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DOI

[10.1007/s10649-006-1688-4](https://doi.org/10.1007/s10649-006-1688-4)

Publication date

2006

Document Version

Final published version

Published in

Educational Studies in Mathematics

[Link to publication](#)

Citation for published version (APA):

Dekker, R., Elshout-Mohr, M., & Wood, T. (2006). How children regulate their own collaborative learning. *Educational Studies in Mathematics*, 62(1), 57-79.
<https://doi.org/10.1007/s10649-006-1688-4>

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HOW CHILDREN REGULATE THEIR OWN COLLABORATIVE LEARNING

ABSTRACT. In this article we analyze the dialogic learning of one pair of students in order to investigate how these students cope with a collaborative learning situation in the classroom. Our aim is to substantiate the claims that not only are young students (8 year olds) capable of solving mathematical problems collaboratively, but that they also take an active role in regulating their collaborative learning activities. More specifically, our claim is that children appear to apply constructs of ‘mathematical level raising’, ‘social interaction’ and ‘division of time’ to steer their own collaborative learning and that they are rather successful in balancing these three aspects. The analysis is exploratory, but this new perspective on collaborative learning is relevant theoretically and consequential for classroom practice.

KEY WORDS: collaborative learning, division of time, mathematical level raising, self-regulation, social interaction

1. INTRODUCTION

1.1. *Multiple perspectives*

Collaborative learning as a means of instruction and class organization is popular both in classrooms and as a topic of research. Much progress in understanding how children learn in such settings has been made since the gap diminished between researchers who are mainly interested in ‘social learning’, i.e. collaborative learning in a socio-cultural setting with relatively open learning goals, and researchers who focus on cognitive aspects of collaborative learning in educational contexts where learning goals are relatively fixed (Van der Linden and Renshaw, 2004). Van Boxtel (2004), for instance, based an inclusive framework for describing, designing and evaluating collaborative concept learning on a review of both socio-cultural and cognitive constructivist studies. The challenge, according to Van Boxtel, is to direct peer interaction towards four characteristics, namely ‘talk about the concepts to be learned’, ‘elaborative contributions from the participants’, ‘a continuous attempt to achieve a shared understanding of the concepts’ (co-construction), and ‘making productive use of the mediation-means (tools) that are available’. As instruments for directing peer interaction she suggested ‘careful construction of the task’ (including

available tools), 'establishing and sustaining a broader setting' (for example, school climate) and 'managing the participation of the students' (in the perspective of their participation in previous and subsequent learning tasks).

Interestingly, Van Boxtel raised the issue of the complex dynamics between diverse aspects of peer interaction. For example, in order to construct an adequate task (including adequate tools for the learners) one might seek to answer the question of what counts more, the prepositional quality of the students' talk about concepts to be learned or the elaborative character of their contributions to the dialogue. Several researchers, who contributed to the book "Dialogic Learning" that was edited by Van der Linden and Renshaw (2004) focused on the issue of multiple interpretation of dialogic learning events. Kaartinen and Kumpulainen (2004) stated that they preferred to provide educators and researchers with "lenses to examine collaborative learning" rather than to try to provide normative guidelines. Dekker et al. (2004) described dialogic learning events, which they interpreted and weighed differently depending on chosen perspective. One of these events, for instance, concerned a teacher who took action to raise students' adherence to classroom norms and thereby prompted collaborative learning. At the same time, however, she inadvertently disturbed an ongoing elaborative dialogue between the students and thus hindered collaborative learning. Erkens, in his contribution to the book, concluded that the main challenge for students, who engage in collaborative learning, is to coordinate activities (Erkens, 2004). This coordination, according to Erkens, requires 'focusing' (coordination of task related strategies), 'grounding' (construction of a common frame of reference), and 'explicit argumentation' (accounting for mutual and shared understanding).

The issue of multiple interpretations was also raised by Even and Schwarz (2003). These authors exemplified how analyses of a lesson using two different theoretical perspectives led to different interpretations and understandings of the same lesson. Even and Schwarz also revisited the claim of Guba and Lincoln (1994) that "theory and facts are quite interdependent—that is, that facts are facts only within some theoretical framework" (p. 107).

Growing interest in studying collaborative learning from multiple perspectives has resulted in new research questions concerning integration, orchestration and coordination. How do educational designers, researchers, teachers and students cope with the manifold perspectives, which are relevant for the quality of collaborative learning but which cannot always be reconciled?

1.2. *The aim of our study*

In our study we follow up on the idea that teachers and educational designers may direct collaborative learning, as indicated by Van Boxtel (o.c.), but argue that the students, too, have to cope with these multiple perspectives. We contend that in order to understand the collaborative process we need to consider what the students bring to the process of regulating and integrating these multiple perspectives. Wood and Yackel (1990) showed that social norms may be initiated by the classroom teacher, but that the students' ability and commitment to adhere to the shared expectations is equally important. In the same vein, we assume that it is important for students to find strategies to approach the 'carefully constructed tasks', to decide for themselves which use they make of 'available tools' and to determine how conscientiously they want to 'prepare themselves for participation in subsequent classroom discussion of their learning'. Although, teachers and the classroom climate can strongly influence the students' commitments, conceptualizations and strategies, our claim is that each pair of students still has to regulate their own collaborative learning. More precisely, we claim that even young students are capable of orchestrating their collaborative learning in such a way that they cope with several perspectives at the same time. This claim does not, of course, imply that the students will always be capable of reconciling the different concerns. It merely implies that they are not only engaged in solving the given mathematical tasks, but also in actively regulating their collaborative learning.

1.3. *Theoretical and practical implications*

Theoretically, this study is interesting because it links research on collaborative learning in a new way to research on individual learning. The idea that students regulate their own learning and that self-regulation contributes to performance is well known and accepted when individual learning is examined (Winne and Butler, 1996). Self-regulation in the form of 'self-explanation' has been shown, for instance, to improve both the acquisition of problem-solving skills by studying worked-out examples and the acquisition of declarative knowledge by studying expository text (Chi et al., 1994; Webb et al., 2002).

Zeidner et al. (2000, p. 749) defined self-regulation as a "systematic process of human behavior that involves setting personal goals and steering behavior toward the achievement of established goals". Self-regulation does not necessarily require that individuals are aware of the processes involved. In this respect self-regulation is distinct from 'metacognition'. Zeidner et al.

(2000, p. 750) stated that “metacognition is commonly construed as the awareness individuals have of their personal resources in relation to the demands of particular tasks, along with the knowledge they possess of how to regulate their engagement in tasks to optimize goal-related process and outcomes.”

In general, self-regulative activities, such as orientation, planning, monitoring, readjustment of strategies, evaluation and reflection, are found to be more typical of strong than poor learners (Wang et al., 1990). In a study on developing mathematical thinking and self-regulated learning, Pape et al. (2003) stated that self-regulated learners are ‘active participants in their own learning’, are ‘able to select from a repertoire of strategies’ and ‘able to monitor their progress in using these strategies towards a goal’. The following factors are, according to Pape and his colleagues, crucial for fostering development of self-regulation in students in a seventh-grade mathematics classroom: ‘multiple representations and rich mathematical tasks’, ‘classroom discourse’, ‘environmental scaffolding of strategic behavior’ and ‘varying needs for explicating and support’. These factors indicate that developing self-regulation in the learning of mathematics requires, among other things, a social-cultural setting where students have the opportunity to engage collaboratively in mathematical tasks and discourse. If this is indeed the case, which we deem plausible, research on self-regulation of collaborative learning of mathematics will be a valuable counterpart of studies on self-regulation of individual learning.

Practically, the findings of a study into self-regulation of collaborative learning may help teachers to better support students and to use help-giving strategies that build on students’ own informal ways of regulating their collaborative learning. Because assistance in collaborative work is most likely relevant for younger students, we focused our research on students who are 8 years old.

1.4. *The three perspectives in our study*

In the study we focused on three perspectives that may be relevant for children during collaborative work in the mathematics classroom. The first perspective is that the children have to learn mathematics by solving the mathematical tasks. The second is that they have to collaborate in accordance to established classroom norms. The third is that time is limited. They have to use allotted time productively in order to be prepared for the next classroom activity, for instance a whole class discussion of the collaborative work. We labeled these perspectives ‘mathematical level raising’, ‘social interaction’ and ‘division of time’, respectively. As researchers,

we took these three perspectives earlier to analyze collaborative learning (Dekker et al., 2004). In Section 2 we will describe the context of the research, which makes it plausible that the children in our study, too, will be familiar with these perspectives, albeit in an intuitive or implicit form.

1.5. *The concept of 'balancing' different perspectives*

The aim of our analysis is to investigate whether the children in our study do indeed deal with the three perspectives (intuitively) and to examine if and how they manage to keep these three aspects in balance. Drawing from research into text comprehension (Otero et al., 2002; Elshout-Mohr and Van Daalen-Kapteijns, 2002), we suppose that 'keeping perspectives in balance' means, first, that students monitor for each separate perspective whether the quality of their work is still satisfactory from the point of view of this perspective. Monitoring consists of continuous checking: "Does our present approach allow us to learn mathematics?", "Is our present approach in line with classroom expectations about collaboration?" and "Do we divide our time productively, in preparation for the next classroom activities that follow?" Second, keeping in balance (referred to as 'balancing') means that action is taken whenever the answer is "no" for one or more perspectives. This negative answer can occur because an original 'balance' is disturbed, but also because the pair has not yet achieved a balance. The initiative to take action may be taken by either child depending on his or her noticing that a quality has dropped below a critical level or has not yet reached a critical level. Action will be directed to changing the approach in order to restore or find balance. Thus, we conceptualize the process of collaborative regulation as a series of balance restorations. We assume that this process is a very dynamic one, because balance restoration may not only involve the 'quality at risk' but other qualities as well. For instance, to restore the quality of the 'mathematical level raising' at a certain moment, a pair of students may have to consider raising their efforts with regard to 'social interaction' (in order to profit more of interactive dialogue) and/or to lower their expectations in regard to 'division of time'.

We want to investigate this dynamic process in a small-scale study, because we aim at precise observation and description of moments where students do and do not take action. Of course, this study will not answer all our questions. Questions will remain, for instance, about factors that influence how students decide on 'critical levels' for each quality. The study will be a first step along this line of research, which is new as far as we are aware of.

2. CONTEXT OF THE RESEARCH

2.1. *The mathematics classroom*

Our study takes place in a third-grade class of 20 students in the United States. The children are about 8 years of age and the teacher has been teaching for about 5 years. The mathematics lessons in the classroom consist of tasks that are problem centered and developed for the purpose of engaging children in thinking mathematically as a means for learning. Additionally, the culture of the classroom frequently entails socially interactive situations. The children solve problems in pairs and then discuss their solutions as a whole class. Diversity of methods of solution is valued as well as explanation of the methods. The social norm established by the teacher for working in pairs indicates that both partners are to try to solve the problems by talking and sharing their strategies. Partners are not expected to agree on one strategy for doing the problem, but they are expected to agree on the answer. If different answers arise, partners are expected to work together to resolve the difference.

2.2. *The mathematical task*

The data of our study consist of a transcript of a videotaped episode in which two students, Amy and Jim, work together on a sheet with a sequence of 8 problems called ‘blob-problems’. The sheet that the two children work on is shown in Figure 1. The episode is 12 minutes long.

A goal in developing the blob-problems was to extend students’ naturally developing conception that multiplication is simply ‘repeated addition’ to the notion of cross products and multiplicative structure as well as learn the multiplication number combinations (‘facts’). The blob-problems were intended to be open-ended and allow for multiple solution strategies that extend from counting single units, using a process of doubling drawn from an extension of the additive structure, to ultimately gaining insight into multiplicative structure as cross products. To reduce the use of a counting strategy, a ‘blob’ from ink spilled, covers the squares, requiring students to mentally visualize the missing squares and create new more efficient strategies for calculating the total amount of squares.

The episode was selected because we expected that the three perspectives would be salient for the children. The task challenges them to raise their mathematical level, they work in the sphere of influence of the classroom culture and in the presence of the teacher, and they expect that a whole class discussion will follow, in which pairs will be expected to take an active part in sharing solutions.

Figure 1. Blob-problems.

3. ANALYSIS FROM DIFFERENT PERSPECTIVES

3.1. *Three perspectives*

Our point of departure is three perspectives, which we deem relevant for understanding how children regulate their collaborative learning of mathematics in a school context. In this section we provide some background information about these perspectives.

3.1.1. *Mathematical level raising*

The perspective of mathematical level raising (MLR-perspective) has level raising as its focus. Students approach mathematical problems at different levels, which can be described as lower and higher from an educational point of view. MRL draws from the theories of Freudenthal (1978) and Van Hiele (1986) to consider learning as occurring in terms of a hierarchy of levels for understanding mathematical ideas. Each level describes the

thinking processes used and the types of ideas thought about rather than how much knowledge a student has. Students progress through each level but these are not age-dependent as in the Piagetian sense. Drawing on this theoretical perspective, a process model for mathematical conceptual level raising was developed by Dekker and Elshout-Mohr (1998). In this empirically based model, four key activities are distinguished for raising the mathematical level of the participants in collaborative learning: to show, to explain, to justify and to reconstruct one's work. The model also indicates how participants can regulate the level raising for each other by asking one another to show and to explain their work and by giving a critique.

For example, the blob-problems can be solved on different levels: by counting, by systematic counting, by multiplying and when the problem is approached as an area problem, by using a formula for measuring the area. The problems also have other characteristics, which are crucial for evoking solutions at different levels: they make sense for the students and are complex.

3.1.2. *Social interaction*

The perspective of social interaction (SI-perspective) is based on the assumption that the social structures that are created in the classroom influence the 'mathematics' a student learns. This view draws from the theory of Bruner (1990, 1996) and others who believe that children need to adapt to a social existence and to develop a system of shared meanings in order to participate as members of their culture. In addition, the theories of Garfinkel (1967) and Goffman (1959) contend that the social structures in everyday life consist of normative patterns of interaction and discourse. Once established, these patterns become the reliable routines found in interactive situations. Individuals, when they participate, come to anticipate certain behaviors for themselves and for others so that much of what happens "goes without saying" (Garfinkel, 1967). In order to understand students' mathematical learning it is therefore necessary to take into account the social situations that teachers establish with their students. The norms (expectations for self and others behavior) underlie the social interaction that reveals the 'practice' of mathematics in the classroom. Moreover, it is thought that learning which is conceptual can benefit considerably from dialogue and collaboration with others (Wood, 2001; Wood et al., in press).

3.1.3. *Division of time*

The perspective of division of time (DT-perspective) has as its focus the engagement of students during their work on a task (Dekker et al., 2004). This perspective draws from theories that contend in order to achieve intended learning outcomes, such as mathematical level raising, students must spend

time on activities that are relevant for that particular learning goal (Carroll, 1963; De Corte and Weinert, 1996; Elshout-Mohr et al., 1999). To communicate learning goals and to elicit relevant student activities, teachers do not only provide tasks, but also inform children about how to accomplish the tasks (individually, collaboratively) and about available time and the features of their work for which they will be held accountable. According to Doyle (1983) students' learning is transformed fundamentally when it is placed in the complex social system of the classroom. Students have to divide their time and attention over more concerns than mere learning.

3.1.4. *Assumption*

The purpose of our study is based on the assumption that the three perspectives are not unknown to children, who have 3 years experience in a school, where the mathematics classroom is characterized by the learning environment as described above. Although it is not expected that 8-year-old students have the perspectives at their disposal in an explicit form, it is plausible that the perspectives are familiar to them in a more intuitive and implicit form as the underlying aspects of everyday school life. We assume that the children in our study, who work on the blob problems, have the experiential knowledge that they have to do something mathematical and that it will need some concentration and mental effort from them (the MLR-perspective), that they have to work together on the task, which demands taking the other's presence, ideas, utterances and activities into account (the SI-perspective) and that they need to be productive and complete tasks within time limits (the DT-perspective). It can be assumed that children know that in order to be effective in the classroom they need to respond to these three aspects of everyday school life.

3.2. *Analysis of the dialogue*

The aim of our research is to investigate whether a pair of children, Amy and Jim, take the three aspects into account and to examine if and how the pair manages to keep them in balance. To this aim we will first analyze the children's dialogue using each of the three perspectives (MRL, SI, and DT). Second, we will look for indications that the children themselves do monitor the quality of their work and take action when this quality is low in one of the three aspects. The claim that we want to substantiate is that the children's actions can be plausibly described as attempts to restore the balance and that, in general, these attempts are fit to achieve this aim. Whether achievement of balance results in the individuals learning of mathematics is not at stake in this study; our purpose is to focus on students' use of regulating processes to monitor learning collaboratively

and to adjust their collaboration in order to achieve ‘balance’ among the three aspects when necessary.

3.2.1. *Analyzing the dialogue*

Analyzing the collaboration from the MLR-perspective requires examination of how the blob problems are solved. Several levels of production can be defined, as we discussed earlier. However, the level as such does not reflect the mental work: a low level solution can be produced with great mental effort. It is the effort to produce, check and improve one’s solution, which reveals that the students take an MLR-perspective. For individual students this effort can be seen in the performance of the key activities. In collaborative learning, therefore, the focus of the analysis is on the students’ effort to show and explain ideas and action to each other with the aim to find common ground for building shared understanding and strategies.

Analyzing the dialogue from the SI-perspective requires examination of the manner in which children collaborate. Are they discussing with each other? Do they seek agreement on the solution? Do they take action when different answers arise? In this analysis the classroom norms should be taken into account. In this collaborative setting, the focus is on whether they both understood each other’s solution and agreed on the answer.

Analyzing the dialogue from the DT-perspective requires examination of the manner in which children take up their work and keep working, comment on the number of problems, try to speed up their work after less productive moments, or propose working methods for the purpose of saving time.

3.2.2. *Finding indications of self-regulation*

We expect that ‘monitoring’ as such will be difficult to recognize in the dialogue, but that it will be feasible to identify moments where children notice that the balance among the three aspects needs adjustment in order to regulate their collaborative learning. An indication that a child notices that the current approach leads to an insufferable descent of the quality of the work from the MLR perspective might be as statement such as: “Now we aren’t multiplying, we are only counting.” An indication that a child notices that the social interaction is at risk might be: “We do have to agree on the answer, don’t we?” An indication that a child notices that the current approach is not adequate from the division of time perspective might be: “We have to hurry, so if you do the drawing, I’ll do the counting.”

As to the ‘adjustments’ of the three aspects to achieve ‘balance’, visible actions are identified and coded such as a change in solution strategy to one

that is more effective or a correction, a minor adjustment of an approach or a drastic transformation. In theory it might also occur that students arrive at an impasse and decide to ask the teacher for help.

4. FIVE FRAGMENTS

4.1. *Overview of the events in the five fragments*

We have selected five fragments for the analysis. In the first fragment the two children, Amy and Jim work on the first blob-problem (see Figure 1). Their way of working is quite balanced in relation to the three perspectives. There is not yet a need for balance restoring, although the SI-perspective is not very strong. In the second fragment, when they work on the second blob-problem, the balance in relation to the MLR-perspective and the SI-perspective is disturbed and Amy takes action by proposing a *drastic transformation of the strategy* for solving the blob-problem. In the third fragment they continue to work on the second blob-problem, but now in a new way. The SI-perspective and the DT-perspective are in balance, but the MLR-perspective is not. Jim proposes an *improvement of the strategy*, which includes some level raising. In the fourth fragment Amy and Jim encounter an unexpected problem, which leads to an orientation on fractions, but also brings the DT-perspective in danger. Amy *corrects* this and then Jim proposes to *adjust their strategy* again, which again leads to some level raising. In the fifth fragment they *collaboratively reflect* on their way of solving the blob-problems.

In three of the fragments something noteworthy happens in the balance between the three perspectives and we see something of the way the students, Amy and Jim, regulate the balance. What the ‘critical levels’ in regard to the three perspectives are and how the monitoring takes place is not always completely evident from the protocol. However, taking into consideration the fragments as a whole, they illustrate that the students are rather successful in regulating the balance by maintaining and restoring the three aspects. The fragments also illustrate that in reality a perfect balance does not exist. Some friction between the three aspects is always present.

4.2. *Fragment 1*¹

[Amy tells Jim that she is late for school because her alarm clock did not go off. Jim has the sheet with the blob-problems in front of him and he starts working on the first problem as she talks.]

- 5 Jim: Let's see 1, 2, 3. 1, 2, 3, 4, 5, 6, 7, 8, 9
(Amy bounces her head as Jim counts the squares with his pencil. Amy leans close to Jim to see the task)
- 6 Amy: Wait a sec.
- 7 Jim: Three groups of 9 or nine groups of 3? (Looks up but not at Amy)
- 8 Amy: 1, 2, 3. 4 5 (starts over) 1, 2, 3 (quickly) 4, 5, 6, 7, 8, 9.
(Counts slowly, turns around in her seat with back to Jim as if thinking)
- 9 Jim: Okay, three grou—nine groups of 3.
- 10 Amy: (Still looks off as if thinking. Her thumb is up) 9.
- 11 Jim: Three groups of 9? 18, 19 (counting on fingers by ones on left hand)
- 12 Amy: (Interrupts) 28! (Turns back to look at Jim)
- 13 Jim: 20, 21, 22, 23, 24, 25, 26, 27. (Uses right hand).
I disagree. I think it is 27. Look. 9 plus 9 equals 18.
(Holds his hands in fists) 18. 19, 20, 21, 22, 23,
24, 25, 26, 27 (shows Amy by counting and putting up one finger at a time).
- 14 Amy: (Watches intently, then looks at Jim for 3 seconds after he says 27.)
Let me— Let me check myself. (Starts to count with fingers. Jim writes on paper.) Let me check. (Whispers to herself looking at paper.) You had 28 and I only have 27.
- 15 Jim: You had 28 and I had 27. (Looking at paper. Writes numbers on paper.)

As researchers we analyzed this fragment (presenting the very start of the dialogic episode) as follows:

The MLR-perspective is evident in several ways. Jim shows an answer, which reveals that he counts a row and a column and that he soon works on the level of systematic counting. He sees very soon that it is three groups of nine or nine groups of three, which is the transposing strategy of multiplication ($3 \times 9 = 9 \times 3$). In solving 3×9 he uses the strategy of doubling the nine and counting on nine, which is essentially the multiplying strategy of dividing ($3 \times 9 = 2 \times 9 + 9$). Amy too shows an answer (L 8, 10, 12). This reveals that she works on the level of counting towards systematic counting, because she keeps track of counting groups of nine with help of her fingers. The answers of Jim and Amy are different. Jim criticizes the answer of Amy and explains his own answer, by means of showing Amy his solution process (L 13). In this

way he regulates Amy's level raising, because she starts to check her own work (L 14), which may be a first step toward reconstruction of her own solution.

The SI-perspective is evident in the fact that the children think aloud to let each other know what they are doing. From the very beginning, Amy has no intention to follow Jim blindly, but takes time to produce a solution of her own and to check herself. The children also compare answers after having solved the problem individually. However, from the SI-perspective we interpret the situation as one in which the expectations for interacting seem to be rather low. The priority of each child appears to be to solve the problem for him- or herself and then compare answers. There does not appear to be a strong expectation that both children will explain their strategies and thinking to one another, even though their answers are different (L 15).

The DT-perspective is not salient in this fragment. However it may have been one of the reasons for Jim to start working, while Amy was not yet ready to do so, and for Amy to join him without protest (L 5).

In this fragment the students see no reason for a *change of strategy*. There are, however, several indications of monitoring. In L 6 Amy notices that Jim is counting so quick that common ground is not established and she says: "Wait a sec". In L 13 Jim notices that he and Amy reached different answers. In accordance to classroom expectations he says "I disagree" and both children check their answers (Jim in L 13 and Amy in L 14). In L 14 Amy is still wondering how the different answers came about, whispering to herself. Thereby she mixes up the different answers. Although Jim corrects her, he does not pick up Amy's implicit cue, which we think is "We are not collaborating as we should."

4.3. *Fragment 2*

[The teacher arrives and promotes the expectation that they resolve their difference in answers. When she leaves, Amy quickly joins Jim in his answer and they start working on the second blob-problem.]

- 26 Jim & Amy: 1, 2, 3, 4, 5, 6, 7, 8, 9. (Jim writes on paper putting numbers in last column.)
- 27 Jim: Either six groups of 9 or nine groups of 6.
- 28 Amy: Oh goll. Let's um do this on paper. (Pulls paper to her.)
- 29 Jim: Oh that's really simple. (Said quickly). Okay. Now 27 plus 18. (Looks at Amy as if intentionally telling her something.)

- 30 Amy: I don't get . . . (Puzzled look on her face)
 31 Jim: (Interrupts.) 27, 37. (Looking at paper)
 32 Amy: I don't . . .
 33 Jim: (Simultaneously) 37, 38, 39, 40, 41 (Puts up one
 finger for each number starting with 38.)
 34 Amy: (Interrupts) Get your white pen out. I get to do it.
 (Giggles)
 35 Jim: Oh, yeah. (Laughing gets out his pencil box from
 under his desk.)

Again, we will first analyze the fragment as we see it as researchers from the three perspectives. Then, we will discuss that the pair, with Amy in the lead, notices that one quality of their work is seriously at risk and that their approach must be drastically transformed.

From the MLR-perspective we see that Jim shows his way of solving by thinking aloud. He feels comfortable in using the transposing strategy of multiplication, and it is probably in line with the MLR-perspective as he sees it. The problem is too difficult for Amy to produce a solution, so she proposes another way of solving: working on paper. Jim tries to persuade her to his way of solving by showing his solution, thinking aloud. Amy implicitly asks for an explanation by saying that she does not understand him, but Jim seems to think, as he did in fragment 1, that showing his solution will do as an explanation for Amy. From the MLR-perspective we see that for Amy, Jim's approach is irrelevant. She has to find another way to do 'something mathematical'.

From the SI-perspective it can be observed that the 'problem' that Amy and Jim encounter with 9×6 is both cognitive and social. Because of the differences in their mathematical capability, they cannot meet the expectation to 'work together', which to them means solving the problem individually and then comparing answers. On the one hand, although she tries, Amy is not able to get Jim to explain to her in ways that she can understand. On the other hand, Jim is not ready to explain because he is still solving the problem out loud and not expecting to provide an explanation for Amy. In regard to the SI-perspective the situation is unsatisfactory from our point of view as researchers, but we also sense that for the children a tension exists in their inability to communicate.

From the DT-perspective we see that Jim proposes quickly a solution in his own way. Amy gets stuck in her own way (L 27). It is doubtful that sufficient progress will be made in solving and completing the assignment.

In this fragment the students see a reason for a *drastic transformation of strategy*. Amy seems to be the first to notice that she does not only

have a problem of her own (in regard to the MRL-perspective) but that the pair work is dropping quickly to a critical level with regard to the SI-perspective, “Oh goll”, “I don’t get. . .”, “I don’t. . .” (L 28, L 30, L 32). From Amy’s perspective, action must be taken. Interrupting Jim, she persuades him to work on paper with a white pen, “Get your white pen out.” (L 34). Interestingly, Jim seems to be readily convinced, “Oh, yeah.” (L 35). Does he agree that restoring the ‘balance’ must have priority, even though it implies a restart at the low mathematical level of drawing squares instead of forming mental images?

4.4. *Fragment 3*

[Jim has drawn with the white pen squares on the blob of the second problem. The teacher returns to check whether Amy and Jim have solved the ‘problem’ of two different answers and thus met the established expectations for working together. Then they continue working on the second blob-problem.]

- 57 Jim: Okay, 1, 2, 3, 4, 5, 6. Okay let’s just (Counts slower)
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14. (Jim is marking
on the paper and Amy is following along counting softer.)
Wait a minute, let’s just split it in half. 1, 2, 3, 4, 5, 6.
- 58 Amy: Let’s count down. How many down? How many down?
- 59 Jim: I’m splitting it in half. (He is making a thick vertical line on
the drawing.) Okay. Now you—I’ll count this one. 1, 2, 3.
(Counts on paper) 4, 5, 6. 7, 8, 9, 10, 11, 12, 13, 14, 15,
16, 17, 18, 19, 20, 21, 22, 23, 24. 25, 26, 27. 27 plus 27
. . . (Looks straight ahead.)
- 60 Amy: Let’s see.
- 61 Jim: . . . equals—(Looks straight ahead.)
- 62 Amy: Let’s see . . . 1
- 63 Jim: (Interrupts.) 54. (Hits elbow on the bottom of the paper and
on the desk.) 54.
- 64 Amy: (Simultaneously with Jim’s “54”) 1, 2, 3, 4 5, 6, 7, 8, 9, 10,
11, 12, 13, 14, . . .
- 65 Jim: (Simultaneously) Hey move your hand. (Jim says this nicely.
He wants to write the number sentence.)
- 66 Amy: 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27. 27. Let’s
see 27 . . .
- 67 Jim: (Interrupts) I got 54.
- 68 Amy: Two plus—7 plus 7 equals—what? (to Jim)
- 69 Jim: I’ll start working on it. Seven plus 7 equals 14.

- 70 Amy: Yeah, yeah. I agree. Yeah. (Said in reference to Jim marking on paper with white pen.) We'll just split them in half, you'll have to draw down here though.

As researchers, we first noticed that from the SI-perspective the interaction evolves into a genuine collaboration and that the opportunities for learning increase for both children. The pen is a tool by which they begin to work together and Jim takes into account that Amy counts slower than he does (L 57). Jim realizes, however that this way of working is not efficient, so he invents a new strategy, to *split in half* the rectangle (L 57). Because they are working collaboratively, this time he explains to Amy what he is doing; he is going to split in half and count only the half by ones and add the two numbers together. Amy can understand this new strategy because he explains it in words (L 57) and by drawing a vertical line (L 59) she can relate her original strategy of counting by ones to Jim's and learn a more efficient strategy (L 60, 62, 64, 66, 68). Now both Jim and Amy use this strategy and jointly produce the answer, even though they are operating on different mathematical levels,

From the MLR-perspective, it should be noted that Jim now works on a lower mathematical level than in the first problem. He also made a shift from treating the problem as a multiplying problem to treating it as an area to be measured by counting the squares. His new approach however still allows for level raising. He reconstructs his way of solving almost immediately (L 57) by making the counting more efficient. He proposes the strategy of splitting in half and doubling, which is connected with a dividing strategy ($6 \times 9 = 3 \times 9 + 3 \times 9$). Amy too is actively involved in mathematical thinking. She shows a solution by proposing to count 'how many down'. She understands Jim's strategy and solves the problem herself by showing her counting one half and then double, as Jim did. Amy's adoption of the strategy also comes to the fore in L 70, where she proposes to use the strategy to solve the next problem.

As from the DT-perspective, there are indications that the children still have this aspect in mind. Jim invents a strategy that is more efficient than counting all squares. We do not know for sure that saving time was his motive, but this explanation is plausible at least. The children also agree on a timesaving division of work (L 70).

This fragment shows how the change in approach restored the quality at risk (the SI-quality) and to restore the 'balance' of the three aspects. Now it seems that Jim was in the lead. By proposing an *improvement of the strategy* Jim took care, at least partially, of the MLR-quality of the new approach, thereby saving the DT-quality too. It may be noticed that Jim

took great care to explain the new strategy by drawing the thick line. Jim evidently agreed that the SI-perspective was very important.

4.5. *Fragment 4*

[Jim draws squares with the white pen on the blobs. Amy starts counting the squares in the third problem.]

- 74 Amy: 1, 2, 3, 4, 5, 6, 7, 8, 9. 9. How can you split 9 in half? You can't. (Giggle)
- 75 Jim: Nope you can't. Unless you had 4 and a half and 4 and a half like \$ 4.50 and \$ 4.50.
- 76 Amy: Yes. Like I had doll-9 dollars in half.
- 77 Jim: You split a doggie in half by cutting him in half!
- 78 Amy: Yeah, making half a hot doggie.
- 79 Jim: No, half a doll. I was talking about a doll. I've done that to my sister before. She wanted to give Daniel, her boyfriend, a Barbie doll for his birthday. And so I had to cut her Barbie doll in half with my boy scout knife.
- 80 Amy: Let's see, 1, 2, 3, 4, 5, 6. 1, 2, 3, 4, 5, 6. (Points to paper as she counts.)
- 81 Jim: Why don't we just split it in half like we did. Oh, 6 split in half.
- 82 Amy: You're writing over your crayon. I'll count one side and then do a double!

This fragment illustrates how a relatively stable 'balance' may be destabilized, in this case by a new aspect of the mathematical task. It also shows how the children cope with this potential threat. From the SI-perspective we see that Amy and Jim collaboratively explore the splitting in half in different contexts and they both try to make sense of each other's examples.

If we look closer from the MLR-perspective we see that Amy asks Jim to explain how to split 9 in half and Jim explains by giving examples of money and cutting something in which one can split something in half. This is a nice orientation on fractions and Amy seems to understand. However (L 77-79), by discussing the examples the children risk to swerve from the purpose and to spend time on ideas without being sure that it would further task performance (the DT-perspective). Amy's concern that the DT-perspective is dropping below a critical level, might well have been a reason for her to start counting the other side of the rectangle. When this proves to be an even number and Jim proposes to split that one, splitting an odd number can be avoided. Thus they can apply once more the 'balanced' approach that they developed earlier.

From our perspective as researchers we conclude that the chance of level raising is touched, but not actualized. By avoiding the splitting of 9, the children are stimulated to make use of splitting in a flexible way, implicitly using the transposing strategy ($9 \times 6 = 6 \times 9$) and the dividing strategy ($6 \times 9 = 3 \times 9 + 3 \times 9$). [From this researchers' point of view we also observed that the children profited in the end from the 'decision' to let the problem of splitting odd numbers rest a while. They had another chance to go into it in on a later problem, which we do not discuss in this paper.]

In this fragment, both children, with Jim in the lead, seem to be carried away by mathematical interest in splitting. Amy is the first to *correct their approach* and return to the problem at hand (L 80). We assume that she feared that splitting doggies or dolls would not lead to a practical solution for the blob-problem at hand, the problem that they had to solve in order to keep up the DT-quality of their work. Jim joins in readily, which shows that the children still (tacitly) adhere to the SI-perspective.

4.6. Fragment 5

[At the end of the lesson the children are expected to share their solutions with the whole class. That leads to a discussion between Amy and Jim about how they solved the blob-problems.]

- 155 Jim: We did too count. That is what we did, didn't we?
 156 Amy: We counted half of it.
 157 Jim: (We counted) on every single one. (Pointing at one of the problems.) Then we counted – we didn't do – we didn't do division or times, we didn't multiply on any of these did we?
 158 Amy: Yeah, I think we did on that one (Points to problem 1.)
 159 Jim: Yeah. . . we multiplied.
 160 Amy: Yeah, but we split out the multiplying. Cus we don't know times. We don't know every answer.
 161 Jim: (Simultaneously) I know times (Jim starts working on problem 7 in an attempt to finish one more problem.)

In this final fragment, we see the children themselves evaluate their way of solving the blob-problems. Jim concludes that they did not solve them by multiplying, so he makes the lowering of the level of solving the blob-problems very clear. Amy gives the reason for the *drastic transformation of the strategy*: 'Cus we don't know times'. She stresses those elements in their strategy that make it more than simple counting.

The fragment is a nice example of *collaborative reflection*. Strictly, this fragment is not an example of monitoring and adjusting, but of another

component of self-regulation of collaborative learning. However, we incorporated it in the paper because it does, in its own way, sustain our claim that even young children think about their collaborative learning and take responsibility for the quality of their shared activities.

5. CONCLUSIONS

The first four fragments and our analysis make plausible our claim that the students in this study took responsibility for keeping balanced the three aspects (intuitively or implicitly) and that they were rather successful in monitoring and adjusting their approach. We observed how each student played a different role in the process and how they collaborated in regulating their collaborative learning. Most interesting in terms of collaborative regulation was, we think, the second fragment. There we saw not only Amy's persistence in notifying Jim that his approach excluded collaboration between the two of them, but also the willingness of Jim to exchange a problem-solving approach that was satisfying for him (from the MLR-perspective) for an alternative that appeared to him less satisfying (from the MLR-perspective), but more promising from the SI-perspective. Subsequent fragments showed that Jim's restart at a lower mathematical level did not imply that he was excluded from further mathematical progress. Jim still encountered mathematical challenges, such as the challenge of splitting in half the odd number nine in Fragment 4.

As to keeping a perfect balance, we argue that certain stability may be maintained some time (i.e., Fragment 3) but that all kinds of factors tend to affect this state. There may be internal factors, such as the wish of a student to exchange a slow or easy approach by an alternative approach that is more effective or more challenging mathematically. There also are external factors, such as new challenges that are provided by the series of problems.

Van Boxtel mentioned three instruments of 'shaping' students' peer interaction, namely 'careful construction of the task' (including available tools), 'establishing and sustaining a broader setting' and 'managing the participation of students' (in the perspective of participation in previous and subsequent learning). These shaping instruments could be observed at the concrete level in the 12-minute episode of Jim and Amy. The carefully constructed blob-task offered students room to use solution strategies at different mathematical levels and to encounter a variety of mathematical difficulties, depending on their approach. The 'white pencil' was available as a tool, and the children used it (in Fragment 2) to prevent an impasse. We think that their giggling and laughing (Fragment 2, L 34 and 35) indicated

that they expected that the teacher would not allow the use of a white pen, because it might elicit low-level solution strategies. We also saw that during the episode the teacher kept reminding the children of the classroom expectation of resolving differences in their answers. Her intervention affirmed that the children themselves were accountable for resolving the difference in answers (to blob-problem 1). Thirdly, the instrument of managing students' participation came to the fore in the children's wish to be prepared for the whole-class discussion. There is a remarkable lack of off-task behavior and, highly interesting, students collaboratively reflect on what they will have to contribute to the class discussion (in Fragment 5). We agree with Van Boxtel that 'shaping' is a good term to describe the influence of important external factors. Students are influenced, but the effects of each factor depend on the dynamic interplay that takes place between the members of each particular pair.

6. DISCUSSION

We think that we demonstrated that it indeed makes sense to describe dialogic work as a process of continuously restoring a 'balance' that tends to be continuously disturbed. On its own, the analysis of a brief collaborative episode of one pair of students leaves many questions unanswered. As yet we have no information about the generalizability of the children's behavior and of our findings. Will Jim and Amy again take responsibility for collaborative learning when they work together with other partners in a pair or a triad? Can we observe similar processes of 'monitoring' and 'adjusting strategies' in other pairs? How do students develop expertise in regulating their collaborative learning, and under which conditions they collaboratively perform activities such as 'orientation' and 'planning'? Further research is also needed to clarify the role of awareness and metacognition in the self-regulation of collaborative learning. To what extent are children aware of their personal resources in relation to the demands of the collaborative task and of the strategies they use to restore a disturbed balance? What we did demonstrate, however, is the feasibility and value of investigating how students regulate their collaborative learning in a classroom setting. This line of research may eventually help to answer the many questions that have risen since researchers started to look at dialogic learning from multiple perspectives.

From a practical point of view, we want to argue that awareness of the degree of sophistication and success of students' regulating processes may help teachers to support students' efforts to work and learn effectively in small groups, to avoid interventions that unintentionally interfere and

to stimulate students to take responsibility for balancing multiple aspects of the collaborative situation. Based on earlier research on help-giving by teachers (Dekker and Elshout-Mohr, 2004) our advice would be to invest great effort in shaping students' collaboration by external factors, such as careful construction of tasks, establishment of classroom norms and managing students participation. Then, during periods of collaborative work, the best approach of a teacher might be to merely encourage students' own process of continuously monitoring manifold qualities of the process and to restore balances that tend to be disturbed. In actual practice this may result in minimal interventions, which rather aim at long-term effects than direct profit.

ACKNOWLEDGMENTS

This study was supported by the Graduate School of Teaching and Learning, University of Amsterdam. The authors thank the reviewers of *Educational Studies of Mathematics* for their useful comments.

NOTE

1. The US classroom research was sponsored by the National Science Foundation, RED 9254939. All opinions are those of the authors.

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