VISUALISATIE VAN CONSTRUCTIEVE ARGUMENTATIE IN COMPUTER-ONDERSTEUND SAMENWERKEND LEREN

Jeroen Janssen
Gijsbert Erkens
Marcel Broeken
Jos Jaspers

Research Centre Learning in Interaction
Universiteit Utrecht

Paper gepresenteerd tijdens de Onderwijs Research Dagen (ORD) 2006

Amsterdam, 10 – 12 mei 2006

Correspondentie richten aan:
Jeroen Janssen
Research Centre Learning in Interaction
Universiteit Utrecht
Postbus 80140
Telefoon: +31 (0)30 2534798
Fax: +31 (0)30 2532352
E-mail: j.j.h.m.janssen@fss.uu.nl
URL: http://edugate.fss.uu.nl

Nederlandse Organisatie voor Wetenschappelijk Onderzoek

SAMENVATTING

Doel van dit onderzoek was om de effecten van de *Shared Space* (SS) op het gedrag van leerlingen in een elektronische leeromgeving te onderzoeken. De SS visualiseert de discussie en de overeenstemming over een onderwerp tijdens online discussies. Verwacht werd dat de SS de media richness van de leeromgeving zou vergroten, meer kritische en exploratieve groepsnormen zou stimuleren, tot positievere percepties van de online samenwerking zou leiden en de samenwerkingsactiviteiten van groepsleden zou beïnvloeden. Om deze verwachtingen te onderzoeken werkten 117 leerlingen in 40 groepen samen aan een Praktische Opdracht voor het vak geschiedenis. Daarvan hadden 59 leerlingen toegang tot de SS, terwijl de overige 58 leerlingen dat niet hadden. De resultaten laten zien dat leerlingen die toegang tot de SS hadden: a) een kritischere groepsnorm rapporteerden, b) een positiever beeld van de eigen samenwerking rapporteerden en c) aangaven hun groepsstrategieën effectiever te vinden. De SS had slechts marginaal effect op de ervaren media richness van de elektronische leeromgeving. Bovendien had de SS slechts een beperkte invloed op de samenwerkingsactiviteiten van groepsleden. De uitkomsten van dit onderzoek laten zien dat visualisatie van discussie en overeenstemming een positieve bijdrage kan leveren aan computer-ondersteund samenwerkend leren.

Over the last decades, numerous advances have been made in information and communication technology. Nowadays, e-mail, real-time chat, file sharing, and instant messaging are being used by more and more people. These developments in ICT have also reached teacher's classrooms. In schools, teachers and students are increasingly using ICT to facilitate learning in various subjects (Lou, Abrami, & d'Apollonia, 2001). ICT applications, such as tutorials, simulations, and computer-mediated communication (CMC) are regarded as promising tools for education. *Computer-supported collaborative learning* (CSCL) is one educational application of ICT which has received considerable attention by educational researchers (e.g., Kreijns, 2004; Strijbos, 2004; Van der Meijden, 2005; Van Drie, 2005). CSCL aims to provide students with an environment that supports and enhances collaboration, in order to facilitate their learning processes (Kreijns, Kirschner, & Jochems, 2003). When using CSCL environments, students usually communicate with group members using discussion forums or chat rooms. A CSCL environment tries to offer tools that facilitate sharing of information and ideas, and the distribution of expertise among group members (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003).

CSCL has been regarded as a potential tool for education for several reasons. First of all, research has demonstrated positive effects of using *ICT in education* (e.g., Fletcher-Flinn & Gravatt, 1995). Second, research has also demonstrated positive effects of using *collaborative learning*. When students work together in small groups, they perform better and learn more, compared to students working individually (Johnson & Johnson, 1999; Slavin, 1996). Third, CSCL is seen as a promising combination of ICT *and* collaborative learning. Indeed, a meta-analysis by Lou, Abrami, and d'Apollonia (2001) demonstrated that combining small group learning with ICT was more effective than combining individual learning with ICT. Additionally, Cavanaugh (2001) demonstrated the effectiveness of interactive distance education technologies. Thus, the perceived potential of CSCL seems to be, at least partially, supported by research outcomes.

Notwithstanding the positive effects of using CSCL, many studies have also demonstrated possible pitfalls when using CSCL (Kreijns et al., 2003). For example, students working in CMC groups sometimes perceive their discussions as more confusing (Thompson & Coovert, 2003), demonstrate higher levels of personal conflict (Hobman, Bordia, Irmer, & Chang, 2002) or participate in unsustained, low quality discussions (Lipponen et al., 2003). In sum, positive and productive social interaction is sometimes lacking during CSCL.

The following sections discuss two problems that may occur during CSCL, namely communication and discussion difficulties due to lower media richness and students' difficulties to conduct critical, yet constructive discussions. Possible explanations for these problems will be described in short. The final section of this introduction will describe how these problems may be addressed in order to facilitate effective CSCL.

Communication difficulties during CSCL

Research has demonstrated that for group members it is difficult to communicate during CSCL (Fuks, Pimentel, & Lucena, 2006). For example, Fjermestad (2004) found that in many studies communication was more difficult in CSCL environments compared to face-to-face (FTF) conditions, concluding that "it is still easier to communicate verbally than through the computer" (p. 250).

Some researchers have argued that the communication problems found during CSCL, may be due to the medium itself. More precisely, traditional CMC systems, such as e-mail or chat, are seen as media that are low in media richness (Daft & Lengel, 1986; Dennis, Kinney, & Hung, 1999). Media richness is defined as a medium's ability to facilitate communication and the establishment of shared meaning. Factors such as the ability of the medium to transmit multiple cues (e.g., facial expressions, gestures, or verbal sound), and

the immediacy of feedback influence its media richness. As media richness decreases, group members will have more difficulties conveying their opinions and ideas and will have more difficulties determining the meaning of group member's messages. Thus, since CSCL environments are sometimes low in media richness because they use discussion boards or chat as a means to communicate, communication difficulties between group members are bound to surface from time to time. However, this may not apply to systems that offer audio or video channels for communication.

Furthermore, when working on group tasks in a CSCL environment, students usually work on complex problems without demonstrably correct answers, which require students to resolve conflicts and differing viewpoints. The type of communication usually offered in CSCL environments, may not be suited to the types of tasks group members are working on during CSCL (Mennecke, Valacich, & Wheeler, 2000). The low media richness of CSCL environments may constrain collaboration in such a way that it does not transmit the type of communication that group members need to solve the task successfully. This may lead to communication difficulties and decreased task performance.

Lack of critical but constructive discussion during CSCL

When group members together, they are usually working on complex problems, which require the input of all group members and which require students to jointly reason about solutions, opinions and strategies. Ideally, group members engage in discussions that are critical, but also constructive. This means that group members are critical of their own and their group member's ideas, that criticism is accepted, and that they offer explanations for their opinions and arguments. These types of discussions have been called exploratory discussions by Mercer (1996) and have been found to enhance learning during group learning activities (Wegerif, Mercer, & Dawes, 1999). However, research has shown that students rarely give arguments during collaboration (Kuhn & Udell, 2003), nor do they offer explanations for their ideas regularly during CSCL (Van der Meijden & Veenman, 2005).

The relative absence of critical but constructive discussion during CSCL may be explained in several ways. First, students may not know how to conduct such discussions and may not posses the necessary skills (Felton & Kuhn, 2001; Weinberger & Fischer, 2006). Second, as stated above, students may find it difficult to conduct constructive conditions in a CSCL environment and may have difficulties interpreting computer-mediated discussions. For example, they may not know whether group members agree or disagree with them. This possibly hampers argumentation and discussion (Adrianson & Hjelmquist, 1991). Finally, group may possess group norms that stimulate consensus among group members, instead of critical or exploratory discussion. Group norms are rules or standards that are accepted by all group members and prescribe group behavior (Postmes, Spears, & Cihangir, 2001). Groups with a critical group norm collaborate more critically and constructively, compared to groups with a consensus group norm. Group norms that stimulate quick consensus instead of critical discussion may contribute to the low quality of some online discussions (Postmes et al., 2001).

Addressing communication and discussion problems using visualizations

The previous sections highlighted two potential problems that may occur during CSCL: communication problems and lack of critical and constructive discussion. This section describes how visualizations of online dialogue may help to address these problems. First, this section describes a visualization called *Shared Space* (SS). The SS visualizes whether group members are agreeing or disagreeing about a topic during online discussion. This visualization has been implemented in an existing CSCL environment. Second, this section describes why and how the SS may address the problems described in the previous sections.

The SS was implemented in the *Virtual Collaborative Research Institute* (VCRI), developed at Utrecht University (Jaspers, Broeken, & Erkens, 2005). This is a groupware environment designed to facilitate CSCL (for an extended description of the VCRI, see the Task and materials section below). More specifically, the SS is an extension of the *Chat tool* of the VCRI program. The SS analyzes all messages typed in the Chat tool by the students.

First, the SS discerns discussion topics based on time intervals. When students do not type messages for more than 59 seconds, a new topic begins. Figure 1 shows a screenshot of the VCRI's Chat tool with SS visualization. The screenshot shows the end of one topic, and the beginning of a new topic.

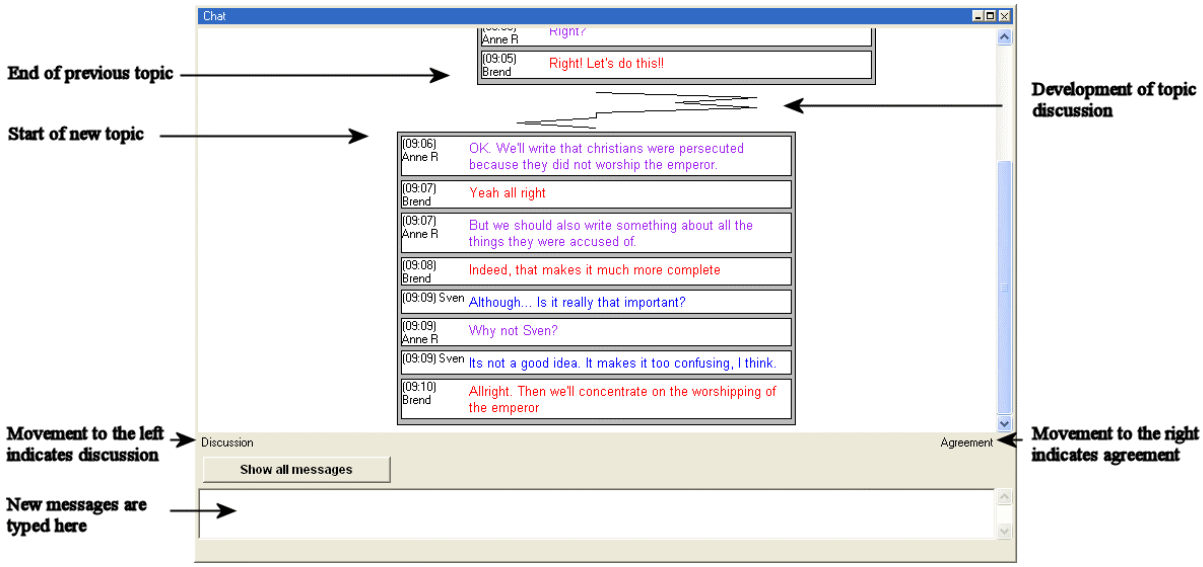

Figure 1 Screenshot of the Chat tool with Shared Space visualization.

Second, the SS analyzes the content of each chat message in order to determine whether it indicates discussion or agreement. For this purpose, the SS determines the communicative function of the message. This is done using the *Dialogue Act Coding (DAC) filter* (see Erkens, Jaspers, Prangsma, & Kanselaar, 2005). This filter uses over 1300 rules based on discourse markers to determine the communicative function of a chat message. Discourse markers are characteristic words or phrases signaling the communicative function of a message. In total, five main categories of communicative functions are distinguished: argumentative, responsive, informative, elicative, and imperative. Each category consists of several subcategories. For example, the elicitative category consists of verification questions, open questions, set questions, and proposals for action. In total, 29 different dialogue acts are distinguished. Of these, confirmations, acknowledgements, and positive evaluations are considered indications of agreement, while denials, verification questions, negative evaluations, and counterarguments are considered indications of discussion or debate. In a prior study (see Erkens et al., 2005), the reliability of the DAC filter was tested and found to be acceptable (over 80% of all messages coded correctly).

Finally, after establishing whether the chat message indicates discussion or agreement, the SS moves the whole topic to the left or to the right in small steps. When the chat message indicates discussion, the SS moves the topic to the left; when it indicates agreement, the SS moves the topic to the right. The movement of the topics corresponds to the "discussion" and "agreement" headings underneath the chat history. The lines above the topics visualize the development of the online discussion. For example, in Figure 1, at the

beginning of the topic, the SS indicated agreement (the line moves to the right), whereas later on the SS indicated debate (the line goes to the left).

It may be hypothesized the SS visualization will help group members overcome the communication and discussion problems described above for several reasons. First, the SS visualization may increase the media richness of the CSCL environment. Because the SS visualizes discussion and agreement, it may be easier for students to determine the meaning of group members' messages. Additionally, it may be easier to identify the different views and positions held by group members. Moreover, the SS may help group members to determine whether there is shared understaning about a topic or subject. Ultimately, this higher media richness may facilitate online discussion.

Second, the SS visualization provides group members with feedback about the manner in which they are conducting their discussions. For example, when the SS moves continually to the right, this tells group members they may be engaged in an uncritical discussion. In contrast, when the SS visualization keeps moving from right to left and back again, this tells students they are engaged in constructive, exploratory discussions. Thus, the feedback provided by the SS visualization may increase students' awareness about their conversational strategies and their group norms.

Finally, by providing them with feedback and by raising their awareness, the SS visualization may help students to engage in group processing. This occurs when group members discuss how well their group is functioning and how group processes may be improved. These discussions may help groups pinpoint, comprehend, and solve collaboration problems and may reinforce successful collaborative behavior (Webb & Palincsar, 1996; Yager, Johnson, Johnson, & Snider, 1986). During these discussions group members may be stimulated to adopt more critical or exploratory group norms (if necessary). In conclusion, it is expected that SS visualization may alleviate some of the communication problems that occur during CSCL, and may help group members to collaborate and discuss more productively.

RESEARCH QUESTIONS

This paper investigates the effects of the SS visualization described above on online collaboration. Participants worked together in small groups on an inquiry group task for their history classes. It is investigated whether the SS visualization (a) increases students perception of media richness, (b) stimulates more critical group norms, (c) leads to more favorable perceptions of collaboration, and (d) triggers different collaborative activities. Thus, this paper addresses the following research questions:

1. Do students with access to SS visualization perceive higher media richness when using the Chat tool, compared to students without SS visualization?
2. Do students with access to SS visualization perceive different, more critical group norms, compared to students without access to SS visualization?
3. Do students with access to SS visualization perceive their online collaboration and communication differently, compared to students without access to SS visualization?
4. Do students with access to SS visualization engage in different collaborative activities, compared to students without access to SS visualization?

METHOD AND INSTRUMENTATION

Design

A posttest-only design with a treatment and a control group was used to answer the research questions. Treatment group students had access to a chat tool with SS visualization, whereas control group students did not. Students were divided into groups of two, three, or four students. Each group of students was assigned to either the treatment or the control group. The treatment group consisted of 59 students collaborating in 20 groups. Similarly, the control group also consisted of 58 students working together in 20 groups.

Participants

Participants came from five different history classes from two secondary schools in The Netherlands. In total, 117 eleventh-grade students (54 male, 63 female) participated in the study. All students were enrolled in the second stage of the pre-university education track. Mean age of the students was 16.17 years (*SD* = .60, *Min* = 15, *Max* = 18). Students were randomly assigned to a group by the researchers. In order to prevent combinations of students who could not get along with each other, the group compositions were checked by their teachers. As a result, three students were assigned to other groups.

Task and Materials

CSCL environment

Group members collaborated in a CSCL environment called VCRI. The VCRI is a groupware program designed to support collaborative learning on research projects and inquiry group tasks. The VCRI-program has been developed at Utrecht University, and has been used in several research projects (e.g., Janssen, Erkens, Kanselaar, & Jaspers, in press; Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005).

Usually, students use the VCRI-program to collaborate in groups of two to four. Every group member works at one computer. Group members use the *Chat* tool to communicate synchronously with group members (see Figure 2). The chat history is stored automatically and can be re-read. To read the description of their group task or to search and read relevant information, students can use the *Sources* tool. This tool lists a number of sources, which can be opened and read from the screen. Group members use the *Co-Writer* as a shared word processor. Using the Co-Writer group members can work simultaneously on different parts of their texts. To collaboratively construct (argumentative) diagrams, students can use the *Diagrammer*. The VCRI-program contains several other tools not shown in Figure 2. For example, the *Forum*, which can be used to asynchronously communicate with other group or class members, or the *Planner*, which can be used to develop plans and assign tasks to group members.

For teachers an alternative version of the VCRI-program is available. Using this so-called *Coach*-program, teachers can monitor the online discussions of their students. Teachers can also send messages in order to answer students' questions, give tips or hints, or to warn students in case of misbehavior. These messages appear in the Chat tool of the appropriate groups. Teachers can also send a message to multiple groups at once. Furthermore, teachers have access to the texts students are writing in the Co-Writer. This way, teachers can monitor the progress of their groups. Finally, the Coach-program provides teachers with descriptive information about the participation rates of their students. In sum, the Coach-program helps teachers to perform two important aspects of supporting

collaboration between students: monitor the progress of group work, and intervene appropriately (Battistich & Watson, 2003).

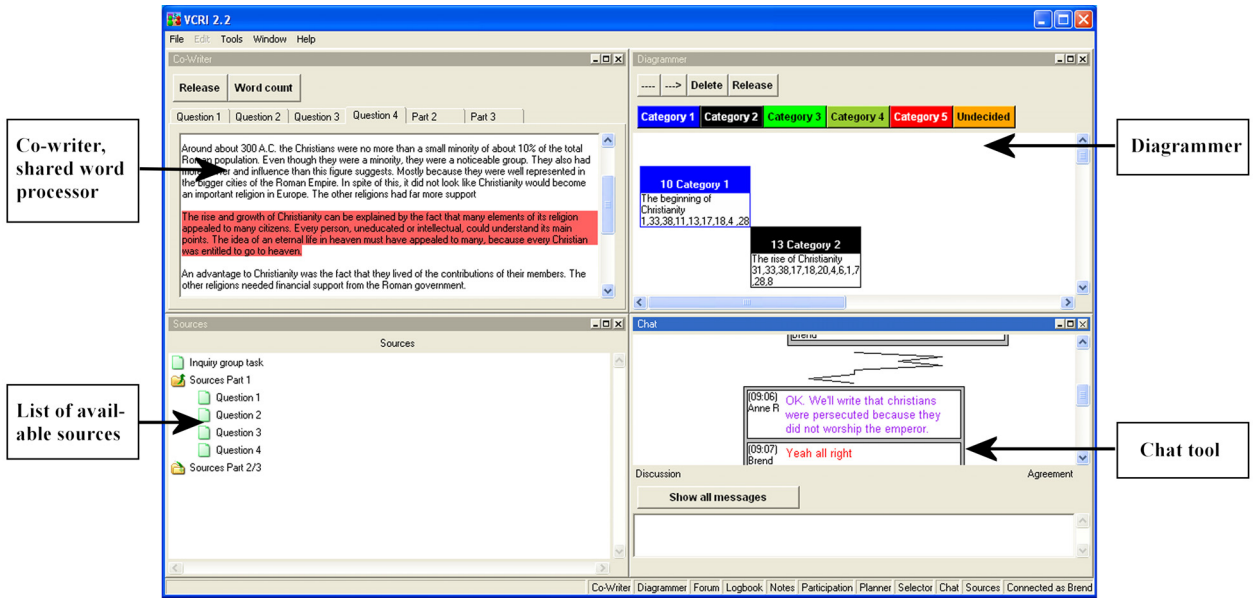

Figure 2 Screenshot of the VCRI program, showing the Co-Writer, Diagrammer, Sources, and Chat tool with Shared Space visualization.

Inquiry group task

Participating students worked together on a historical inquiry group task, developed together with the teachers involved in the study. Subject of the task was "The first four centuries of Christianity". The task consisted of three different parts that addressed different aspects of the subject. The introduction of the task stressed the importance of working together as a group to successfully complete the inquiry task. Students were told they had eight lessons to hand in their reports, and they would receive a group grade for their reports.

For the first part of the inquiry task, the groups had to answer four different questions pertaining to the first four centuries of Christianity. To answer these questions, 12 different sources were available to the students. Additionally, students could search the Internet or their textbooks for more information. To complete the second part of the inquiry group task, the groups had to study 40 different historical and more contemporary sources about the subject. These sources needed to be categorized into up to five different categories by the group members. Furthermore, group members were instructed to construct a diagram of their categorization using the Diagrammer. Finally, group members had to write a short text, explaining how and why they categorized the different sources. For the final part of the inquiry task, group members had to collaboratively write an essay of at least 1200 words. The essay had to explain why and how Christianity developed from a small 'cult' into the main religion of the Roman Empire.

The inquiry group task can be characterized as an open-ended task; meaning the task does not have a standard procedure and no single right answer. Furthermore, the inquiry task was quite complex and extensive; therefore, no single group member was likely to solve the task on his or her own. Thus, the participation of all group members was necessary to successfully complete the task.

Treatment: Shared Space Visualization

Students in the treatment condition had access to the Chat tool with SS visualization (see above). Students in the control condition had access to a regular Chat tool. This Chat tool was similar to the Chat tool with SS visualization, but did not discriminate between topics and did not move to the left or right to indicate agreement or debate.

Procedure

Group members collaborated on the inquiry group task for a period of about four weeks. In total eight classroom hours were devoted to the inquiry group task. During these hours students worked together on the task, with each student working on a separate computer in one or two computer labs. Students were seated as far from their group members as possible, in order to stimulate them to use to the VCRI-program to communicate with group members.

Before the first computer lesson, students received information about the task and the group compositions from their teachers. During the computer lessons, the teachers were available to answer task-related questions, while the experimenters were standby to solve technical problems or to address technical questions. Students were allowed to work on the inquiry group task during free periods. Thus, students could work on the task in the media center when they had spare time in their timetable. Students were not able to access the CSCL-environment from their homes; it was only accessible from school. After eight lessons, the groups handed in their final versions of the group task.

After the last lesson, a questionnaire was administered to the students. This questionnaire contained several items pertaining to perceived media richness, group norm perception, and perception of online collaboration and communication. In total, the questionnaire contained 48 items. Students expressed their opinions using a 5-point scale ranging from 1 (=*completely disagree*) to 5 (=*completely agree*). Due to absence or sickness, 20 students did not complete the posttest questionnaire. Thus, for the posttest questionnaire the total number of respondents was 97 students.

Measures

Perceived media richness of the Chat tool

To measure perceived media richness of the Chat tool, the questionnaire completed by the students during the posttest contained a 15-item scale that addressed various aspects pertaining to the media richness of the Chat tool. The scale's items addressed whether students found discussion and communication through the Chat tool pleasurable and enjoyable, whether they were aware of agreements and disagreements during online discussions, and whether they could explain things easily to group members (Dennis et al., 1999). Sample items of this scale included: "I could easily explain my opinions using the Chat", "Communicating through the Chat is impersonal" (reverse scored), and "During discussion in the Chat it is clear whether there is agreement among group members". The items formed a homogeneous scale, as indicated by a Cronbach's alpha of .92. Therefore, the ratings of the students were averaged to create a score for "*perceived media richness*". Higher scores for this variable indicate a higher perceived media richness of the Chat tool for collaboration and discussion.

Group norm perception

To measure students' perceptions of group norms, the questionnaire completed by the students during the posttest contained three scales. The first scale consisted of three items, and asked students whether they perceived their group as a critical one. The items

were based on the work of Postmes et al. (2001). Sample items of this scale were: "Our group is critical" and "People in our group are generally critical". The Cronbach's reliability coefficient for this scale was .84. In order to obtain a score for "critical group norm perception", students' responses to the three items were averaged. Higher scores on this variable indicate a more *critical group norm perception*.

The second scale investigated whether students perceived their group as having consensual group norms. This scale also consisted of three items based on the work of Postmes et al. (2001). Sample items of this scale included: "In this group people generally adapt to each other" and "In this group you have to act independently". Cronbach's alpha for this scale was .59. Again, students' ratings for the three items were averaged to obtain a score for "consensual group norm perception". A high score on this variable corresponds to a more *consensual group norm perception*.

Finally, the third scale examined whether group members perceived their group as having *exploratory group norms*. This scale consisted of seven items, modeled after the ground rules for exploratory talk formulated by Mercer and colleagues (e.g., Mercer, Wegerif, & Dawes, 1999; Wegerif et al., 1999). During exploratory talk, group members are critically, yet constructively engaged in discussions. This type of talking and reasoning has been shown to improve collaboration and individual knowledge acquisition (Mercer et al., 1999; Wegerif et al., 1999). "During collaboration, we shared all relevant information" and "During discussions, criticism and counterarguments were accepted" were sample items of this scale. Since Cronbach's alpha for this scale was found to be .74, students' answers to the seven items were averaged to obtain a score for "exploratory group norm perception". Students with a high score on this variable perceive a more exploratory group norm, compared to students with a low score.

Perception of online collaboration and communication

To investigate whether students with access to the SS visualization perceived their online collaboration and communication differently than students without access to the SS visualization, the posttest questionnaire contained three scales. The first two scales were developed in a previous study (Janssen, Erkens, & Schep, submitted).

The first scale consisted of seven items and addressed *positive group behavior*, such as equal participation of group members, and helping group members (Webb, 1995). Sample items included: "We collaborated well during the group task", and "We helped each other during collaboration". Cronbach's alpha was examined for this scale and found to be .82. Thus, students' responses to the individual items were averaged into a single score for "positive group behavior". Higher scores on this measure indicate more occurrences of positive group behavior.

Five items formed the second scale. These items addressed occurrences of *negative group behavior* such as conflicts and free riding behavior (O'Donnell & O'Kelly, 1994). Sample items of this scale are: "I had to do most of the work during collaboration" and "There were conflicts in our group". Students' responses to the five items were averaged to obtain a score for "negative group behavior". Cronbach's alpha for this scale was found to be .68. Higher scores on this variable indicate more occurrences of negative group behavior.

The final scale addressed students' *perceived effectiveness of their group's task strategies*. This scale was based on the work of Saavedra, Early, and Van Dyne (1993). This scale consisted of eight items that assessed the choices made and the strategies chosen by the group members during online collaboration. Sample items of this scale include: "Our group almost never experimented with other ways to perform the task" (reverse scored) and "We planned our group work effectively". Cronbach's alpha was .81 for this scale. Students' scores on the items were averaged into a single score for "effectiveness of group task

strategies". Students with a high score for this measure, perceived their group's task strategies as more effective, compared to students with a low score on this measure.

Collaborative activities

To answer the fourth research question, regarding the influence of the SS visualization on students' collaborative activities, a coding scheme was used. This coding scheme was developed and used in a previous study (Janssen et al., in press). The aim of this coding scheme was to provide insight into the task- and group-related processes taking place between students while working together on the inquiry group task. This section describes the categories, unit of analysis, segmentation and coding procedure and interobserver reliability of the coding scheme.

Description of the coding scheme. Different types of activities are necessary to successfully complete a group task. These types of activities are reflected by the four different dimensions of the coding scheme. Each dimension contains two or more coding categories. In total, the scheme consists of 19 categories.

The first dimension referred to *performance of task-related activities*. These activities are aimed at solving the problem at hand, such as expressing ideas or opinios and asking questions (Jehn & Shah, 1997). This dimension contained two categories pertaining to the discussion of relevant task-related information: exchanging and sharing task-related information (*TaskExch*) and asking task-related questions (*TaskQues*). In brackets, the abbreviations of the codes are given. These abbreviations will be used from time to time in the analyses presented below.

The second dimension referred to *regulation and coordination of task-related activities*, encompassing four categories. Metacognitive activities that regulate task performance, such as making plans and monitoring task progress, are considered important to successful group performance (Artzt & Armour-Thomas, 1997; Van der Meijden & Veenman, 2005). First, planning (*MTaskPlan*) involved discussion of strategies necessary to complete the task, choice of appropriate strategies, and delegation of task responsibilities. Second, monitoring (*MTaskMoni*) involved exchange of information that could be used to monitor task performance and progress, and assessing the amount of time available. Finally, evaluation involved appraisal and discussion of task performance and progress, which could be either positive (*MTaskEvl+*) or negative (*MTaskEvl-*).

Performance of social activities was the third dimension of the coding scheme. Besides devoting time to the task-related aspects of collaboration, group members also have to attend to the social and emotional element of collaboration to successfully complete a group task (Kreijns, 2004; Kumpulainen & Mutanen, 1999; Rourke, Anderson, Garrison, & Archer, 1999).This dimension contained five categories. First, greetings (*SociGree*) were included, since they contribute positively to group atmosphere and a feeling of social presence (Rourke et al., 1999). Second, social support remarks (*SociSupp*) referred to comments that contributed positively to group atmosphere, such as exchanging positive comments, displaying positive emotions, and disclosure of personal information. Third, social resistance remarks (*SociResi*) referred to behaviors that contributed negatively to group atmosphere, such as insulting group members and displaying negative emotions. Fourth, shared understanding (*SociUnd+*) referred to confirmations and indications of agreement, which serve to reach and maintain joint understanding. Similarly, loss of shared understanding (*SociUnd-*) referred to denials, disagreements, and expressions of incomprehension.

The fourth dimension referred to *regulation and coordination of social activities*. Group members need to discuss collaboration strategies, monitor their collaboration process, and evaluate and reflect on the manner in which they collaborated. This dimension contained four categories. First, planning (*MSociPlan*) involved discussion of collaboration strategies,

such as helping each other, or proposals to work together on certain tasks. Second, monitoring (*MSociMoni*) referred to the exchange of information that could be used to monitor group processes. Finally, evaluation involved appraisal and discussion of group processes and collaboration, which could be positive (*MSociEvl*+) or negative (*MSociEvl*-).

Statements that addressed neutral, negative, or positive technical aspects of the CSCL environment were also included in the coding scheme (codes *TechNeut*, *TechNega*, and *TechPosi*). Finally, statements that did not fit into any of the previously mentioned categories were coded as *Other*. These codes mostly referred to nonsense and off-task remarks.

Unit of analysis. To examine students' collaborative activities during online conversation, an appropriate unit of analysis had to be chosen. Using entire chat messages as the unit of analysis would be an intuitive choice, but during online collaboration some students only send one sentence per chat message, while others type several sentences that combine multiple clauses (Howell-Richardson & Mellar, 1996). Furthermore, even within in a single sentence, multiple concepts, ideas and statements may be expressed (Strijbos, Martens, Prins, & Jochems, 2006). Thus, it may be necessary to segment a message into even smaller parts that can be meaningful in their selves. Therefore, the chat messages sent by the participating students were segmented into *dialogue acts* (Erkens et al., 2005; Janssen et al., in press). Dialogue acts indicate the communicative function of a message (responding, informing, argumentation, commanding, or eliciting). One dialogue act corresponds to a sentence or a part of a compound sentence that can be regarded meaningful in itself and has a single communicative function.

Segmentation and coding procedure. Segmentation and coding of the chat conversation was done using the *Multiple Episode Protocol Analysis* (MEPA) computer program (Erkens, 2005). Chat messages were segmented into dialogue acts using a *segmentation filter*. A filter is a program, which can be specified and used in the MEPA program for automatic rule based coding or data manipulation. The segmentation filter automatically segments messages into dialogue acts, using over 150 decision rules. Punctuation marks (e.g., full stop, exclamation mark, question mark, comma) and connectives (e.g., "and", "but", "because") are used by the filter to segment messages into dialogue acts. Using filters dramatically speeds up the segmentation process, and ensures segmentation rules are applied consistently. After all chat protocols were segmented into dialogue acts, the dialogue acts were subsequently coded with the coding scheme using the MEPA program.

Interobserver reliability. In the abovementioned previous study, a satisfactory overall Cohen's Kappa of .86 was found. The category Kappa's (Cicchetti, Lee, Fontana, & Dowds, 1978) ranged from .67 to 1.00. For the purpose of the current study, one rater coded 796 collaborative activities from four random protocols from the previous study. To calculate test-retest reliability, the results of this coding were compared to the results of the previous study. An overall Cohen's Kappa of .94 was found (category Kappa range: .78 - 1.00).

Data Analysis

To investigate the effects of the SS on students' collaborative activities during CSCL, one solution would be to compare the collaborative activities of students who used the SS to the collaborative activities of students who did not use the PT, using an independent samples *t* test with *condition* (SS or no SS) as an independent variable. However, it is important to note that students' collaborative activities are most likely *nonindependent* (Bonito, 2002; Kashy & Kenny, 2000). *Mutual influence* is the most important source of nonindependence when students collaborate (Kenny, Mannetti, Pierro, Livi, & Kashy, 2002). That is, what one group member says, is influenced by, and influences the contributions of other group members. Therefore, students who are in the same group behave in more or less similar ways. Thus, it is expected that students who are, for example, in a group with group

members who are focused on task-related activities, will also be stimulated to focus on task-related activities; whereas students in groups with a focus on social activities will also concentrate more on social activities. To address to problem of nonindependence, *multilevel analysis* was used to examine the effects of the SS, since this type of analysis can be used when data have a hierarchically nested structure (e.g., students nested within groups) and nonindependence is present.

The multilevel analyses involved estimating two models: an empty model and a model including one or more predictor variables. For both models, the deviance (a measure of the goodness of fit of the model) was computed. By comparing the deviance of the latter model to the empty model, a decrease in deviance can be calculated. When this decrease in deviance is significant (tested with a χ^2 test), the latter model is considered a better model. In addition, the estimated parameters of the predictor variables can be tested for significance by dividing the regression coefficient by its standard error. This so-called *t*-ratio has approximately a standard normal distribution (Snijders & Bosker, 1999). In conclusion, the effect of the SS is considered to be significant when its *t*-value as well as its corresponding χ^2-value is significant.

Since group members shared the same experiences during collaboration (Schellens, Van Keer, & Valcke, 2005), the line of reasoning concerning nonindependence of students' collaborative activities can be extended to the other individual measures used in this study (research questions one, two, and three). For example, because group members may discuss their satisfaction with the collaboration, they may influence each other so that they hold more or less the same opinion (Kashy & Kenny, 2000). Thus, the effects of the SS on students' perceived media richness, group norm perception, and perception of online collaboration and communication, will be examined using multilevel analysis as well.

RESULTS

Perceived Media Richness of the Chat Tool

The first research question addressed the impact of the SS visualization on students' perception of the media richness of the Chat tool. It was hypothesized that treatment group students would perceive the Chat tool as more media rich, and thus more suitable for online collaboration and discussion, because it visualizes agreement and discussion among group members. On average, treatment group students perceive higher media richness (M = 3.26, SD = .80) compared to control group students (M = 3.01, SD = .76). However, multilevel analyses of the questionnaire data indicate that the effect of the SS only approaches statistical significance, $t(95) = 1.59$, $p = .06$; $\chi^2 = 2.41$, $p = .12$.

Group Norm Perception

The impact of the SS visualization on students' group norm perception was the focus of the second research question. Since the SS visualizes whether group members engage in constructive but critical online discussions, it was expected that the SS would stimulate more critical and less consensual group norms. Thus, it was expected that treatment group students would perceive their group's norm as more critical and less consensual. The results presented in Table 1 show that this expectation was only partially confirmed. Regarding critical group norm perception, no statistically significant differences between treatment and control group students were found, $t(95) = .00$, $p = 1.00$. Similarly, no differences were found regarding consensual group norm perception, $t(95) = .35$, $p = .36$. However, Table 1 shows that on average treatment group students obtained higher scores for the exploratory group norm perception scale than did control group students. Moreover, the multilevel analyses

revealed a significant effect of the SS on exploratory group norm perception, $t(95) = 2.03$, $p = .02$. This indicates that treatment group students perceived that their groups were engaged more in critical but constructive online discussions, compared to control group students.

Table 1 Mean scores for group norm perception and results of multilevel analyses.

	Treatment group students ($N = 48$)		Control group students ($N = 49$)				
	M	*SD*	*M*	*SD*	*Coeff.*	*SE*	χ^2
Critical group norm perception	3.24	.86	3.25	.65	.000	.085	.000
Consensual group norm perception	3.50	.89	3.46	.66	.022	.062	.123
Exploratory group norm perception	3.82	.53	3.60	.53	.108*	.053	3.933*

Note. Mean scores along scales ranging from 1 (=*completely disagree)* to *5* (=*completely agree*). * $p < .05$.

Perception of Online Collaboration and Communication

The results for research question two are presented in Table 2. On average, students perceived their collaboration and communication was quite positive and perceived their group's strategy as effective. This is indicated by the high scores on positive group behavior and effectiveness of group task strategy. Students did not perceive negative group behavior to occur very often.

It was expected that treatment group students would perceive their online collaboration and communication differently, compared to control group students. This is partially confirmed by the multilevel analyses. Treatment group students reported more occurrences of positive group behavior compared to control group students, $t(95) = 2.31$, $p = .01$. Furthermore, treatment group students perceived their group's task strategies to be more effective, compared to control group students, $t(95) = 2.53$, $p = .01$. However, treatment group students reported similar levels of negative group behavior compared to control group students, $t(95) = -1.25$, $p = .11$.

Table 2 Mean scores for perception of online collaboration and communication and results of multilevel analyses.

	Treatment group students ($N = 48$)		Control group students ($N = 49$)				
	M	*SD*	*M*	*SD*	*Coeff.*	*SE*	χ^2
Positive group behavior	3.93	.54	3.62	.58	.155*	.067	4.909*
Negative group behavior	2.34	.72	2.54	.68	-.100	.079	1.532
Effectiveness of group task strategy	3.73	.56	3.42	.62	.165**	.065	6.066**

Note. Mean scores along scales ranging from 1 (=*completely disagree)* to *5* (=*completely agree*). * $p < .05$.

Collaborative activities

For the fourth research question, it was examined whether treatment group students were engaged in different collaborative activities than control group students. In Table 3, the mean frequencies of collaborative activities are presented. For the descriptions of the collaborative activities the reader is referred to the Method and Instrumentation section. The

number in parentheses indicated how many percent of the total number of collaborative activities were devoted to a specific activity. As can be seen from Table 3, students were mostly busy regulating the completion of the group task, by formulating plans (*MTaskPlan*, 22%), or monitoring task progress (*MTaskMoni*, 13%). Furthermore, many activities were directed to signaling and monitoring shared understanding (*SociUnd*+, 20%). Finally, students devoted a lot of effort to maintaining a positive social climate in their group by sending many social support remarks (*SociSupp*, 10%).

To examine the effect of the SS on students' collaborative activities, multilevel analyses were used as well. In this case, two predictors were added to the multilevel models. Besides condition (SS or no SS), number of dialogue acts typed was included in the model. This was done to account for the fact that, that some groups typed more dialogue acts and were generally more active than others. By including this predictor in the model, the effect of the SS could be investigated independent of number of dialogue acts typed by students.

Table 3 also lists the results of the multilevel analyses. Number of dialogue acts typed was a significant predictor for all collaborative activities, except positive evaluations of social activities (*MSociEvl*-). This indicates that in most cases participation was related to collaborative activities. For example, the more a student participated during online discussions by typing more dialogue acts, the more questions he or she asked (*TaskQues*).

Additionally, Table 3 also shows that condition was a significant predictor for some collaborative activities. First, having access to the SS was related significantly negatively to the number of task-related questions asked (*TaskQues*) by a student, $t(114) = -2.69$, $p = .00$. Students who had access to the SS send significantly less task-related questions, independent of the number of dialogue acts they typed. Second, the coefficient for *SociUnd*+, indicates a negative effect of the SS on the number of messages which were aimed at reaching and maintaining mutual understanding, $t(114) = -1.89$, $p = .03$. When students had access to the SS, they typed significantly less messages aimed at mutual understanding. This effect should be interpreted with caution however, since the corresponding χ^2-value was only marginally significant, $\chi^2 = 3.44$, $p = .06$. Finally, Table 3 indicates the SS had an effect on the number of negative technical remarks (*TechNega*) made, $t(114) = -1.89$, $p = .03$. Students with access to the SS typed less negative comments about the program. Again, this effect should be interpreted with caution, as the corresponding χ^2-value was only marginally significant, $\chi^2 = 3.39$, $p = .07$.

CONCLUSION AND DISCUSSION

This study examined the effects of the Shared Space (SS) on students' behaviors in a CSCL environment. The SS visualizes whether group members are agreeing or disagreeing about a topic during online discussion. The results show that students with access to the SS visualization tend to perceive the CSCL environment as more media rich, although this effect only approached significance. Second, the results show an effect of the SS on group norms. Students with access to the SS visualization report more exploratory group norms. Third, students with access to the SS visualization reported more positive group behavior and perceived their group's task strategies as more effective. The SS visualization only had a small effect on students' collaborative activities. Students with access to the SS visualization asked less task-related questions, were less busy maintaining and indicating shared understanding, and made less negative remarks about the CSCL environment.

Table 3 Mean frequencies and standard deviations of collaboration acts and multilevel analyses of the effects of condition.

	Treatment group students (N = 59)			Control group students (N = 58)			Total (N = 117)			Effect of condition		
	M Freq.	(%)	*SD*	*M* Freq.	(%)	*SD*	*M* Freq.	(%)	*SD*	Coeff.	*SE*	χ^2
Performing task-related activities												
- Info exchange (*TaskExch*)	19.75	(7.43)	18.89	24.84	(6.63)	27.89	22.27	(7.02)	23.81	-3.45	2.41	2.00
- Asking questions (*TaskQues*)	8.17	(4.11)	6.99	12.33	(3.01)	10.42	10.23	(3.56)	9.06	-2.18**	0.81	6.62*
Coordinating/regulating task-related activities												
- Planning (*MTaskPlan*)	61.32	(21.61)	41.84	63.71	(21.47)	45.35	62.50	(21.54)	43.44	-2.62	4.29	0.37
- Monitoring (*MTaskMoni*)	36.31	(12.93)	22.25	36.48	(12.64)	22.62	36.39	(12.78)	22.34	0.12	-0.85	0.23
- Positive evaluations (*MTaskEvl+*)	6.12	(1.87)	5.51	5.72	(1.98)	6.14	5.92	(1.92)	5.80	0.12	0.63	0.03
- Negative evaluations (*MTaskEvl-*)	5.92	(2.32)	5.66	6.31	(1.77)	5.07	6.11	(2.04)	5.36	-0.32	0.35	0.85
Performing social activities												
- Greetings (*SociGree*)	8.71	(3.31)	7.10	10.31	(3.06)	10.31	9.50	(3.18)	8.68	-0.98	1.12	0.76
- Social support (*SociSupp*)	31.93	(8.64)	24.05	30.03	(0.51)	30.03	30.99	(9.58)	30.49	0.28	2.88	0.01
- Social resistance (*SociResi*)	10.69	(2.91)	9.87	8.67	(3.66)	8.67	9.69	(3.29)	10.12	0.90	1.08	0.69
- Mutual understanding (*SociUnd+*)	54.15	(21.69)	31.74	65.26	(19.09)	65.26	59.66	(20.38)	41.59	-6.95*	3.68	3.44
- Loss of mutual understanding (*SociUnd-*)	11.68	(4.12)	8.66	11.29	(4.07)	11.29	11.49	(4.09)	8.32	-0.04	0.73	0.00
Coordinating/Regulating social activities												
- Planning (*MSociPlan*)	4.98	(1.29)	4.98	3.98	(1.56)	3.59	4.49	(1.42)	4.36	0.46	0.46	0.98
- Monitoring (*MSociMoni*)	14.25	(3.83)	10.68	12.36	(5.07)	11.89	13.32	(4.45)	11.29	0.76	1.07	0.50
- Positive evaluations (*MSociEvl+*)	.76	(.07)	1.81	.34	(.32)	1.21	.56	(.20)	1.55	0.20	0.14	2.06
- Negative evaluations (*MSociEvl-*)	.63	(.15)	.96	.48	(.25)	1.14	.56	(.20)	1.05	0.06	0.09	0.47
Technical												
- Neutral technical (*TechNeut*)	4.02	(1.41)	3.85	4.45	(1.38)	4.92	4.23	(1.39)	4.40	-0.33	0.46	0.54
- Negative technical (*TechNega*)	2.14	(1.09)	2.65	3.24	(.64)	4.50	2.68	(.86)	3.71	-0.61*	0.32	3.39
- Positive technical (*TechPosi*)	.49	(.10)	.88	.34	(.13)	.78	.42	(.12)	.83	0.06	0.06	0.81
Other	6.20	(1.14)	10.36	3.84	(2.77)	6.98	5.03	(1.96)	8.89	1.12	0.91	1.50

Note. * $p < .05$; ** $p < .01$.

In all, these results show that the SS had a positive effect. First, the SS seemed to facilitate communication and discussion. Students perceived the medium as marginally more media rich. Furthermore, students needed to devote less effort to maintaining and signaling shared understanding. Second, the SS stimulated a more critical, exploratory group norm perception. Treatment group students perceived their group as more engaged in a constructive but critical online discussion. Finally, the SS influenced students to their group's behavior as more positive and their group's task strategies as more effective.

Several limitations of this study should be kept in mind. First, the effect of the SS on group performance and individual achievement are not clear. Therefore, future analyses will focus on the quality of the group products written by the groups. Second, it is not clear how students perceived and interpreted the SS visualization. Did students interpret the visualization correctly? This may have had an impact on the effect of the visualization. This will be analyzed further by examining the chat discussions.

Overall, the results of this study were positive. Whether these results can be replicated with other students, other types of groups or using different types of tasks, remains to be seen. In our own future research, we will explore the merits of visualization during collaboration further.

ACKNOWLEDGEMENT

This project was funded by NWO, the Netherlands Organisation for Scientific Research under project number 411-02-121.

REFERENCES

Adrianson, L., & Hjelmquist, E. (1991). Group processes in face-to-face and computer mediated communication. *Behaviour and Information Technology, 10*(4), 281-296.

Artzt, A. F., & Armour-Thomas, E. (1997). Mathematical problem solving in small groups: Exploring the interplay of students' metacognitive behaviors, perceptions, and ability levels. *Journal of Mathematical Behavior, 16*(1), 63-74.

Battistich, V., & Watson, M. (2003). Fostering social development in preschool and the early elementary grades through co-operative classroom activities. In R. M. Gillies & A. F. Ashman (Eds.), *Co-operative learning: The social and intellectual outcomes of learning in groups* (pp. 19-35). London/New York: RoutledgeFalmer.

Bonito, J. A. (2002). The analysis of participation in small groups: Methodological and conceptual issues related to interdependence. *Small Group Research, 33*(4), 412-438.

Cavanaugh, C. S. (2001). The effectiveness of interactive distance education technologies in K-12 learning: A meta-analysis. *International Journal of Educational Telecommunications, 7*(1), 73-88.

Cicchetti, D. V., Lee, C., Fontana, A. F., & Dowds, B. N. (1978). A computer program for assessing specific category rater agreement for qualitative data. *Educational and Psychological Measurement, 38*(3), 805-813.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554-571.

Dennis, A. R., Kinney, S. T., & Hung, Y. T. C. (1999). Gender differences in the effects of media richness. *Small Group Research, 30*(4), 405-437.

Erkens, G. (2005). Multiple Episode Protocol Analysis (MEPA). Version 4.10. Retrieved October 24, 2005, from http://edugate.fss.uu.nl/mepa/

Erkens, G., Jaspers, J., Prangsma, M., & Kanselaar, G. (2005). Coordination processes in computer supported collaborative writing. *Computers in Human Behavior, 21*(3), 463-486.

Felton, M., & Kuhn, D. (2001). The development of argumentive discourse skill. *Discourse Processes, 32*(2-3), 135-153.

Fjermestad, J. (2004). An analysis of communication mode in group support systems research. *Decision Support Systems, 37*(2), 239-263.

Fletcher-Flinn, C. M., & Gravatt, B. (1995). The efficacy of computer assisted instruction (CAI): A meta-analysis. *Journal of Educational Computing Research, 13*(3), 219-241.

Fuks, H., Pimentel, M., & Lucena, C. J. P. (2006). R-U-Typing-2-Me? Evolving a chat tool to increase understanding in learning activities. *International Journal of Computer-Supported Collaborative Learning, 1*(1), 117-142.

Hobman, E. V., Bordia, P., Irmer, B., & Chang, A. (2002). The expression of conflict in computer-mediated and face-to-face groups. *Small Group Research, 33*(4), 439-465.

Howell-Richardson, C., & Mellar, H. (1996). A methodology for the analysis of patterns of participation within computer mediated communication courses. *Instructional Science, 24*(1), 47-69.

Janssen, J., Erkens, G., Kanselaar, G., & Jaspers, J. (in press). Visualization of participation: Does it contribute to successful computer-supported collaborative learning? *Computers & Education*.

Janssen, J., Erkens, G., & Schep, A. (submitted). Gender differences in online collaboration styles.

Jaspers, J., Broeken, M., & Erkens, G. (2005). Virtual Collaborative Research Institute (VCRI) (Version 2.2). Utrecht, The Netherlands: Utrecht University.

Jehn, K. A., & Shah, P. P. (1997). Interpersonal relationships and task performance: An examination of mediation processes in friendship and acquaintance groups. *Journal of Personality and Social Psychology, 72*(4), 775-790.

Johnson, D. W., & Johnson, R. T. (1999). *Learning together and alone: Cooperative, competitive, and individualistic learning* (5th ed.). Boston: Allyn and Bacon.

Kashy, D. A., & Kenny, D. A. (2000). The analysis of data from dyads and groups. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 451-477). Cambridge: Cambridge University Press.

Kenny, D. A., Mannetti, L., Pierro, A., Livi, S., & Kashy, D. A. (2002). The statistical analysis of data from small groups. *Journal of Personality and Social Psychology, 83*(1), 126-137.

Kreijns, K. (2004). *Sociable CSCL environments: Social affordances, sociability, and social presence.* Unpublished PhD thesis, Open Universiteit, Heerlen, The Netherlands.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior, 19*(3), 335-353.

Kuhn, D., & Udell, W. (2003). The development of agrument skills. *Child Development, 74*(5), 1245-1260.

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.

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction, 13*(5), 487-509.

Lou, Y., Abrami, P. C., & d'Apollonia, S. (2001). Small group and individual learning with technology: A meta-analysis. *Review of Educational Research, 71*(3), 449-521.

Mennecke, B. E., Valacich, J. S., & Wheeler, B. C. (2000). The effects of media and task on user performance: A test of the task-media fit hypothesis. *Group Decision and Negotiation, 9*(6), 507-529.

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

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.

Postmes, T., Spears, R., & Cihangir, S. (2001). Quality of decision making and group norms. *Journal of Personality and Social Psychology, 80*(6), 918-930.

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (1999). Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education, 14*(2), 50-71.

Saavedra, R., Earley, P., & Van Dyne, L. (1993). Complex interdependence in task-performing groups. *Journal of Applied Psychology, 78*(1), 61-72.

Scarloss, B. A. (2002, April). *Assessing complex academic performance at the group level.* Paper presented at the American Education Research Association (AERA) annual meeting, New Orleans, LO.

Schellens, T., Van Keer, H., & Valcke, M. (2005). The impact of role assignment on knowledge construction in asynchronous discussion groups: A multilevel analysis. *Small Group Research, 36*(6), 704-745.

Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology, 21*(1), 43-69.

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. London: Sage Publications.

Strijbos, J. W. (2004). *The effect of roles on computer-supported collaborative learning.* Unpublished PhD thesis, Open University, Heerlen, The Netherlands.

Strijbos, J. W., Martens, R. L., Prins, F. J., & Jochems, W. M. G. (2006). Content analysis: What are they talking about? *Computers & Education, 46*(1), 29-48.

Thompson, L. F., & Coovert, M. D. (2003). Teamwork online: The effects of computer conferencing on perceived confusion, satisfaction and postdiscussion accuracy. *Group Dynamics, 7*(2), 135-151.

Van der Meijden, H. (2005). *Knowledge construction through CSCL: Student elaborations in synchronous, asynchronous, and three-dimensional learning environments.* Unpublished PhD thesis, Radboud University Nijmegen, The Netherlands.

Van der Meijden, H., & Veenman, S. (2005). Face-to-face versus computer-mediated communication in a primary school setting. *Computers in Human Behavior, 21*(5), 831-859.

Van Drie, J. (2005). *Learning about the past with new technologies: Fostering historical reasoning in computer-supported collaborative learning.* Unpublished PhD thesis, Utrecht University, Utrecht, The Netherlands.

Van Drie, J., Van Boxtel, C., Jaspers, J., & Kanselaar, G. (2005). Effects of representational guidance on domain specific reasoning in CSCL. *Computers in Human Behavior, 21*(4), 575-602.

Webb, N. M. (1995). Group collaboration in assessment: Multiple objectives, processes, and outcomes. *Educational Evaluation and Policy Analysis, 17*(2), 239-261.

Webb, N. M., & Palincsar, A. S. (1996). Group processes in the classroom. In D. C. Berliner (Ed.), *Handbook of educational psychology* (pp. 841-873). New York: Simon & Schuster Macmillan.

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.

Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education, 46*(1), 71-95.

Yager, S., Johnson, R. T., Johnson, D. W., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *Journal of Social Psychology, 126*(3), 389-397.