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Peer Interaction in Three Collaborative Learning Environments

Judith Kleine Staarman
THE OPEN UNIVERSITY, MILTON KEYNES, UNITED KINGDOM

Karen Krol
UNIVERSITY OF AMSTERDAM, AMSTERDAM, THE NETHERLANDS

Henny van der Meijden
RADBOUD UNIVERSITY NIJMEGEN, NIJMEGEN, THE NETHERLANDS

ABSTRACT

The aim of the study was to gain insight into the occurrence of different types of peer interaction and particularly the types of interaction beneficial for learning in different collaborative learning environments. Based on theoretical notions related to collaborative learning and peer interaction, a coding scheme was developed to analyze the verbal interactions of student dyads in three collaborative learning environments: an environment with face-to-face interaction, an environment with face-to-face interaction around the computer, and an environment with interaction mediated by computers. Quantitative analyses were undertaken to determine the types of interaction that occurred in the three learning environments and the incidence of interactions beneficial for learning, and some examples were provided to illustrate this. The results showed most of the interactions in all three of the learning environments to be cognitive in nature. More regulative interactions occurred when a computer was involved. Interactions beneficial for learning occurred more often in the environments involving face-to-face interaction than in the learning environment involving computer mediated interaction.

INTRODUCTION

There is a growing emphasis on peer interaction in recent studies of socially-mediated learning. Several studies show a specific type of peer interaction to be beneficial for learning, and the outcomes of cooperative learning have also been found to be largely determined by the quality of the peer interactions involved (see for example Damon & Phelps, 1989; Kneser & Ploetzner, 2001; Mercer, 1996; Webb & Farivar, 1999; Webb, Troper, & Fall, 1995).

The mechanisms underlying the effectiveness of social interaction for learning are explained from different approaches to peer learning, namely the social-behavioral approaches (motivational and social cohesion approaches), cognitive developmental approaches (socio-cognitive and socio-cultural approaches) and the cognitive elaboration approach (O'Donnell & O'Kelly, 1994). According to the social-behavioral approaches, peer learning occurs when members of a group are moving toward a goal and when the accomplishment of the goal by any one member of the group requires that other members also reach the goal. Within the cognitive developmental approach, both the socio-cognitive (based on the work of Piaget) and the socio-cultural approach (based on the work of Vygotsky) emphasize the role of social interaction in the construction of knowledge. Both cognitive approaches maintain that peer learning provides rich and necessary opportunities for students to reflect upon reactions and perspectives of other peers. This reflection may lead to the revision of students' cognitive systems and such revisions can, in turn, lead to the establishment of new meanings (Cole & Wertsch, 1996; De Lisi & Goldbeck, 1999; Hogan & Tudge, 1999).

In this article, learning is considered as a collective participatory process of active knowledge construction (Salomon & Perkins, 1998) and peer interaction is considered from a cognitive elaboration approach (Webb, 1991). The cognitive elaboration approach emphasizes the cognitive processes performed by students working together and attempts to determine the circumstances under which social interaction benefits learning. According to the cognitive elaboration approach, interaction with others leads to the active processing of information by the student, which can then, in turn, modify the student's cognitive structures. Elaboration refers to the detailed explanations that occur when a student provides examples, uses different representations, explains a concept, or supplies specific argumentation. The process of elaboration involves explicit comparison of different perspectives or conceptions, the development of shared meaning, and the co-construction of new knowledge and/or collaborative resolution of conflicting points of view. When students discuss a topic together or try to solve a problem, they verbalize their thoughts and subsequently, verbalization elicits elaborative cognitive processes (Van Boxtel, 2000). The role of verbalization in the cognitive elaboration approach is critical, as is shown by several studies of Webb (1989, 1991). One important conclusion from her work is that when children in a small group are asked for help, their achievement is associated with the quality of the response they provide: elaborated responses are associated with positive achievement, whereas the provision of simply the correct answer (without elaboration) is not. According to Webb (1991) it is likely that in providing elaborated answers, students rehearse and reorganize their understanding using earlier information or prior knowledge.

Studies by both Webb and Farivar (1994, 1999) and King (1994, 1999) have provided empirical support for the view that so-called elaborative interaction contributes to the use of more elaborate conceptions in subsequent situations. King (1994) examined the relations between the types of questions posed and the answers provided during a collaborative task and found higher-order questions to elicit higher-level answers. Asking for help in this way can support the interaction during collaborative learning (King, 1990; King, Staffieri, & Adelgais, 1998). Higher-order questions trigger elaborated explanations, which can positively influence the performance of both the provider and the recipient (King, 1999). The provision of elaborated help encourages the explainer to clarify and reorganize existing material, fill any gaps, and thereby understand the relevant material better. Van Boxtel, Van der Linden, and Kanselaar (2000) found that elaborative verbalization that occurs during the collaborative activity can lead to reflection, awareness, (re) organization, differentiation, fine-tuning and expanded knowledge. De Jong (1992) argued that summarizing and drawing conclusions are important learning activities which can result in new cognitive structures. In addition, Mercer (2000) provided us with insight into the importance of finding a common ground to create a shared frame of reference. This shared frame of reference can be established, for example, by asking verification questions.

In sum, certain types of interaction are assumed to be more beneficial for learning than other types of interaction, as emphasized by King (1994), Webb (1991), and Van Boxtel et al. (2000). In the present study, the focus is on interactions that are considered beneficial for learning, such as posing higher-order questions (asking for elaborated help), providing elaborated explanations, explicitly referring to earlier information or prior knowledge, summarizing and drawing conclusions and funding of common ground by asking verification questions.

Research Questions

The exchange of ideas, information, and opinions, as occurs during peer interaction, does not occur very frequently in traditional education as the children are typically asked to learn individually. In collaborative learning environments, however, a context is created in which students are challenged to work together to solve problems. The purpose of this study is to examine how students interact in three collaborative learning environments, with a focus on interactions that are beneficial for learning. In this explorative study, we used the same instruments and method of analysis in three related studies in order to gain insight into similarities and differences regarding peer interaction in different learning environments.

The specific research questions were as follows.

1. Which types of peer interaction occur in the different collaborative learning environments?

2. Do the collaborative learning environments differ with regard to the incidence of interactions beneficial for learning?

METHOD AND INSTRUMENTATION

Learning Environments

For purposes of the present study, four research conditions were distinguished using three learning environments: 1) a condition in which face-to-face interaction was used to solve a mathematics task, 2) a condition in which computer-mediated interaction was used to solve a mathematics task, 3) a condition in which face-to-face interaction was used to solve a language task, and 4) a condition in which interaction around computers was used to solve a language task. The three learning environments and subjects included in the four conditions are described below (see also Table 1).

Learning environment A: Face-to-face interaction in collaborative learning. The first learning environment was created as part of the research program "Implementing cooperative learning" with a focus on the implementation of cooperative learning in seven elementary schools. Within this learning environment, conditions one and three were established: one condition in which 20 sixth-grade students worked in mixed-sex and mixed-ability dyads on a mathematics task (Condition 1) and another condition in which 20 sixth-grade students worked in mixed-sex and mixed-ability dyads on a language task (Condition 3).

Learning environment B: Computer-mediated interaction in collaborative learning. The second learning environment was created as part of the research program "Knowledge Building through Computer Supported Collaborative Learning (CSCL)" with a focus on the role of synchronous versus asynchronous web communication tools. Within this learning environment, 20 students from a single sixth-grade class worked together in mixed-ability dyads on the same mathematics task that was used in learning environment one but with their communication mediated by the computer via a chat program (Condition 2).

Learning environment C: Interaction around the computer. The third learning environment was created as part of the research program "ICT Support for Interactive Language Education" with a focus on the interactive processes that occur within elementary school literacy practices with and without computers. In a literacy learning environment, 20 students from two parallel fourth-grade classes worked together on a computerized language task in single-sex, mixed-ability dyads (Condition 4). The language task was similar to the task used in the first learning environment but slightly adapted and simplified in order to match the abilities of fourth-grade students and to make the task suitable for the computer.

TABLE 1

Overview of the learning environments, conditions, grades and number of dyads

Learning environment	Condition/Task	Grade	# of Dyads
A. Face-to-face without computer	Condition 1 Mathematics Task	6	10
	Condition 3 Language Task	6	10
B. Computer mediated collaboration (communication by synchronous chat)	Condition 2 Mathematics Task	6	10
C. Face-to-face collaboration around the computer	Condition 4 Language Task	4	10

Procedures

For conditions one, three, and four, each dyad was taken from the classroom into a room where the materials were already set up. For condition two, the students worked in two different computer rooms within the same school, which meant that they were not able to see the person with whom they were collaborating. In condition two, the computers were connected via the Internet, and the dyads worked together using a computer chat tool. In conditions one and three, a paper and pencil version of the task was presented. In condition four, the language task was presented on a laptop computer with both keyboard and mouse control. The computer was positioned in such a manner that both of the students could see the screen and had equal opportunities to use the keyboard and mouse.

For all of the conditions, the dyads were formed on the basis of the scores of the students on nationally standardized mathematics and reading comprehension tests. The dyads consisted of either one low- and one average-achieving student or one average- and one high-achieving student (see Jones & Carter, 1994). We assumed that mixed-ability grouping would require the students to help each other work within each other's zones of proximal development (Vygotsky, 1978). In addition, both mixed-sex dyads and single-sex dyads were formed on the basis of current notions on the forming of dyads in different learning contexts in order to guarantee equal opportunities for boys and girls to participate. In conditions one, three, and four, the teacher was also consulted after formation of the dyads in order to avoid any problematic dyads. If a problematic dyad had been formed, an alternative dyad was formed. Such selection was not necessary for condition two, as the students did not know with whom they were collaborating.

For all four conditions, the researchers briefly introduced the task and explicitly stated that the students needed to work together to solve the task. The students were allowed to ask the researchers about technical problems but not the task. In conditions one, three, and four, the interactions of the dyads were videotaped and transcribed verbatim. In condition two, the chat conversations were saved.

Tasks and Materials

To elicit peer interaction, two tasks were developed for use within the four conditions. One task was a standardized cooperative mathematics task; the other was a language task specifically designed for the present study.

Mathematics task. To promote reasoning and collaboration, use was made of a balance beam task based on the tasks of Ros (1994) and Tudge (1992). Students must predict the position of the balance beam for various configurations of weight and distances. They are given a worksheet with 15 problems of increasing difficulty to solve. The first five problems contain a picture of a scale with the weights placed on it and a text explaining the problem and stating a question. After discussion of the possible answer, the students could either draw it on the worksheet or type it into the chat box. After each one of the first five problems, the students are given the answer to the previous question with an explanation of the problem in the form of an illustration on the next page. The students are then asked to evaluate their own answer. And after these initial five practice-and-feedback questions, they are expected to use the relevant strategies to solve the next ten questions, which are more difficult than the first five and do not include feedback.

Language task. In order to promote collaboration, a reading comprehension task was developed using a text from the reading instruction method of Aarnoutse and Van de Wouw (1992) and the principles of reciprocal teaching (Brown & Palincsar, 1989) which trains students to formulate questions, visualize and clarify a problem or problems, summarize the most important elements of a text, and predict the ending to a story. Both of the students in a dyad receive basically the same story but written in a different order, which makes them dependent on each other for completion of the task. In one version of the story, a boy and a girl sail clockwise around a pirate island; in the other version, they sail counter-clockwise around the island. Given that the boat approaches the island from a different side in the different versions of the story, the students must share information in order to get a complete picture and answer the questions. The students are not allowed to read each other's texts although they are allowed to read parts of text aloud or explain their story to the other. The two texts are approximately equal in length and difficulty. The language task consists of nine questions. The first questions require the students to discuss their stories to determine the most important differences between the texts. After these questions, feedback is provided on the next page and the students are expected to be able to answer the other questions using similar strategies. The next questions require the students to find the meanings for difficult words that are mentioned in one of the texts and explained in the other. The students must also locate certain places mentioned in the story on an unfinished map, consider names for these places, and predict the end of the story.

Verbal Interaction Analyses

Coding scheme. In this study, a coding scheme was developed and applied to map the peer interaction that occurs during collaborative learning. The conceptual framework was provided by several studies of peer interaction (e.g., King, 1999; Kumpulainen & Mutanen, 1999; Mercer, Wegerif, & Dawes, 1999; Webb & Farivar, 1999). Following Henri (1992), Vermunt (1992), and Veldhuis-Diermanse (1999), we distinguished three basic categories of interaction: cognitive, affective, and regulative. The cognitive category encompasses the following aspects: asking (verification) questions, providing answers, providing information and accepting or not accepting a previous contribution. Within the affective category of interaction, both positive and negative affective expressions were coded as well as greetings during the chat task. The regulative category of interaction contained codes for the planning and evaluation of an activity and the provision of instructions. In addition to the aforementioned categories of interaction, reading the task or the text aloud was also coded. When remarks did not fit into any of the categories (e.g., "Did you see that movie on TV yesterday?"), they were coded as "miscellaneous" (see Appendix A for the coding scheme).

The coding scheme was applied under different collaborative conditions and adapted on several occasions. Within the cognitive category, for example, it became clear that rather than providing answers to the questions posed by the other student, answers were often provided to the task questions; we therefore decided to make no distinction between answering a question posed by another student or answering a question from the task.

Coding of the transcripts. All of the videotapes were transcribed verbatim. Both the verbal and chat interactions were then divided into conversational turns, with each turn possibly containing several utterances. The unit for the coding of the interactions was the utterance, defined as the contribution of a single participant, with a single communicative function. An utterance could vary from a single word to a longer stretch of talk by one and the same student. The 40 transcripts were next coded using the computer program Multiple Episode Protocol Analysis (MEPA) developed by Erkens (2001). Two researchers trained themselves on the use of the program and the formulation of the coding rules using three transcripts from dyads not participating in the study. Each utterance was coded with one of the codes from the coding scheme. The interrater agreement was then established on the basis of eight transcripts or 20% of all the transcripts randomly selected from each of the four conditions. The percentage agreement was found to be 85% with a reliability coefficient of .83 (Cohen's Kappa).

Data analysis. The unit of analysis for the analyses undertaken as part of this study was the dyad as the interaction between two students was assumed to be interdependent. Descriptive analyses were used to examine the types of interaction that occurred with independent samples t-tests applied to identify significant differences between the conditions. The following types of interactions were considered to be beneficial for learning: providing elaborated information, asking complex questions, answering with elaboration, and accepting or rejecting statements with elaboration, referring to earlier information or prior knowledge, summarizing and concluding and asking verification questions.

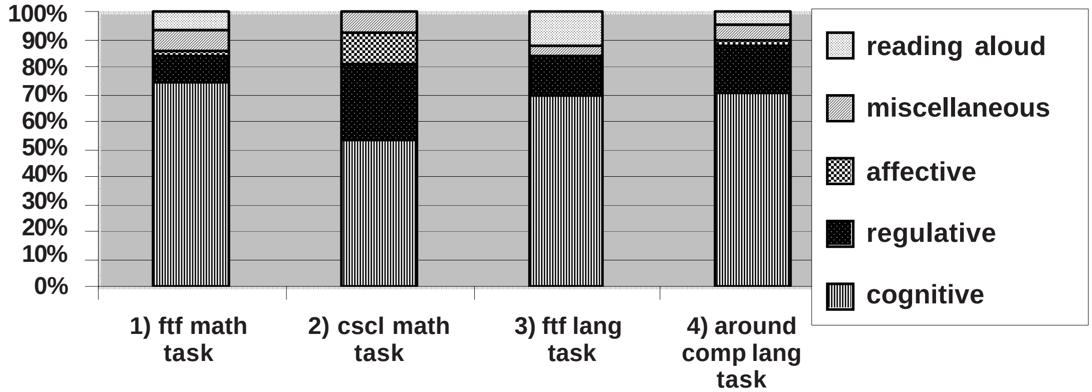
RESULTS

Analysis of the Verbal Interactions

The first research question concerns the types of interactions that occur in the different collaborative learning environments and whether they are beneficial for learning or not. Given that some of the dyads talked more than others, it was necessary to use percentages to examine the different categories of interaction. Figure 1 contains an overview of the distribution of cognitive, affective, regulative, miscellaneous, and reading aloud utterances across the 1) face-to-face mathematics task condition, 2) computer-mediated mathematics task condition, 3) face-to-face language task condition, and 4) the language task around computers condition. As can be seen, more than 50% of the utterances in each condition were of a cognitive nature.

FIGURE 1

Percentage Utterances of Different Types Across Four Conditions



In Table 2, the distribution of the specific categories of interaction according to the percentage of the total number of utterances collapsed across the four different conditions is presented. As can be seen, only *regulative activities, accepting without elaboration, answering without elaboration,* and *providing not-elaborated information* occurred in more than 10% of the utterances.

TABLE 2

Percentage of Occurence of the Coded Utterances Over the Four Conditions

Percentage of occurrence	Utterances
Less than 2%	Accepting with elaboration, Answering with elaboration, Asking complex questions, Referring to earlier information, Rejecting with elaboration, Greetings
Between 2% and 5%	Providing elaborated information, Summarizing and concluding, Regulative instruction, Affective utterances, Rejecting without elaboration
Between 5% and 10%	Asking verification questions, Asking simple questions, Reading aloud, Miscellaneous
More than 10%	Regulative activities, Accepting without elaboration, Answering without elaboration, Providing not-elaborated information

Further inspection of the distribution of the different categories of interaction across the four research conditions revealed the following. *Answering without elaboration* frequently occurred in all conditions. *Accepting without elaboration* occurred most frequently in the first condition while *regulative activities* frequently occurred in the second and fourth conditions. In the third condition, *answering without elaboration* predominated, together with *providing not-elaborated information*. In both of the conditions involving a computer (i.e., conditions two and four), many more *regulative activities* occurred than in the face-to-face conditions (i.e., conditions one and three).

The second research question concerned the incidence of interactions beneficial for learning across the different collaborative learning conditions. In two conditions, the structured mathematics task was used; in the other two conditions, the less structured language task was used. In order to minimize the influence of the task differences, only within-task comparisons were conducted (i.e., conditions one and two involving the math task were compared with each other and conditions three and four involving the language task were compared with each other).

In Table 3, the descriptive statistics and test results are presented for each condition. Independent samples t-tests showed significant differences between condition one (face-to face mathematics task) and condition two (computer-mediated mathematics task). The dyads in condition two showed significantly more *affective utterances* ($p = .00$) and regulative activities ($p = .00$) than the dyads in condition one, which showed significantly more *accepting without elaboration* ($p = .00$), *accepting with elaboration* ($p = .01$), *answering with elaboration* ($p = .00$), *referring to earlier information* ($p = .04$), and *summarizing and concluding* ($p = .01$).

The independent samples t-tests also showed significant differences between condition three (face-to-face language task) and condition four (language task around computers).

TABLE 3

Descriptive statistics and test results for the mathematics task and the language task

	Condition 1		Condition 2				Condition 3		Condition 4			
	Face-to-face mathematics task		Computer-mediated mathematics task				Face-to-face language task		Around the computer language task			
	M	SD	M	SD	t	p	M	SD	M	SD	t	p
Cognitive Utterances												
Asking simple Questions	4.69	2.87	6.47	3.63	-1.22	.24	11.07	5.71	12.98	1.98	-1.00	.33
Asking complex questions	.49	.51	.65	.84	-.52	.61	.81	.66	.20	.29	2.72	.01*
Asking verification questions	7.01	4.92	6.08	4.92	.42	.68	6.89	6.21	2.76	2.21	1.98	.06
Answering without elaboration	10.91	2.02	14.02	4.65	-1.94	.07	13.11	3.87	11.37	4.58	.92	.37
Answering with elaboration	4.34	2.23	1.73	1.12	3.31	.00**	.89	.93	.96	.56	-.19	.85
Accepting without elaboration	21.15	4.24	10.60	4.94	5.13	.00**	10.22	4.78	8.30	4.22	.95	.35
Accepting with elaboration	2.29	1.90	.41	.60	3.00	.01**	1.55	1.43	1.25	2.32	.34	.74
Providing not-elaborated information	7.13	4.20	4.20	2.39	1.92	.07	17.88	6.11	21.13	5.99	-1.20	.25
Providing elaborated information	2.84	1.51	2.13	1.60	1.02	.32	1.65	1.11	1.57	.89	.17	.86
Rejecting without elaboration	3.12	1.98	2.49	2.09	.70	.49	.90	.85	3.10	1.54	-3.95	.00**
Rejecting with elaboration	2.53	2.79	.74	.89	1.93	.07	.57	.59	1.32	.81	-2.35	.03*
Referring to earlier information	2.49	2.56	.57	1.03	2.20	.04*	.88	1.66	1.86	1.31	-1.47	.16
Summarizing and concluding	5.67	1.87	3.19	2.04	2.83	.01*	3.06	1.80	3.35	1.43	-.40	.70
Affective utterances												
Affective utterances (positive and negative)	2.19	2.06	8.33	5.16	-3.49	.00**	.98	.69	2.05	1.77	-2.12	.05*
Greetings			2.82	1.45								
Regulative utterances												
Regulative activities (e.g., planning)	6.85	2.77	25.46	7.92	-7.01	.00**	11.13	6.71	13.05	4.05	-.78	.45
Regulative instruction	2.33	2.01	2.09	1.86	.28	.79	2.77	1.45	4.12	2.93	-1.30	.21
Reading aloud	6.43	7.74					12.70	7.42	4.29	4.60	3.05	.01**
Miscellaneous	7.51	3.78	8.01	6.04	-.22	.83	3.22	2.08	6.36	2.64	-2.95	.01**

** = $p < .01$, * = $p < .05$

The dyads in condition four produced significantly more *affective utterances* (p = .05), *miscellaneous* (p = .01), *rejecting without elaboration* (p = .00), and *rejecting with elaboration* (p = .03) while the dyads in condition three showed significantly more *asking complex questions* (p = .01) and *reading aloud* (p = .01).

In Table 3, the interactions beneficial for learning have been highlighted. It should be noted that only 16.2% of all the coded utterances could be considered beneficial for learning. Significant differences were nevertheless found between conditions one and two for *accepting with elaboration* (p = .01), *answering with elaboration* (p = .00), *referring to earlier information* (p = .04), and *summarizing and concluding* (p = .01), with the face-to-face condition one scoring higher. With regard to conditions three and four, significant differences were only found for *asking complex questions* (p = .01), with the face-to-face condition 3 scoring higher.

Examples of the Verbal Interactions

To support the quantitative analyses and illustrate the differences found between the conditions, some examples will be presented. The most striking differences occurred for conditions one versus two or the face-to-face versus the computer-mediated mathematics task. The following examples can be regarded as illustrative and typical for the interaction that took place in these conditions.

Example 1

Sample of Face-to-Face Mathematics Task Interaction (Condition One)

Student J: Jan[a]	/ = pause shorter than 3 seconds
Student S: Susanne	// = pause longer than 3 seconds

1. J: I will do the drawing.
2. S: No it is my turn now.
3. J: I think the seesaw will be in balance.
4. S: Yes, no. / We have a seesaw in our yard.// And if you hang on the end of the
5. seesaw, you are much heavier.
6. J: Yes, look here. / ‘cause there are two children on this side, and on the other side
7. just one. //
8. S: So this side is much heavier.
9. J: ‘Cause look here // the left side is this long and the other side is twice as long. //
10. In fact you could divide this part in three.
11. S: In three pieces of equal length. //
12. J: So one child will be sitting on this side and two on the other side // That means the
13. seesaw is in balance.
14. S: Yes, in balance.

[a] Names have been changed to preserve the anonymity of students.

Example 2

Computer-Mediated Mathematics Task Interaction (Condition Two)

Student S: Steven
Student A: Anne

1. S: I’ll do the next problem.
2. S: The seesaw will be in balance.
3. A: Yes I think so too. Do we agree?
4. S: Yes we agree.
5. A: Okay, let’s do the next problem.
6. S: Okay.

In example 1, both Jan and Susanne explain what they think the solution may be. Susanne refers to her home situation, with a seesaw in the yard and explains on the basis of her own experiences, just how the seesaw can be balanced (line 4). Then Jan explains that even though there are two children on one side of the seesaw and just one on the other side, it can still be in balance (lines 6 and 9). This is in marked contrast to the computed-mediated interaction in which Steven immediately provides the answer, Anne promptly agrees, and they move on to the next problem. Although the two students agree, whether they both understood the solution remains unclear. In condition one, that is, more elaborated responses occurred than in condition two.

DISCUSSION

In this explorative study, we intended to gain insight into peer interaction in different learning environments, and make comparisons between these environments. In order to do so, elementary students in three different learning environments completed the same tasks and the peer interactions were analyzed using one coding scheme. Given either a mathematics or language task to solve, four conditions were created: 1) a face-to-face mathematics task condition, 2) a computer-mediated mathematics task condition, 3) a face-to-face language task condition, and 4) an around-the-computer language task condition. Because of the explorative nature of the study it is difficult to draw general conclusions and to generalize the findings. However, since the same method of analysis was used for all the interactions and various variables were kept constant throughout the learning environments, we think that some comparisons between the environments can be made.

In this study, the first research question concerned the types of peer interaction found to occur in the different conditions. In conditions one, three, and four, more than 70% of the coded utterances was cognitive in nature. In condition two or the computer-mediated condition, 53% of the coded utterances was of a cognitive nature.

Comparison of the different conditions showed the two computer conditions (i.e., conditions two and four) to involve more regulative utterances than the face-to-face conditions (i.e., conditions one and three). The regulative utterances were mainly for coordination purposes although we had expected the students particularly in condition two (with the computer-mediated mathematics task) to undertake the most activities focused on finding a common ground since these students were not able to see each other. We had also expected that especially these students would use relatively more verification questions to check whether their partner understood the answer and whether they could proceed to the next problem or not.

Given our interest in the incidence of the interactions beneficial for learning, we examined the incidence of the specific cognitive utterances across the different conditions. Unfortunately, only 16.2% of the coded cognitive utterances were considered to be beneficial for learning. In light of the characteristics of the tasks designed to elicit elaboration and collaborative interaction, we expected to find more elaboration. In addition to the importance of the development of suitable tasks, research has shown that teaching students how to elaborate or reason, for example by teaching “ground rules” for collaboration, can have a positive effect on peer interaction in collaborative activities (see for example Mercer et al., 1999).

With regard to the differences we found across conditions with respect to the occurrence of utterances beneficial for learning, the dyads in condition one scored significantly higher than the dyads in condition two with regard to *accepting with elaboration*, *answering with elaboration*, *referring to earlier information*, and *summarizing and concluding*. This result is in line with findings from Wegerif and Mercer (1997) who found the computer medium to influence the type of talk during interactions and extensive reasoning to be more common in face-to-face interactions. The dyads in condition two scored significantly higher on *affective utterances* than the dyads in condition one, which is in keeping with the results of a study by Hara, Bonk, and Angeli (2000) who found 27% of the communication in computer-mediated situations to consist of expressions of feelings, self-introductions, jokes, compliments, greetings, and closures. In computer-mediated interactions at a distance, nonverbal cues such as facial expressions, directions of gaze, and posture, are non-existent. This means that the students may compensate for the lack of nonverbal cues by typing relatively more affective information than they otherwise might provide. In addition to the provision of affective information, the students in the computer-mediated condition in our study also produced more regulative utterances than the students in the face-to-face condition. Contrary to our expectation of relatively more regulative utterances pertaining to the content of the task in this condition, however, we found most of the regulative utterances to be procedural.

The comparison of conditions three and four revealed the following results. With regard to the interactions beneficial for learning, the dyads performing the face-to-face language task (condition three), scored significantly higher in the utterances that were coded as *asking complex questions* than the dyads performing the around-the-computer language task (condition four). Conversely, the dyads in condition four produced relatively more *affective utterances* and *rejecting with elaboration* than the students in condition three. In contrast to the dyads in the computer-mediated mathematics task (condition two), the dyads performing the around-the-computer language task (condition four) were seated behind a computer and thus communicating face-to-face, which originally led us to expect that the interactions in this condition would not vary considerably from those in the comparable face-to-face language task (condition three). However, as in the computer-mediated mathematics task condition, the interactions in the around-the-computer condition showed significantly more utterances of a regulative nature than the interactions in the face-to-face language task condition without the computer. Inspection of the transcripts showed many of the regulative utterances reflected the search for the right words to type into the computer. This finding is not very surprising in itself, it does however, highlight the importance of typing skills for children working around the computer. Since typing issues accounted for many of the regulative utterances, it can be expected that a significant amount of time was spent finding keys and spelling the right words on the keyboard. This result would argue for a better integration of typing skills in the regular elementary school curriculum.

In interpreting the results of the present study, some possible limitations should be taken into account. First, the study was performed in real school settings and not an experimental laboratory. Nevertheless, the students were taken out of their classrooms to complete the mathematics or language task, which may have influenced the ecological validity of the results. Second, the study involved different elementary school grades. Whereas conditions one, two, and three involved sixth-grade students, condition four involved fourth-grade students. It is very possible that this age difference may have influenced the results of the study. In general, compared to grade six students, students in grade four have developed less knowledge and skills on several domains. This may account for the significant differences in the category *asking complex questions*. However, we did not evaluate the interaction of students in terms of the domain related content, only whether interaction beneficial for learning occurred. In addition, limited typing skills may have been a inhibiting factor resulting in relatively more time spent on regulative activities at the expense of time spent on cognitive activities. Moreover, we tried to minimize the influence of different grades by using a simplified version of the language task to fit the level of the fourth-grade students.

Third, the use of a coding scheme to characterize the verbal interactions of the different dyads may be open to critique (Barnes & Todd, 1977; Edwards & Mercer, 1987). According to Barnes and Todd (1977), meaning is not something fixed but dependent on context and therefore difficult to code. Nevertheless, we think that we were sufficiently able to capture the communicative functions of meanings of the utterances that we were interested in for this study. Moreover, the use of a coding scheme did make it possible to compare the interaction across various conditions, since the coding procedure was sufficiently reliable. However, with a coding scheme, the richness of the interactions is lost and therefore, in future research, alternative types of analyses may be undertaken in order map in more detail the dynamics of collaborative peer interaction. Fourth, the present data were collected on one single occasion. In future research, we aim to collect data on multiple occasions in order to provide information on the development and stability of the observed interactions. Finally, future research on peer interactions should be undertaken to determine if the interactions that we assumed to be beneficial for learning did indeed affect the learning outcomes of the students positively.

Address correspondence concerning this article to:

Judith Kleine Staarman
Ctr. for Research in Education & Educational Technology
Educational Dialogue Research Unit
The Open University
Milton Keynes MK7 6AA United Kingdom
Tel: +44 (0)1908 654017
j.kleinestaarman@open.ac.uk

REFERENCES

Aarnoutse, C., & Van de Wouw, J. (1992). *Wie dit Leest: Een methode voortgezet lezen aansluitend bij Veilig Leren Lezen.* Tilburg, The Netherlands: Uitgeverij Zwijsen.

Barnes, D., & Todd, F. (1977). *Communication and learning in small groups.* London: Routledge .

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393-451). Hills Dale, NJ: Lawrence Erlbaum Associates.

Cole, M., & Wertsch, J. V. (1996). Beyond the individual-social antinomy in discussions of Piaget and Vygotsky. *Human Development*, 39(5), 250-256.

Damon, W., & Phelps, E. (1989). Critical distinctions among three approaches to peer education. *International Journal of Educational Research*, 13(1), 9-19.

De Jong, F. P. C. M. (1992). *Zelfstandig leren.* [Self-regulated learning].Doctoral dissertation, Katholieke Universiteit Brabant, Tilburg, The Netherlands

De Lisi, R., & Golbeck, S. L. (1999). Implications of Piagetian theory for peer learning. In A. King (Ed.), *Cognitive perspectives on peer learning* (pp. 3-37). Mahwah, NJ: Lawrence Erlbaum Associates.

Edwards, D., & Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom.* New York, NY: Methuen.

Erkens, G. (2001). Multiple Episode Protocol Analysis. [Computer program]: Utrecht University, Department of Education, Utrecht, The Netherlands.

Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science*, 28(2), 115-152.

Henri, F. (1992). Computer conferencing and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing*. London: Springer-Verlag.

Hogan, D. M., & Tudge, J. R. H. (1999). Implications of Vygotsky's theory for peer learning. In A. M. O'Donnell & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 39-65). Mahwah, NJ: Lawrence Erlbaum Associates.

Jones, M.G., & Carter, G. (1994). Verbal and nonverbal behavior of ability-grouped dyads. *Journal of Research in Science Teaching*, 31(6), 603-619.

King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Educational Research Journal*, 27(4), 664-687.

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Educational Research Journal*, 31(2), 338-368.

King, A. (1999). Discourse patterns for mediating peer learning. In A. M. O'Donnell (Ed.), (1999). *Cognitive perspectives on peer learning*. (pp. 87-115). Mahwah, NJ: Lawrence Erlbaum Associates.

King, A., Staffieri, A., & Adelgais, A. (1998). Mutual peer tutoring: Effects of structural tutorial interaction to scaffold peer learning. *Journal of Educational Psychology*, 90(1), 134-152.

Kneser, C., & Ploetzner, R. (2001). Collaboration on the basis of complementary domain knowledge: observed dialogue structures and their relation to learning success. *Learning and Instruction*, 11(1), 53-83.

Kumpulainen, K., & Mutanen, M. (1999). The situated dynamics of peer group interaction: an introduction to an analytic framework. *Learning and Instruction*, 9(5), 449-473.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (1999). *Computer supported collaborative learning: A review.* Nijmegen: Department of Educational Sciences, University of Nijmegen.

Leseman, P. P. M., Rollenberg, L., & Gebhardt, E. (2000). Co-construction in kindergartners' free play: Effects of social, individual and didactic factors. In H. Cowie & G. Van der Aalsvoort (Eds.), *Social interaction in learning and instruction: The meaning of discourse for the construction of knowledge.* Amsterdam, Netherlands: Pergamon/ Elsevier Science Inc.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and Instruction,* 6(4), 359-377.

Mercer, N. (2000). *Words and minds: How we use language to think together.* London: Routledge.

Mercer, N., Wegerif, R., & Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. *British Educational Research Journal,* 25(1), 95-111.

O'Donnell, A. M., & O'Kelly, J. (1994). Learning from peers: Beyond the rhetoric of positive results. *Educational Psychology Review,* 6(4), 321-349.

Ros, A. A. (1994). *Samenwerking tussen leerlingen en effectief onderwijs: De invloed van de leerkracht.* [Cooperation between peers and effective education: The influence of the teacher]. Doctoral dissertation, Groningen University, Groningen, The Netherlands.

Salomon, G., & Perkins, D. N. (1998). Individual and social aspects of learning. In A. Iran-Nejad (Ed.), *Review of Research in Education* (Vol. 23, pp. 1-24). Washington, DC: American Educational Research Association.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *Journal of the Learning Sciences,* 1(1), 37-68.

Tudge, J. R. H. (1992). Processes and consequences of peer collaboration: A Vygotskian analysis. *Child Development,* 63(6), 1364-1379.

Van Boxtel, C. (2000). *Collaborative Concept Learning: Collaborative learning tasks, student interaction and the learning of physics concepts.* Doctoral dissertation, Utrecht: University, Utrecht, The Netherlands.

Van Boxtel, C., & Roelofs, E. (2001). Investigating the quality of student discourse: what constitutes a productive student discourse? *Journal of Classroom Interaction,* 36(2), 55-62.

Van Boxtel, C., van der Linden, J., & Kanselaar, G. (2000). Collaborative learning tasks and the elaboration of conceptual knowledge. *Learning and Instruction,* 10(4), 311-330.

Veldhuis-Diermanse, E. (1999). *Computer Supported Collaborative Learning in higher education.* Paper presented at the ICO conference 1999, Utrecht, The Netherlands.

Vermunt, J. D. H. M. (1992). *Leerstijlen en het sturen van leerprocessen in het hoger onderwijs.* [Learning styles and the regulation of learning processes in higher education]. Doctoral dissertation, Katholieke Universiteit Brabant, Tilburg, The Netherlands.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research,* 13(1), 21-39.

Webb, N. M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education,* 22(5), 366-389.

Webb, N. M., & Farivar, S. (1994). S. (1994). Promoting helping behavior in cooperative small groups in middle school mathematics. *American Educational Research Journal,* 31(2), 369-395.

Webb, N. M., & Farivar, S. (1999). Developing productive group interaction in middle school mathematics. In A. King (Ed.), *Cognitive perspectives on peer learning* (pp. 117-149). Mahwah, NJ: Lawrence Erlbaum Associates.

Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology,* 87(3), 406-423.

Wegerif, R., & Mercer, N. (1997). A dialogical framework for researching peer talk. In R. Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom.* Clevedon: Multilingual Matters.

Wegerif, R., Mercer, N., & Dawes, L. (1999). From social interaction to individual reasoning: An empirical investigation of a possible socio-cultural model of cognitive development. *Learning and Instruction,* 9(6), 493-516.

APPENDIX A: Coding Scheme

Code	Name	Description	Example
COGNITIVE: ASKING QUESTIONS			
CHV1	Asking simple questions: facts and answers, it does not ask for elaboration.	The student asks about a fact or just asks what the answer is. The question does not provoke an explanation	• Twelve? • And after that?
CHV2	Asking complex questions: comprehension and explanations	The student requests an explanation/ elaboration	• Why is that?
CHVER	Asking verification questions	The students asks a question to find out whether the other agrees with his remarks/conclusions/ answers	• On the right side, or not? • Do you also think that one is going down? • So that one is going down, right?
COGNITIVE: ANSWERING (WITH OR WITHOUT ELABORATION)			
CHG1	Answering without elaboration	The student just answers the question but does not give an explanation or elaboration	• Yes, I think the left side is going down • It must be nine.
CHG2	Answering with elaboration (using arguments or by asking a counter-question)	The student answers by explaining how the problem can be solved and explains why the problem must be solved that way (giving arguments with keywords like: “because” and “that’s why”). Sometimes a counter-question is asked to let the other think first.	• I think the situation remains the same because they’re the same weight. • Now I know that one as well. Because, look, the heaviest is on the outside. I think this must be exactly halve…
COGNITIVE: PROVIDING INFORMATION (WITH OR WITHOUT ELABORATION)			
CI1	Providing not-elaborated information	The student formulates an idea or thought, but does not give an explanation	• The left side will go down
CI2	Providing elaborated information	The student formulates an idea or thought and gives an explanation	• The left side will go down, because the dinosaur is much heavier than the child
CIT	Referring to earlier remark/ information	The student refers to earlier formulated information	• I think the same thing that happened earlier will happen here. Now that one is 4 times as long • There this one was three kilo’s as well.
CIE	Summarizing/concluding	The student evaluates the content summarizes or concludes.	• So this must be one and a half. Because this is twice as much as that.
ACCEPT-	Accepting without elaboration	The student accepts the contribution from the other without comment/addition	• Yes • Yes, okay.
ACCEPT+	Accepting with elaboration	The student accepts the contribution from the other and adds a comment/elaboration.	• Yes, I think so because here it’s 6/it’s still going down • Yes, six. Yes, cause this is the same length
NACCEPT-	Rejecting without elaboration	The student does not accept the contribution from the other without comment/addition (no explanation for not accepting).	• Can’t put that one here! • That’s all right. Wanna bet that’s the right answer? • I have three here!
NACCEPT+	Rejecting with elaboration	The student does not accepts the contribution from the other with comment/addition (gives explanation for not accepting).	• I don’t think here, because then it will go down • No, because here it was just like the other children. Here they are with less and there with more
AFFECTIVE			
A	Affective utterances (positive and negative)	The student makes a positive or negative remark about the other or about the task	• Yes, well, that’s not so hard • Duh, this is really difficult… (ironic)
GR	Greetings	To indicate the presence or absence of a person	• Hello
REGULATIVE			
RV	Regulative: planning, monitoring	The students plan the execution of the task, divide the tasks, guard the execution of the task, keep the time	• May I do the drawing? • Not so precise, otherwise we will never finish on time
RINS	Regulative: Instructing	One student instructs the other	• Just make the drawing! • Just a straight line here and then two little puppets on top there
REST			
VOORL	Reading aloud	The students are reading the task or text aloud	
AND	Miscellaneous	Interactions / remarks that do not fall into any category. Not task-related remarks, non-finished sentences.	• Then it… • (draws) Right... and then.... grass....