6 triads taken from a study into the effects of scaffolding on metacognitive activities (Molenaar, van Boxtel & Sleegers, 2010). The selected triads were in the control group of this study. We selected these groups because the metacognitive activities in their discourse are not influenced by scaffolding and represent how groups normally monitor and control their learning in computer-based learning environments. The triads were from 6 different classes divided over three schools. The teachers assigned the students to triads based on the principle of heterogeneity (mixed gender, reading and computer ability and school performance). The triads came from grade 4(1), 5(3) and 6(2) of elementary education in the Netherlands. Names used in the examples are not the real names of the students and students and their parents agreed to participate in this study.
Virtual learning environment and assignment

The e-learning environment used in this study is called Ontdeknet. It focuses on supporting students in their virtual collaboration with experts (Molenaar, 2003). The experts provide students with information about their expertise, namely knowledge about their country for this study. The experts’ contributions were edited by the editor of Ontdeknet. The teacher gives the assignment to the students and monitors their progress. Collaborative learning is implemented at two levels: students collaborating with an expert in a virtual environment and with each other face-to-face in small groups behind the computer. The total duration of the study was 8 lessons of 1 hour. In the first lesson, the students were given instructions about the task and the electronic learning environment in which they performed the task and made a pre-test and during the last lesson they filled in different questionnaires. In 6 lessons the triad worked on a task called “Would you like to live abroad?” The goal of the task was to explore a country of choice (New Zealand or Iceland), write a paper on the findings and decide if they would like to live in this country. The triads worked on one computer and had access to an inhabitant of the country. They could consult the expert by asking questions and requesting information about different topics about the country that they were interested in. In the expert section, the requested information about the country was written by the expert and questions were answered in a forum. The task to write a paper about the country was preceded by 4 sub-tasks: introducing the group, writing a goal statement, selecting a country and specifying topics of interest in a mind map to further support the collaboration with the expert. All tasks were integrated into the working space of the triads, where they also wrote the paper. The performance of the triads was stored in the learning environment. All lessons were supervised by the same researcher (the first author).

Measurement

The discourse analysis

The discourse of 6 groups (36 hours) was audio-taped, transcribed (15,531 turns) and analyzed in six steps. The reliability reported for every step is based on the coding of two independent raters that analyzed the discourse of 2 randomly selected triads (2500 turns). First, we detected the metacognitive activities in the groups (Molenaar et al., 2010). All turns were coded with mutually exclusive and exhaustive categories. The categories were cognitive, metacognitive, relational, procedural, off task, not-codable activities and teacher activity (see table 14 for an overview). There was excellent (Fleiss, 1981) agreement for these categories: the kappa was $K=0.92$. Cohens’ kappa was highest for the category metacognitive activities $K=0.94$ and lowest for category non-codable activities $K=0.82$. 
Table 14. Main categories of our coding schema

<table>
<thead>
<tr>
<th>Main category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacognitive activity</td>
<td>Turns about monitoring and controlling the cognitive activities during learning</td>
</tr>
<tr>
<td>Cognitive activity</td>
<td>Turns about the content of the task and the elaboration of this content</td>
</tr>
<tr>
<td>Relational activity</td>
<td>Turns regarding the social interaction between the students in the triad</td>
</tr>
<tr>
<td>Procedural activity</td>
<td>Turns regarding the procedures to use the learning environment</td>
</tr>
<tr>
<td>Teacher/researcher</td>
<td>Turns that are made by the teacher or the researcher.</td>
</tr>
<tr>
<td>Off task</td>
<td>Turns that are not relevant to the task.</td>
</tr>
<tr>
<td>Not codable</td>
<td>Turns that are too short or unclear to interpret</td>
</tr>
</tbody>
</table>

Second, we determined the metacognitive episodes. Metacognitive episodes are sequences of turns that discuss the same topic and of which at least one turn is a metacognitive activity. The episode starts with the first metacognitive activity and ends with the last turn dealing with the same topic. An example of a metacognitive episode: (“We start with the first chapter of our paper; What are we going to discuss in the first chapter?; Lets read the information about animals in New Zealand” ). Two researchers independently determined the metacognitive episodes of the 6 groups; the intercoder-agreement was 71%. All inconsistencies between the two coders were re-coded in mutual agreement.

Third, we determined the form of metacognitive activities namely individual-, other- or social metacognitive activities in the episodes. Individual metacognitive activities occur when one student is regulating his or her own cognitive activities; for example (“Stop I need to think about this”). Other-metacognitive activities occur when a group member regulates the individual cognitive activity of another group member, for example (“What are you doing?; I am trying to understand this question”). Social metacognitive activities occurs when one or more group members regulate their collaborative cognitive activities, for example: (“What are we writing?; The goal statement; What is the goal statement?; That is where you write what you want to learn”). Cohen’s kappa was 0.91 which indicates excellent agreement (Fleiss, 1981).

Fourth, we established if there was shared attention among the group members at the start of the metacognitive activities. In case the topic discussed in the episode was talked about in the turns preceding the metacognitive episode, we coded it as in the group’s shared attention. An example of a metacognitive episode shared in attention is (“In New Zealand there are much different animals; This is wrong we cannot write there are much different animals; Ok let’s write many different animals”). In this example, the topic is (“In New Zealand there are much different animals”). This sentence is in the group’s shared attention, as two group members are contributing to the construction of the same sentence, when one group member monitors that the sentence is wrong. An example of a metacognitive episode not shared in attention: (“In New Zealand there are many different animals; We need to discuss the language too”). Here a group member introduces a new
topic to discuss in the group’s paper, when the group’s attention is focused on constructing the sentence. Cohen’s kappa was 0.72 which indicates acceptable agreement (Fleiss, 1981).

Fifth, for the social metacognitive activities which are a proportion of all metacongitive episodes, we distinguished four types of interaction around metacognitive activities: ignored, accepted, shared or co-constructed metacognitive activities. Ignored metacognitive activities occur when the group members do not relate to nor engage in another group member’s metacognitive activity, for example: *Let’s read this chapter; I am so happy*. Accepted metacognitive activities occur when the group members engage in a metacognitive activity with a cognitive activity, for example: (“*Let’s write down hobbies; My hobbies are Tennis and Ballet*”). Shared metacognitive activities occur when a group member relates to a metacognitive activity with another metacognitive activity, for example: “*We do not know what to do next; True, but I do not know what to do either; What do you think?*”. Finally, when group members not only relate to but also engage in each other’s metacognitive activities, we speak of co-constructed metacognitive activities, for example: “*Let’s start again with the first part of the chapter; Ok what are we describing in the first chapter; We discuss the language of the country, let’s read the chapter about language*”. Cohen’s kappa was 0.86 which indicates good agreement (Fleiss, 1981).

Finally, we determined whether the metacognitive activities are facilitating the group’s process. A facilitating metacognitive episode develops, activates or confirms the group’ cognitive activities that consequently support the group process (Iiskala et al, 2011). For example “*Let’s start again with the first part of the chapter; Ok what are we describing in the first chapter; we discuss the language of the country, let’s read the chapter about language*”. This metacognitive episode facilitates the group process as it activates new activities that support the group progress. Metacognitive activities that do not facilitate the group process when they stop appropriate cognitive activities or slow cognitive activities with inappropriate representations (Iiskala et al, 2011). For example “*We do not know what to do next*”; “*True, but I do not know what to do either*”; “*What do you think?*”. This metacognitive episode slows the group process and it does not support further progress, thus does not facilitate the group process. Cohen’s kappa was 0.71 which indicates acceptable agreement (Fleiss, 1981).

**Analysis**

To answer our first research question, we the frequency of different types of interaction around metacognitive activities in social metacognitive episodes are computed. To answer our second research question, we calculated the association between shared attention and different types of metacognitive interaction using the Chi-square ($\chi^2$). A significant $\chi^2$ indicates that the occurrence of shared attention among the different types of metacognitive interaction is significantly different from chance. To analyze the relationship between shared attention and each type of metacognitive activities, we calculated the odds ratios.
The odds ratio is an effect size for categorical data \(^9\) (Fields, 2005), which indicates how much more/less likely it is for a particular type of metacognitive interaction to be in shared attention compared to the other types of interaction. We use the same analysis to determine the relation between the type of interaction and the function of the metacognitive episodes (third research question).

**Results**

We start with descriptive information about the number of metacognitive episodes and the forms of metacognitive activities in the episodes. Among the 15,153 turns in the conversation of the triads during 36 hours, there were 2649 metacognitive turns (17.5%). We saw a relatively equal participation of all group members in the different episodes. We found 1150 metacognitive episodes of which 62 (6.2%) were individual metacognitive activities, 92 (9.3%) other-metacognitive activities and the remaining 996 (84.5%) were social metacognitive activities. There was a clear distinction between the individual, other and social metacognitive activities. Examples of individual metacognitive activities “Stop I need to read that” and “I need to write this down to remember it” and examples of other metacognitive activities “Where are you?” and “What is it you do not understand?” clearly focused at individual cognitive activities. Social metacognitive activities are clearly directed at the group’s cognitive activities, such as “We have not read this properly” or “We have not writing about the language of the country”. This indicates that although there are different forms of metacognitive activities during collaborative learning the amount of individual and other- metacognitive activities in this sample is not very high.

**Metacognitive activities embedded in interaction**

The first research question is: how are metacognitive activities embedded in the group’s interaction, i.e., to what extent do ignored, accepted, shared and co-constructed metacognitive activities occur? As mentioned earlier, to find answers for this question we only used the social metacognitive activities, thus all social metacognitive activities accumulate to 100%. Figure 14 provides an overview of the frequency of different types of interaction and table 15 provides the specifications per triad.

We found 218 (22%) episodes with ignored metacognitive activities. There is some variation between the six triads ranging from 18% to 27% of ignored metacognitive activities (see table 15). Many instances of ignored metacognition are simple comments such as (“What are we doing?”). Group members just ignore these attempts. However, there are also examples were the group ignores social metacognitive activities that are precise statements. For example, the group members were writing a chapter about the

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\(^9\) Odds ratio \(_{\text{ignoredMC in shared attention}}\) = odds ignored metacognitive activities in shared attention/ odds ignored metacognitive activities not in shared attention.

Odds ratio \(_{\text{otherMC in shared attention}}\) = odds other metacognitive activities in shared attention/ odds other metacognitive activities not in shared attention.

Odds ratio = Odds ratio \(_{\text{ignoredMC in shared attention}}\)/Odds ratio \(_{\text{otherMC in shared attention}}\).
economy of Iceland. They formulate sentences together such as (“Everything is really expensive on Iceland”). Kim monitors that the last sentence is not correct and asks (“Can we please remove the last sentence; it does not fit in this context?”) Ellen just ignores this comment and continues with (“I write; everything is really expensive on Iceland”). Here the group continues without taking the comment from Kim into consideration, even though here statement is not difficult to interpret.

We found 218 (22%) episodes with ignored metacognitive activities. There is some variation between the six triads ranging from 18% to 27% of ignored metacognitive activities (see table 15). Many instances of ignored metacognition are simple comments such as “What are we doing?”. Group members just ignore these attempts. However, there are also examples were the group ignores social metacognitive activities that are precise statements. For example, the group members were writing a chapter about the economy of Iceland. They formulate sentences together such as “Everything is really expensive on Iceland”. Kim monitors that the last sentence is not correct and asks “Can we please remove the last sentence; it does not fit in this context?” Ellen just ignores this comment and continues with “I write; everything is really expensive on Iceland”. Here the group continues without taking the comment from Kim into consideration, even though here statement is not difficult to interpret.

We found 317 (32%) episodes with accepted metacognitive activities. There is some variation between the six triads ranging from 22% to 32% of accepted metacognitive activities. Accepted metacognitive activities are followed by a cognitive activity indicating that the group member(s) engaged in the metacognitive contribution. For example, Joep makes a plan to enter words into the mind map “What do we want to know about Iceland?” Kim immediately makes a new entry in the mind map “I want to know which the language they speak; what language do you speak?” Kim’s contribution indicates that her response to Joep’s planning contribution proposing another topic that can be discussed in the mind map.
We found 418 (41%) episodes with shared metacognitive activities, in which group members relate to the same topic in different metacognitive contributions. There is quite some variation between the six triads ranging from 33% to 56% of shared metacognitive activities. For example, we see a group trying to formulate their next activity “What did it say there?”. They relate to each other’s contributions “Why do we do that?” and “What are we going to do next?”, but they do not engage in each other’s questions providing answers to each other. Consequently, they do not manage to construct a new plan to continue.

Finally, 43 (5%) episodes showed co-constructed metacognitive activities. There is quite some variation between the six triads ranging from 2% to 10% of co-constructed metacognitive activities. In these episodes, the group members related to the same topic and engaged in collaboratively constructing new metacognitive activities. For example, the group members collaboratively monitor their progress on filling in the mind map. Kim states that they are done as they have 6 entries “We are done we have six entries”, which is confirmed by Joep “Yes we have 6 entries”. Then Ellen suggests to do one more “Let’s do one more”, contradicting the fact that they are finished. Then Kim claims that 6 is enough, “No we only need 6 entries”. This raises Ellen’s counter argument that an essential element is missing “No, we also need to put language as an entry”. In this example, the group members engage in a discussion about whether they are going to add more entries, integrating each other’s knowledge in criticizing each other’s contributions collaboratively building towards cognitive activities that optimize their work.

Table 15. Types of interaction per group and percentage of the total social metacognitive activities per group

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
<th>Ignored</th>
<th>Accepted</th>
<th>Shared</th>
<th>Co-constructed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>125</td>
<td>34 (27%)</td>
<td>45 (36%)</td>
<td>41 (33%)</td>
<td>5 (4%)</td>
</tr>
<tr>
<td>Group 2</td>
<td>136</td>
<td>31 (23%)</td>
<td>39 (29%)</td>
<td>52 (38%)</td>
<td>14 (10%)</td>
</tr>
<tr>
<td>Group 3</td>
<td>162</td>
<td>33 (20%)</td>
<td>53 (33%)</td>
<td>68 (42%)</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>Group 4</td>
<td>205</td>
<td>37 (18%)</td>
<td>46 (22%)</td>
<td>115 (56%)</td>
<td>7 (3%)</td>
</tr>
<tr>
<td>Group 5</td>
<td>168</td>
<td>31 (18%)</td>
<td>64 (38%)</td>
<td>70 (42%)</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>Group 6</td>
<td>200</td>
<td>52 (26%)</td>
<td>70 (35%)</td>
<td>72 (36%)</td>
<td>6 (3%)</td>
</tr>
<tr>
<td>Total</td>
<td>996</td>
<td>218 (22%)</td>
<td>317 (32%)</td>
<td>418 (41%)</td>
<td>43 (5%)</td>
</tr>
</tbody>
</table>

We found 418 (41%) episodes with shared metacognitive activities, in which group members relate to the same topic in different metacognitive contributions. There is quite some variation between the six triads ranging from 33% to 56% of shared metacognitive activities. For example, we see a group trying to formulate their next activity “What did it say there?”. They relate to each other’s contributions “Why do we do that?” and “What are we going to do next?”, but they do not engage in each other’s questions providing answers to each other. Consequently, they do not manage to construct a new plan to continue.

Finally, 43 (5%) episodes showed co-constructed metacognitive activities. There is quite some variation between the six triads ranging from 2% to 10% of co-constructed metacognitive activities. In these episodes, the group members related to the same topic and engaged in collaboratively constructing new metacognitive activities. For example, the group members collaboratively monitor their progress on filling in the mind map. Kim states that they are done as they have 6 entries “We are done we have six entries”, which is confirmed by Joep “Yes we have 6 entries”. Then Ellen suggests to do one more “Let’s do one more”, contradicting the fact that they are finished. Then Kim claims that 6 is enough, “No we only need 6 entries”. This raises Ellen’s counter argument that an essential element is missing “No, we also need to put language as an entry”. In this example, the group members engage in a discussion about whether they are going to add more entries, integrating each other’s knowledge in criticizing each other’s contributions collaboratively building towards cognitive activities that optimize their work.

Shared attention

In our second research question we proposed that shared attention at the beginning of an episode could sustain more transactive interaction. As expected, we found a significant association between the type of the interaction and shared attention $\chi^2 (3)=29.86$, p<0.000.

In figure 15 an overview is given of the relation between the type of interaction and in shared attention. The percentage indicated in the circles shows the percentage of the episodes that were started with shared attention among the group members, thus 54% of the accepted metacognitive activities started with shared attention among the group members. In order to understand this association better, we looked at the odds ratio, which...
indicates the odds of specific type of interaction to be in shared attention compared to the odds of other types of interaction to be in shared attention.

*Figure 15. Percentage of episodes in shared attention specified per type of interaction.*

Episodes with ignored metacognitive activities were in shared attention 37.6% of the time. This seems to represent the fact that based on the odds ration ignored metacognitive activities were 2.2 times less likely to be in shared attention at the beginning of the episode compared to the other types of metacognitive activities embedded in interaction. Episodes with accepted metacognitive activities were in shared attention 53.6% of the time. This seems to represent the fact that based on the odds ration ignored metacognitive activities were 1.4 times more likely to be in shared attention at the beginning of the episode compared to the other types of metacognitive activities embedded in interaction. Episodes with shared metacognitive activities were in shared attention 59.4% of the time. This seems to represent the fact that based on the odds ration ignored metacognitive activities were 1.63 times more likely to be in shared attention at the beginning of the episode compared to the other types of metacognitive activities embedded in interaction.

**Function**

To answer our third research question, we examined if episodes with more transactive interaction would be more likely to facilitate the group process. We found a significant association between the type of interaction and facilitation $\chi^2 (3)=423.63, p<0.000$. In figure 16 an overview is given of the relation between the type of interaction and facilitation, representing the percentage of metacognitive activities that were facilitating the group process of a particular type of interaction. For example, 98% of the co-constructed metacognitive activities facilitated the group process.
In order to understand this association better, we calculated the odds ratio, which indicates the odds of specific type of interaction to facilitate the group process compared to the odds of other types of interaction to facilitate the group process. Episodes with ignored metacognitive activities did hardly facilitate the group process. This seems to represent the fact that based on the odds ration ignored metacognitive activities were 67 times less likely to facilitate the group process compared to metacognitive activities embedded in other types of interaction. Episodes with accepted metacognitive activities facilitated the group process 82% of the time. This seems to represent the fact that based on the odds ratio accepted metacognitive activities were 15.1 times more likely to facilitate the group process than metacognitive activities embedded in other types of interaction. Episodes with shared metacognitive activities facilitated the group process 70% of the time. This seems to represent the fact that based on the odds ration shared metacognitive activities were 2.1 times more likely to facilitate the group process than metacognitive activities embedded in other types of interaction. Finally, episodes with co-constructed metacognitive activities facilitated the group process 98% of the time. This seems to represent the fact that based on the odds ration co-constructed metacognitive activities were 30 times more likely to facilitate the group process than metacognitive activities embedded in other types of interaction.

**Co-constructed metacognitive activities that facilitate the group process**

Our findings indicate that co-constructed metacognitive activities are most likely to facilitate learning and that they are most likely to occur when the group has a shared attention at the beginning of the episode. In example 6, we show an example of this type of interaction between the students. In this example the group is formulating sentences for their paper based on the summary they made from experts’ information. All three students are participating in this discussion and thus there is shared attention at the start of the metacognitive episode. It starts with Rob who notices that they are done writing the summary of the first diary of the expert. Then Jacob adds that this is already more than the
summary, but Rob insist this is the summary of general information about New Zealand. Susan contributes to this discussion that the last sentences were really about distances. Rob agrees and suggests a different approach namely making two chapters. Susan agrees and creates a new chapter. Then the group continues to formulate new sentences for the new chapter about distances. The metacognitive activities are embedded in an interaction that is co-constructive as Jacob is engaging in Rob’s contribution, Rob relates to Jacob’s comment and Suzan engages in both previous comments. Rob and Jacob finalize the metacognitive episode engaging in Susan’s comment. These co-constructed metacognitive activities support the group to monitor their cognitive activities and help them to construct a paper with a better quality. Hence, they facilitate the group’s process differentiating between two different elements in the group’s paper.

**Example 6. An example of co-constructed metacognitive activities that facilitate learning**

<table>
<thead>
<tr>
<th>Student name</th>
<th>turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susan</td>
<td>Trains drive for long days,</td>
</tr>
<tr>
<td>Jacob</td>
<td>Doctors often come by airplane, komma, they…..</td>
</tr>
<tr>
<td>Susan</td>
<td>With the airplane</td>
</tr>
<tr>
<td>Rob</td>
<td>This is what we had to write down; this was the summary of the first diary of the expert.</td>
</tr>
<tr>
<td>Jacob</td>
<td>This was already more than the first summary</td>
</tr>
<tr>
<td>Rob</td>
<td>This is about the country, are we still writing about the country,</td>
</tr>
<tr>
<td>Susan</td>
<td>No actually we are not writing about the country, but about distances</td>
</tr>
<tr>
<td>Rob</td>
<td>Then we have to do this differently;</td>
</tr>
<tr>
<td>Jacob</td>
<td>Then we can make two chapters; the country and the distances</td>
</tr>
<tr>
<td>Susan</td>
<td>Ok hold on I make a new chapter</td>
</tr>
<tr>
<td>Rob</td>
<td>Lets’ start with the chapter about the distances</td>
</tr>
<tr>
<td>Susan</td>
<td>Yes, we can use the sentence: trains drive for long days</td>
</tr>
<tr>
<td>Jacob</td>
<td>Yes and doctors often come with an airplane,</td>
</tr>
<tr>
<td>Rob</td>
<td>Perfect and we can add the size of the country….</td>
</tr>
<tr>
<td>Rob</td>
<td>New Zealand consists of two island</td>
</tr>
</tbody>
</table>

**Discussion**

In this article we focused on how metacognitive activities were embedded in the interaction between the group members and how that influences the quality of the metacognitive activities. Additionally, we explored if more transactive interaction is supported by shared attention. We analyzed 996 metacognitive episodes of 6 triads working on an open research task in an electronic learning environment. We found that the majority of metacognitive activities were focused at the group level. Yet, there also were individual and other metacognitive activities confirming the proposition that there are several forms of metacognitive activities along the social spectrum (Hadwin & Oshige, 2011; Iiskala et al, 2011). The study showed that instances of individual and other metacognitive activities are clearly distinguishable from instances of social metacognitive activities. From these data we learned that social metacognitive activities are not necessarily performed by more than one group member. An example of social
metacognition produced by one person is “After this we are going to write the goal statement”. This planning activity is clearly directed at the social level, namely the activities of the group. Thus even though this activity is produced by only one group member, we believe it should be considered as social metacognition.

Furthermore, this analysis indicated that groups’ metacognitive activities are indeed embedded in different types of interaction. We found ignored, accepted, shared and co-constructed metacognitive activities in our sample. Most metacognitive activities were shared, as they were embedded in episodes in which the group members related to each other’s metacognitive contributions with new metacognitive remarks. There also was a substantial amount of accepted metacognitive activities that were immediately engaged in by the group members in new cognitive activities. There were quite some ignored metacognitive activities that were not taken up by the group members at all. Finally, we only found a restricted number of co-constructed metacognitive activities. The results showed that the metacognitive activities in small groups are indeed embedded in different types of interaction. The co-constructed social metacognitive activities were also found in other studies of metacognitive activities in collaborative settings. There it was referred to as socially shared metacognition (Iiskala et al., 2004: 2011). However, co-constructed metacognitive activities did as expected not occur frequently and therefore we showed that it is important to investigate how metacognitive activities are embedded in less transactive interaction.

In this study we further elaborated on the role of shared attention supporting transactive interaction among the group members. We found that ignored metacognitive activities were less likely to be in shared attention of the group members. On the other hand, accepted and shared metacognitive activities were more likely to have shared attention at the beginning of the metacognitive episode. Finally, co-constructed metacognitive activities were even more likely to have shared attention at the beginning of the episode. Therefore it seems that shared attention is supportive to medium and high transactive interaction, which is in concurrence with earlier findings of Barron (2000; 2003) that shared attention supports transactive interaction.

We also explored if more transactive interaction was more likely to facilitate the group’s process. Episodes with ignored metacognitive activities never facilitated the group process. Metacognitive episodes with accepted metacognitive activities are likely to facilitate the group process as do episodes in which metacognitive activities are shared. Finally, episodes in which metacognitive activities are co-constructed were as expected much more likely to facilitate the group process. Thus metacognitive activities embedded in medium transactive interaction are likely to facilitate and metacognitive activities embedded in high transactive interaction almost always facilitate the group process. These findings co-occur with earlier findings from collaborative learning research (Chi, 2009; Webb, 2009; Weinberger & Fischer, 2006). We verified that metacognitive activities in more transactive interaction are more likely to facilitate the group process.
These findings have two consequences: first, for the analysis of metacognitive activities in small groups, it is important to take into account the type of interaction these activities are embedded in. Consequently, in comparative analysis of metacognitive activities during collaborative learning, for example, to understand why one group outperforms another group, the focus should not only be on the quantity of metacognitive activities, but also on the type of interaction these metacognitive activities are embedded in. Looking at these two elements can enhance our understanding of how metacognitive activities in social settings influence learning.

Second, our findings have a number of implications for instructional designs that focus on supporting metacognitive activities in small groups. They should aim at creating shared attention among the group members to support more transactive interaction. Moreover, designs should intend to reduce ignored metacognitive activities and elicit accepted, shared and especially co-constructed metacognitive activities. So far, instructional designs supporting metacognitive activities such as scaffolding have mainly looked at the effect on students’ learning achievements and the stimulation of metacognitive activities. This study indicates that the students’ interaction around metacognitive activities is also an important aspect to take into consideration when evaluating the effect of instructional designs in collaborative settings. As more transactive interaction is more likely to facilitate the group process an important future research question is to gain a better understanding of what stimulates groups to engage in transactive interaction and how instructional designs can influence this.

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