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Visualizing Participation to Facilitate Argumentation

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Introduction

Over the last decades advanced information and communication technologies (ICT) have developed rapidly, which has led to many new computer applications, such as e-mail, chat rooms, video conferencing, simulations, and discussion forums. Many educational designers, policy makers, researchers, and teachers have embraced these applications as potentially useful tools for education. This interest has inspired many comparative studies, examining the effects of using ICT in education. Results of a meta-analysis showed that educational applications of ICT can have moderate positive effects on students' learning (Fletcher-Flinn & Gravatt, 1995).

More recently, educational researchers have begun to explore the combination of ICT applications and collaborative learning. As a result, a relatively new field of educational design and educational research has developed. This field, *computer-supported collaborative learning* (CSCL), deals with issues concerning collaboration, learning processes, and the use of *computer-mediated communication* (CMC). The primary aim of CSCL is to provide an environment that supports and enhances collaboration between students, in order to enhance students' learning processes (Kreijns, Kirschner, & Jochems, 2003). During CSCL, students work on group tasks, and produce a group product. A CSCL environment usually offers tools that facilitate sharing of information and ideas, and the distribution of expertise among group members (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003). When students collaborate in a CSCL environment, they use CMC to communicate with group members. CMC can be either synchronous (e.g.,

through a chat facility or video conferencing), asynchronous (e.g., through a forum or e-mail), or a combination of both.

Because CSCL combines collaborative learning and the use of ICT, various educational, social, and motivational benefits of CSCL have been suggested and documented by research. First, concerning *educational goals*, students report higher levels of learning in CMC groups, compared to FTF groups (Hertz-Lazarowitz & Bar-Natan, 2002). More importantly, when compared to FTF groups, students in CMC groups deliver more complete reports, make decisions of higher quality, and perform better on tasks that require groups to generate ideas (Fjermestad, 2004). Second, concerning *social goals*, researchers have found that CMC groups, compared to FTF groups, engage in more complex, broader, and cognitively challenging discussions (Benbunan-Fich, Hiltz, & Turoff, 2003), and group members participate more equally (Fjermestad, 2004). Finally, CSCL also seems to affect *motivational outcomes*, since students who collaborated in CMC groups report higher levels of satisfaction (Fjermestad, 2004). Thus, it seems that CSCL can have a positive effects for education.

However, many studies have also demonstrated that several of things can, and in fact *do* go wrong during CSCL. A number of studies have shown that during CSCL, several communication- and interaction problems can occur between students. These results are in contrast with the studies mentioned above; some results even seem to contradict the results of other studies. For instance, students working in CMC groups sometimes perceive their discussions as more confusing, compared to FTF groups (Thompson & Coovert, 2003). Furthermore, Hobman, Bordia, Irmer, and Chang (2002) found higher levels of personal conflict between students working in CMC groups, compared to FTF groups. As a result, CMC groups need more time to reach consensus and make decisions (Fjermestad, 2004). Moreover, they are

less productive, and group cohesiveness is lower (Straus, 1997; Straus & McGrath, 1994). These problems can also influence the results CMC groups attain. For example, compared to FTF groups, CMC groups need more time to complete tasks (Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002; Fjermestad, 2004), perform worse on mixed-motive tasks (Barkhi, Jacob, & Pirkul, 1999), and report lower levels of satisfaction (Baltes et al., 2002). In sum, several problems can occur during CSCL, and therefore its potential may not always be realized.

Visualization of participation: A solution?

In the section above, contradictory results concerning the possible benefits of CSCL were mentioned. Another important contradictory result found in CSCL studies concerns participation levels and equality of participation. Some studies report more equal participation of group members in CMC groups (e.g., Fjermestad, 2004), whereas other studies report dominance of some group members (e.g., Savicki, Kelley, & Ammon, 2002). Furthermore, in some CSCL studies researchers report low participation rates of all participating students (Lipponen et al., 2003; Veldhuis-Diermanse, 2002). It seems CMC groups may suffer from the same debilitating effects that sometimes occur in FTF groups (O'Donnell & O'Kelly, 1994; Salomon & Globerson, 1989), such as social loafing (group members invest less effort in a group, compared to working individually), or the free rider effect (students let other group members do the work).

If CSCL sometimes results in low overall participation rates or unequal participation, this is a cause for concern, since group productivity and student achievement depends on students' participation during argumentative discussions (Cohen, 1994; Weinberger & Fischer, 2006). When students participate equally during collaboration, every group member has the opportunity

to contribute to group processes, to participate in knowledge construction, to give or request explanations, and to use and refine his or her skills (Webb, 1995). Given the importance of participation and equal participation, it is therefore important to ensure high levels of participation and equal participation of group members during CSCL.

One way to improve participation in CSCL may be through visualization of participation. Such a technique visualizes how much each group member relatively contributes to group discussion. It can be hypothesized that visualization of participation affects participation through *motivational* and *feedback* processes. These will be explained below.

Visualization of participation may influence collaboration through motivational processes. Motivational processes have been used to explain *why* students put effort into collaboration (Abrami & Chambers, 1996; O'Donnell & O'Kelly, 1994). To counter productivity loss in groups (e.g., caused by free-riding), a possible solution could be to provide group members with an incentive that enhances their motivation to contribute to collaboration (Shepperd, 1993). When participation of group members is visualized, this makes the contribution of each group member to the group identifiable; establishesing a link between a group member and his or her contribution to the collaboration (Jermann, 2004). This identifiability may provide several motivational incentives for group members to invest effort into collaboration. For example, visualization of participation can motivate group members to participate more, because they are unable to “hide in the crowd” and they can be evaluated negatively when they participate insufficiently. This *social evaluation* can motivate students to increase their participation (Shepperd, 1993). In addition, though *social comparison*, that is, through comparing themselves to other group members, students may be motivated to set higher

standards and to try to increase their participation (Michinov & Primois, 2005; Wheeler, Suls, & Martin, 2001).

Additionally, visualization of participation can also be considered a form of *external feedback* (Butler & Winne, 1995), that is, feedback generated by sources other than the student him- or herself (i.e., by teachers, group members, or computer displays). First, external feedback may provide students with information, which they can use to *monitor* their problem solving progress. External feedback allows students to determine whether selected strategies are working as expected, and whether group performance and products are up to standard. Thus, visualization of participation may provide group members with feedback on how well they are collaborating, and whether they have selected an appropriate collaboration strategy (i.e., equal participation of all group members). Similarly, visualization of participation can also be used for *group processing*. Group processing occurs when group members discuss how well their group is functioning and how group processes may be improved (Webb & Palincsar, 1996). These discussions may help groups pinpoint, comprehend, and solve collaboration problems (e.g., free riding by some group members) and may contribute to successful collaborative behavior (Yager, Johnson, Johnson, & Snider, 1986). Group processing is also facilitated because visualization of participation may serve a *mediating* purpose, since it may help group members to externalize and articulate their thoughts about collaboration processes by providing them with appropriate information and concepts (Fischer, Bruhn, Gräsel, & Mandl, 2002; Teasley & Roschelle, 1993). For example, after examining the visualization, a group member may feel someone is free riding, which may stimulate him or her to discuss this with other group members by referring to the visualization.

Second, the external feedback provided by visualization of participation can also raise students' *awareness* of the group processes and activities taking place. Because visualization of participation shows group members' participation rates, it could raise students' awareness of group processes, and more specifically, of participation. Several researchers have suggested that awareness can play an important role in facilitating CSCL (Gutwin & Greenberg, 2004; Kirschner, Strijbos, Kreijns, & Beers, 2004). When students are collaborating, they have to be aware of the activities of their group members, because it allows them to decide which activities they have to engage in. This enables them to anticipate group members' actions.

In order to investigate the degree to which visualization of participation stimulates group members' participation rates and facilitates argumentative knowledge construction, Janssen, Erkens, Kanselaar, and Jaspers (in press) developed a tool which visually clarified the quantity and the homogeneity/heterogeneity of participation. This so-called Participation Tool, visualized the contributions of each group member to the group's online communication. In the study by Janssen et al. (in press), students with access to the Participation Tool (treatment group students) participated more actively during online collaboration (more and longer utterances) and engaged more deeply in the coordination of social activities compared to students without access to the Participation Tool (control group students).

These findings raise two new questions. (1) Is participation a sufficient condition for effective argumentative knowledge construction? (2) Does improving participation also improve the quality of argumentative knowledge construction? Although participation and equaly participation are important prerequisites for successful collaboration, it is important to establish that this improvement in participation also leads to increases in students' use of argumentation during collaboration. It is important that students engage in argumentation knowledge

construction during collaboration, because it helps them expand their argumentive and domain-specific knowledge (Andriessen, Baker, & Suthers, 2003; Weinberger & Fischer, 2006).

Research Questions

The present study seeks to extend the findings of the previous study (c.f., Janssen et al., in press). Firstly, by investigating whether participation is a sufficient condition for argumentative knowledge construction. This is accomplished by examining whether the PT has an impact on students' use of argumentative dialogue acts. Furthermore, the impact of the PT on the argumentation patterns that develop within the groups of students are examined. Secondly, by asking whether improving participation also helps to improve the quality of argumentative knowledge construction. Finally, the relationship between argumentation use in online collaboration and the quality of argumentative knowledge construction is examined. In sum, the following research questions are addressed:

1. Do students who have access to the PT use more argumentative dialogue acts than students who do not have access to the PT?
2. Do groups who have access to the PT engage in longer sequences of argumentation than groups who do not have access to the PT?
3. Do groups who have access to the PT perform better on an inquiry group task than groups who do not have access to the PT?

4. Do successful groups (those who perform better on the inquiry group task) use different argumentation patterns than less successful groups?

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 the PT; control group students did not. Three different classes participated in the study. Each class was randomly assigned to either the treatment or the control group. Thus, all students from one class were in the same condition: either treatment or control. Two classes were assigned to the treatment group, and one class was assigned to the control group. The treatment group consisted of 55 students (17 groups), and the control group of 17 students (5 groups).

Participants

Participants were 72 eleventh-grade students (30 male, 42 female) from a secondary school in The Netherlands. Students came from three different classes and were enrolled in the second stage of the pre-university education track. Mean age of the students was 16 years (*SD* = .58, *Min* = 15, *Max* = 18). Three treatment group students were omitted from all analyses because they attended less than half of the lessons. Therefore, the final number of participants was 52 treatment group and 17 control group students.

During the experiment, the participating students collaborated in groups of three or four; students were randomly assigned to a group by the researchers. Therefore, group composition was heterogeneous with respect to ability and gender. In order to eliminate combinations of students who could not get along with each other, the group compositions were verified by their teachers. The initial group compositions were approved.

Task and Materials

CSCL environment: VCRI

Participating students collaborated in a CSCL-environment called *Virtual Collaborative Research Institute* (VCRI, Jaspers, Broeken, & Erkens, 2004). VCRI is a groupware program designed to support collaborative learning on research projects and inquiry tasks. Every student works at one computer. Figure 1 shows a screenshot of the VCRI-program, detailing the most important tools.

The *Chat* tool is used for synchronous communication between group members. The chat history is stored automatically and can be re-read at any time. Students can read the description of the group task and search for relevant historical information using the *Sources* tool. The *Co-Writer* is a shared word-processor, which can be used to write a group text. Using the Co-Writer, students can work simultaneously on different parts of their texts. The *Statusbar*, in the bottom of the screen, displays who is online, and which tools group members are currently using, and thus serves as a tool to raise students' workspace awareness (Gutwin & Greenberg, 2004). Other tools of the VCRI-program, not shown in Figure 1, include for example the *Planner*, which can be used to organize and plan group activities, the *Diagrammer*, which can be used to construct

argumentative diagrams, and the *Reflector*, which is used by students to reflect on group processes.

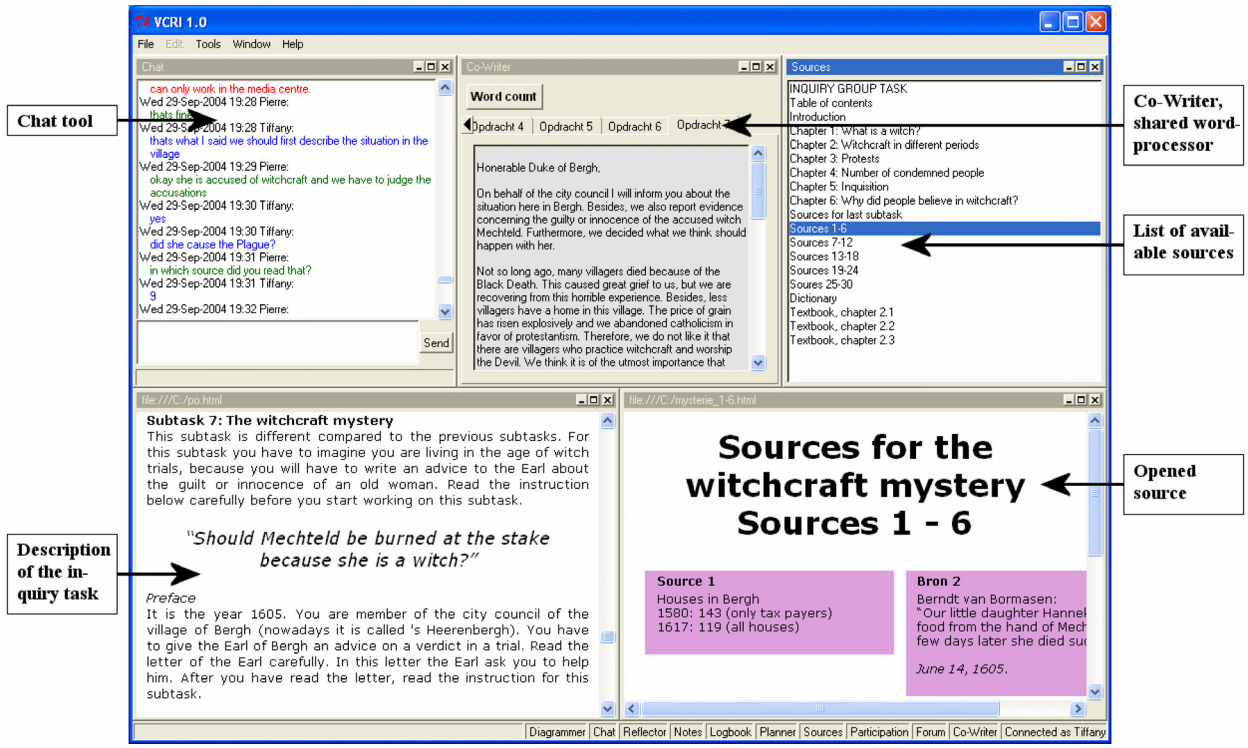

Figure 1 Screenshot of the VCRI, detailing the most important tools.

Inquiry group task

The participating students collaborated on a historical inquiry group task. Inquiry tasks are an important part of the curriculum in the Dutch upper secondary levels. Subject of the task was witchcraft and the persecution of witches. The groups had to use different historical and (more) contemporary sources to answer questions and co-author argumentative texts. Approximately 40 sources from textbooks and the Internet were available to the students through the *Sources* tool. Students were instructed to use the VCRI program to communicate with group members. Students were told they had eight lessons to complete the inquiry task.

The introduction of the task stressed the importance of working together as a group on the subtasks, and pointed out that group members were themselves responsible for the successful completion of the task. To successfully complete the inquiry group task, all group members had to participate during the group process. Positive interdependence and individual accountability were incorporated in the group task, thus making high levels of collaboration necessary in order to successfully complete the group task (Johnson & Johnson, 1999).

Treatment: Participation Tool

To answer the research questions the VCRI was augmented with a new tool, the *Participation Tool* (PT). The PT visualizes how much each group member contributes to his or her group's *online communication*, through for example the Chat tool shown in Figure 1. The PT does not take into account students' activities in other tools, such as the shared word processor.

In the PT, each student is represented by a sphere; group member's spheres are grouped together. For example, Figure 2 shows a class of students. The students from this class were assigned to several groups. For instance, the four spheres in the upper right of the Figure represent one group of four students. While students are communicating with each other in the online environment, the PT is continually updated, allowing students to compare their participation rates to those of their group members.

In the PT, the *distance* of a sphere to the group center indicates the *number of messages sent* by the student, compared to the other group members. If a sphere is close to the center, the student has sent more messages compared to a student who is farther away from the center. The *size* of a sphere indicates the *average length of the messages* sent by a student, compared to the

other group members. If a sphere is smaller, the student has sent shorter messages compared to a student whose sphere is bigger.

Using the PT, students can zoom in, to examine their own group more closely, or zoom out to examine the whole class. In Figure 2, the PT is zoomed out, displaying much of the class. This enables students to examine the participation rates of students from other groups. For instance, the *distance of a group* to the center of the whole class indicates the *number of messages* this group has sent, compared to other groups. Thus, a group that has sent many messages is located closer to the center of the class, compared to a group that has sent a few messages. In addition, the *size of the grey circles* in the middle of each group, indicate the *average length of the messages* sent by the groups. If a grey circle is bigger, this group has sent longer messages compared to a group whose grey circle is smaller.

The PT can be opened and examined by students at any time. The visualization can be rotated using the mouse, to examine the visualization from a different perspective. The PT can display students' cumulative participation rates (i.e., total number of messages sent), but can also display a moving average. The moving average displays students' participation rates during the past 20 minutes. After a while, the moving average display is more sensitive to changes than the cumulative display. This is because when students have sent many messages, sending one long message does not influence the cumulative display very much. But in a period of 20 minutes, the number of messages is limited, which means that sending one long message has more impact on the visualization (i.e., the size of the sphere will increase more dramatically). Furthermore, it is important to note that students are *not forced* to use the PT. In order words, it is available and students can use it whenever they want, but they can also choose to ignore or close it whenever they want.

Finally, it should be noted that the PT visualizes the *quantity* of the online communication between group members and the equality of participation between group members. Obviously, the quality of the messages sent by the students is also very important for successful collaboration. The PT does not visualize the quality of the messages sent by the students. Nonetheless, quantity of communication is also important for successful collaboration. For example, when unequal participation exists between group members, this is an indication of free riding behavior. Furthermore, if a group member only types a few messages, he or she cannot be regarded a full-fledged group member, although his or her messages may be of high quality. In short, quality and quantity of collaboration should go hand in hand. Ideally, group members should contribute many, high-quality messages to the online discussion.

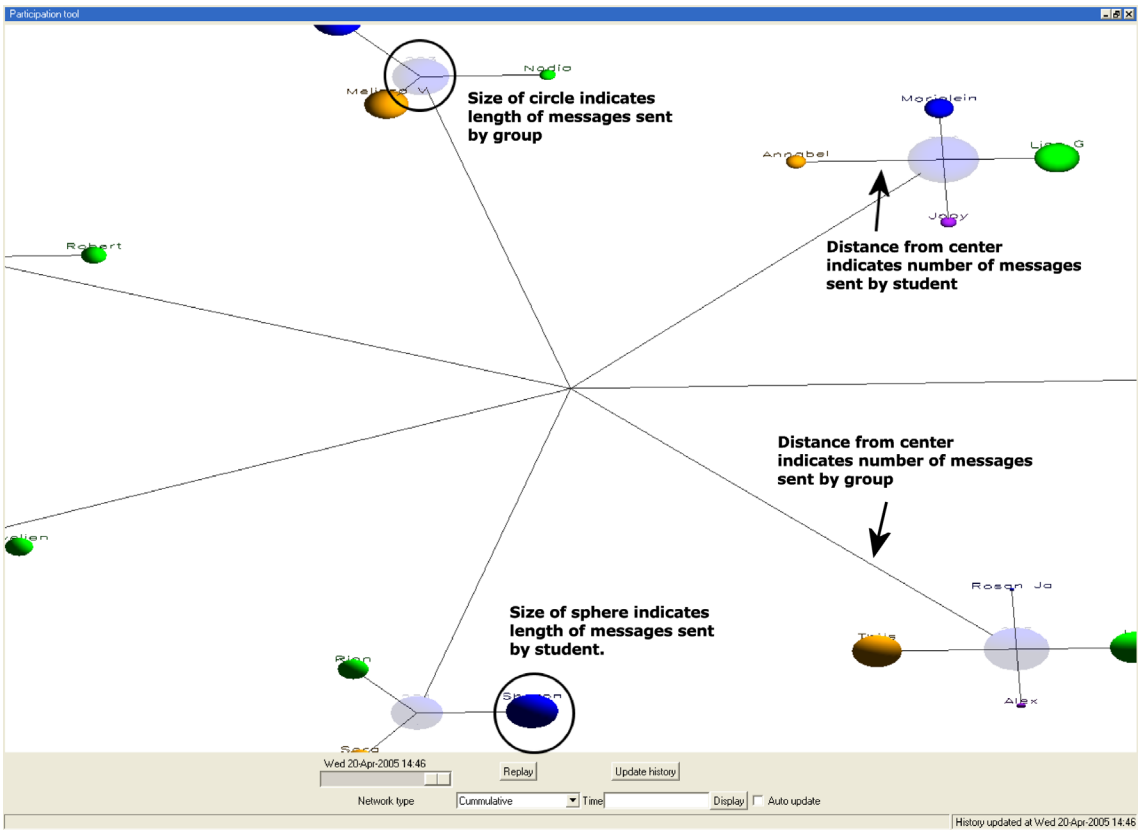

Figure 2 Screenshot of the Participation Tool.

Measures

Argumentative dialogue acts

To examine the impact of the PT on students' use of argumentative dialogue acts, an automatic coding procedure was used. This procedure identifies the communicative function of each utterance typed by students during online collaboration and communication (Erkens, Jaspers, Prangsma, & Kanselaar, 2005). Five main communicative functions are distinguished: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (e.g., confirmations, denials, and answers), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands). A total of 29 different dialogue acts are specified. For instance, an *imperative action* (*ImpAct*) indicates a commanding utterance with regard to a specific action to be taken. Of the 29 dialogue acts, seven different argumentative dialogue acts are distinguished. These are summarized in Table 1.

Table 1 Argumentative dialogue acts.

Argumentative dialogue act	*Example*
Argument – Reason (ArgRsn)	"because we have to write an advice on the guilt or innocence of the old woman"
Argument – Counter (ArgCnt)	"but witches were nearly always poor"
Argument – Conditional (ArgCon)	"if you didn't, you could be accused yourself!"
Argument – Then (ArgThn)	"then it's bad for the economy"
Argument – Disjunctive (ArgDis)	"or the devil appeared in the form of a woman's husband"
Argument – Conclusion (ArgCcl)	"thus I am not sure whether the Catholics were either for or against"
Argument – Elaboration (ArgEla)	"and maybe we could have a discussion about task 7"

To automatically code a protocol and identify which dialogue acts are used during collaboration, the *Multiple Episode Protocol Analysis* (MEPA) computer program is used (Erkens, 2005). This program can be used for the analysis and coding of collaborative

discussions. Additionally, the program offers facilities for automatic coding. A production rule system was created that automatically categorizes utterances into dialogue acts. A set of *if-then* rules uses pattern matching to look for typical words or phrases, in this case for discourse markers. Discourse markers are characteristic words or phrases signaling the communicative function of a sentence in conversation in natural language (Schiffrin, 1987). For example, "*because*" at the beginning of an utterance usually indicates a *reason*. The developed production rule system consists of a rule system for automatic segmentation of utterances in single messages (300 rules) and a rule system for dialogue act coding (1,300 rules). This way, MEPA is able to code a protocol consisting of 1,000 utterances in less than a second.

Sequences of argumentation

To answer the second the research question, sequences of argumentation were examined. Using MEPA, sequences consisting of two, three, four, or five arguments were identified. A sequence of argumentation was defined as two or more consecutive argumentative dialogue acts. This way, differences between treatment and control groups could be examined.

Group performance scores

To answer the third research question regarding the influence of the PT on group performance, the quality of the texts written by the groups for the subtasks of the inquiry group task was examined. Using this assessment form, three quality aspects were assessed for each subtask. *Use of sources* referred to the manner how students incorporated the available sources into their texts. This quality aspect contained two items: completeness of sources used in the written text, and copy-pasting of information from sources to the written texts. *Content and*

argumentation referred to the manner in which students formulated their answers and supported their answers with arguments. Since each subtask addressed different aspects of witchcraft, the content and argumentation aspect was formulated differently for each subtask. However, the scoring-scale was the same for each aspect. The amount of items that addressed content and argumentation also differed for each subtask, since some subtasks were more extensive than others. *Text construction and language* referred to the manner how students' written text had an adequate text construction and correct language. This quality aspect contained three items: text construction, text structure, and correctness of language use.

All items of the assessment form were answered on a 3-point scale, with 0 indicating poor quality and 2 good quality. To determine whether students directly copy-pasted information from the sources to their text, the program WCopyFind (http://plagiarism.phys.virginia.edu/Wsoftware.html) was used. This program compares written texts to the available sources and determines how many percent of the written text is copy-pasted directly from the sources. This percentage was used to determine whether the group received 0, 1, or 2 points. Groups that copy-pasted less than 34% of their text from the sources, received 2 points; groups that pasted more than 66% of their text received no points. In total, groups could receive up to 12 points for subtasks one, five and seven, 14 points for subtasks two, four and six, and 18 points for subtask three. Thus, in total 96 could be earned. In the analyses presented below, results will be presented for total points earned and points earned for each subtask.

To check the objectivity of the scoring, two researchers independently scored a number of tasks. Each researcher filled out the assessment form for 8 to 10 groups for four subtasks. For use of sources, content and argumentation, and text construction and language, interrater

agreement reached 88.5%, 77.5%, and 75.0% respectively. Furthermore, to examine the internal consistency of the scoring procedure, Cronbach's alpha was calculated and was found to be .81.

Argumentation patterns of successful versus less successful groups

The final research question concerned whether successful groups used different argumentation patterns compared to less successful groups. We conducted sequential analyses of the arguments group members constructed. In lag-sequential analysis (Bakeman & Gottman, 1997; Wampold, 1992), the transition patterns between the arguments in a discourse protocol can be statistically tested on different intervals (lags) between the events. The results of the sequential analyses can be presented in a *transition diagram*. A transition diagram is a diagram which shows which sequences of dialogue acts occur more frequently than would be expected based on chance. This way it is possible to examine the argumentation patterns of successful and less successful groups. To examine whether successful groups engage in different cycles of argumentation compared to less successful groups, two transition diagrams were constructed: a transition diagram showing the significant transitions of the five most successful groups and a transition diagram showing the significant transitions of the five least successful groups. Success was defined as the score assigned to the text written by the groups (see the previous paragraph).

Results

Argumentative dialogue acts

Table 2 shows the mean frequencies and standard deviations of the argumentative dialogue acts used by treatment and control group students. The numbers in parentheses indicate how many percent of the total number of dialogue acts were devoted to a type of argument. As can be seen from Table 2, counterarguments were used most often by students. Disjunctive arguments were used the least. About 4% of the total amount of dialogue acts were counterarguments.

Table 2 Mean frequencies and standard deviations of argumentative dialogue acts.

	Treatment group (N = 52)			Control group (N = 17)			Total (N = 69)		
	M		*SD*	*M*		*SD*	*M*		*SD*
Argument	Freq.	(%)		Freq.	(%)		Freq.	(%)	
Reason	7.10	(2.24)	6.00	4.76	(2.01)	4.12	6.52	(2.18)	5.66
Counter	12.85	(4.19)	10.57	7.71	(3.18)	4.58	11.58	(3.94)	9.68
Conditional	4.46	(1.42)	4.11	1.94	(.08)	1.48	3.84	(1.27)	3.79
Then	5.69	(1.90)	4.19	3.94	(1.59)	3.91	5.26	(1.82)	4.17
Disjunctive	1.37	(.40)	1.84	.47	(.22)	.62	1.14	(.35)	1.67
Conclusion	7.38	(2.31)	7.56	4.59	(1.87)	4.27	6.70	(2.20)	6.97
Elaboration	9.29	(2.67)	9.13	6.06	(2.60)	3.60	8.49	(2.65)	8.22

In order to determine whether students with access to the PT used different types of argumentative dialogue acts during online collaboration, multilevel analysis was used. First, a model was constructed which included the number of dialogue acts typed by a student. This was done because some students typed more dialogue acts than others. Furthermore, participation was found to be higher in the treatment group (see Janssen et al., in press). By including dialogue

acts, the effects of the PT could be investigated independent of the total number of dialogue acts sent.

Table 3 Results of multilevel analysis for dialogue acts, including total number of dialogue acts and condition as predictors.

	Total number of dialogue acts		Condition			
	Coeff.	*SE*	Coeff.	*SE*	% Var. expl.	χ^2
Reason	.030**	.003	.537	1.248	57.36	53.45**
Counter	.049**	.005	1.782	1.950	59.32	53.66**
Conditional	.018**	.002	1.430*	.781	54.46	49.09**
Then	.019**	.003	.313	1.016	44.89	36.53**
Disjunctive	.007**	.001	.409	.383	38.18	30.04**
Conclusion	.038**	.004	.706	1.595	59.34	58.26**
Elaboration	.047**	.004	.427	1.417	68.06	72.97**

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

Table 3 shows the results of the multilevel analyses. As can be seen from Table 2, there were some differences between treatment and control group students, concerning use of argumentative dialogue acts. On average, treatment group students use more arguments during collaboration. However, as can be seen from Table 3, the effect of the condition (access to the PT or no access to the PT) was not significant for most types of argumentative dialogue acts. Nonetheless, a significant effect of the PT was found on conditional arguments: students with access to the PT used more conditional arguments than students without access to the PT.

Sequences of argumentation

The second research question concerned whether treatment groups engaged in longer sequences of argumentation than control groups. As can be seen from Table 4, most sequences of argumentation were only two arguments long. Longer sequences occurred less frequently. To examine differences between treatment and control groups, *t* tests for independent samples were

used. The expectation that treatment groups would engage in longer sequences of argumentation was partially confirmed. Indeed, treatment groups constructed significantly more sequences of three arguments than control groups did. No significant differences were found between treatment and control group students for sequences of five, four and two arguments.

Table 4 Differences between treatment and control groups concerning sequences of argumentation.

	Groups with access to the PT (N = 17)		Groups without access to the PT (N = 5)				
	M	*SD*	*M*	*SD*	*t*	*df*	*P*
Five arguments	.13	.20	.05	.09	.94	20	.36
Four arguments	.31	.35	.11	.15	1.25	20	.23
Three arguments[a]	.97	.62	.50	.23	2.61*	18.26	.02
Two arguments	5.53	2.04	3.52	1.30	2.07	20	.05

Note. [a] Equal variances not assumed; * $p < .05$.

Group performance scores

The third research question concerned the effects of the PT on groups' performance scores. Table 5 shows the results of the comparison between treatment and control groups.

Table 5 Means and standard deviations for treatment and control groups for group performance scores.

	Treatment groups (N = 17)		Control groups (N = 5)				
Group performance scores	*M*	*SD*	*M*	*SD*	*t*	*p*	*ES*
Total score	*66.47*	*10.66*	*64.80*	*8.70*	*.32*	*.75*	*.16*
- Subtask 1	1.37	.33	1.47	.18	-.60	.55	-.33
- Subtask 2	1.38	.32	1.14	.20	1.54	.14	.80
- Subtask 3	1.27	.34	1.47	.27	-1.16	.26	-.61
- Subtask 4	1.39	.36	1.49	.26	-.53	.60	-.29
- Subtask 5	1.39	.30	1.27	.15	.89	.38	.43
- Subtask 6	1.42	.24	1.20	.24	1.81	.09	.92
- Subtask 7	1.51	.37	1.40	.45	.55	.59	.28

Note. To increase comparability, scores for the subtasks were standardized, with 0 being the minimum amount of points and 2 the maximum.

Differences were tested using *t* tests for independent samples. On average, treatment groups attained higher total performance scores, but the difference was not significant, and the resulting *ES* was small. Inspection of Table 5 shows that on average, treatment groups scored higher compared to control groups on four of the seven subtasks. None of the differences were statistically significant. However, for subtasks two and six, the *ES*s (.80 and .92, respectively) were rather high and in favor of the treatment groups.

Argumentation patterns of successful versus less successful groups

To examine whether use of argumentative dialogue acts was related to group performance, transition diagrams of successful and less successful groups were computed. Figure 3, shows the transition diagram of the five most successful groups. In the Figure, the 29 dialogue acts are shown. The arrows indicate significant transitions between dialogue acts. In the upper part of Figure 2 several significant transitions between argumentative are shown. As can be seen in the Figure, significant transitions were found between several argumentative dialogue acts. For example, counter arguments (ArgCnt) are usually followed by conditional arguments (ArgCon), while then-arguments (ArgThn) are usually followed by concluding arguments (ArgCcl). Furthermore, reasons (ArgRsn) do not have significant transitions with other argumentative dialogue acts.

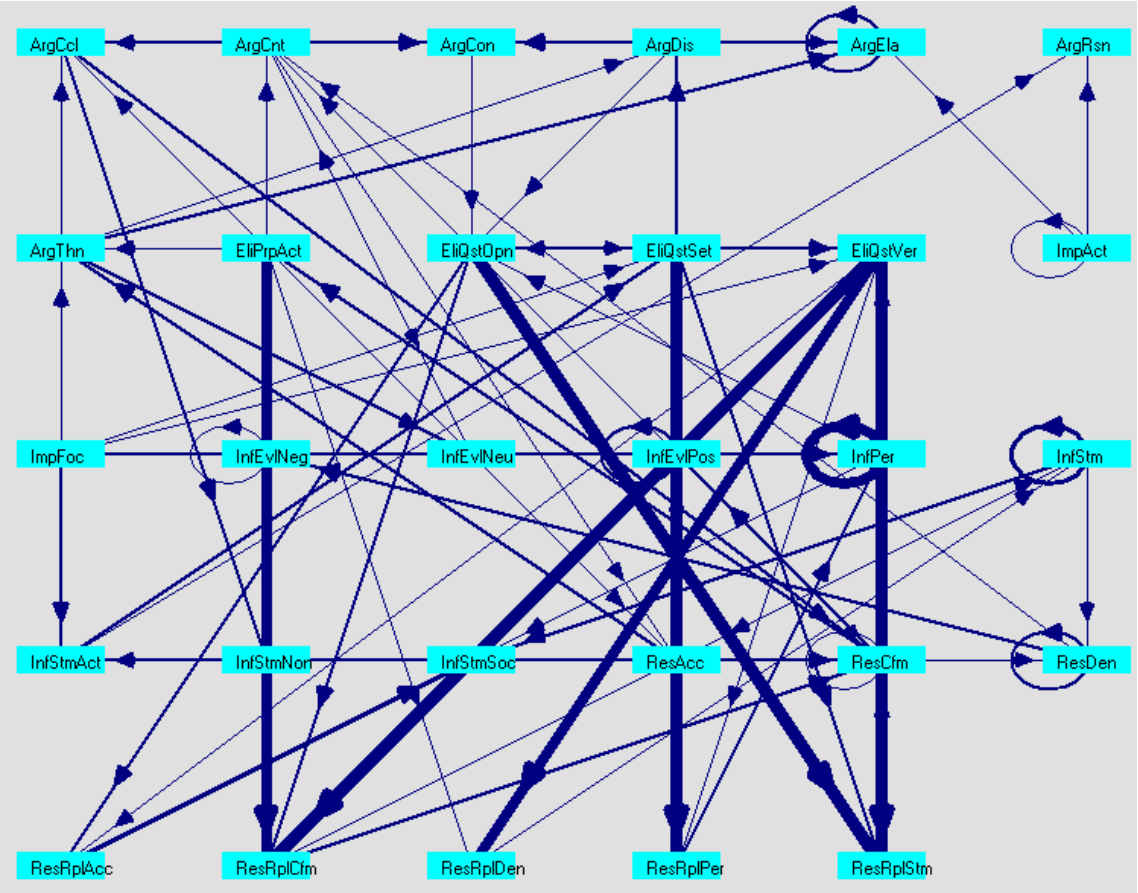

Figure 3 Transition diagram of the five most successful groups.

In contrast, the transition diagram shown in Figure 4 shows different transitions between argumentative dialogue acts compared to the one shown in Figure 3. For example, there is no tranisition between then-arguments (ArgThn) and concluding arguments (ArgThn). On the other hand, significant transitions were found between elaborative arguments (ArgEla) and reasons (ArgRsn), and vice versa. From the sequential analysis it thus becomes clear that successful groups engage in different patterns of arguments compared to less successful ones.

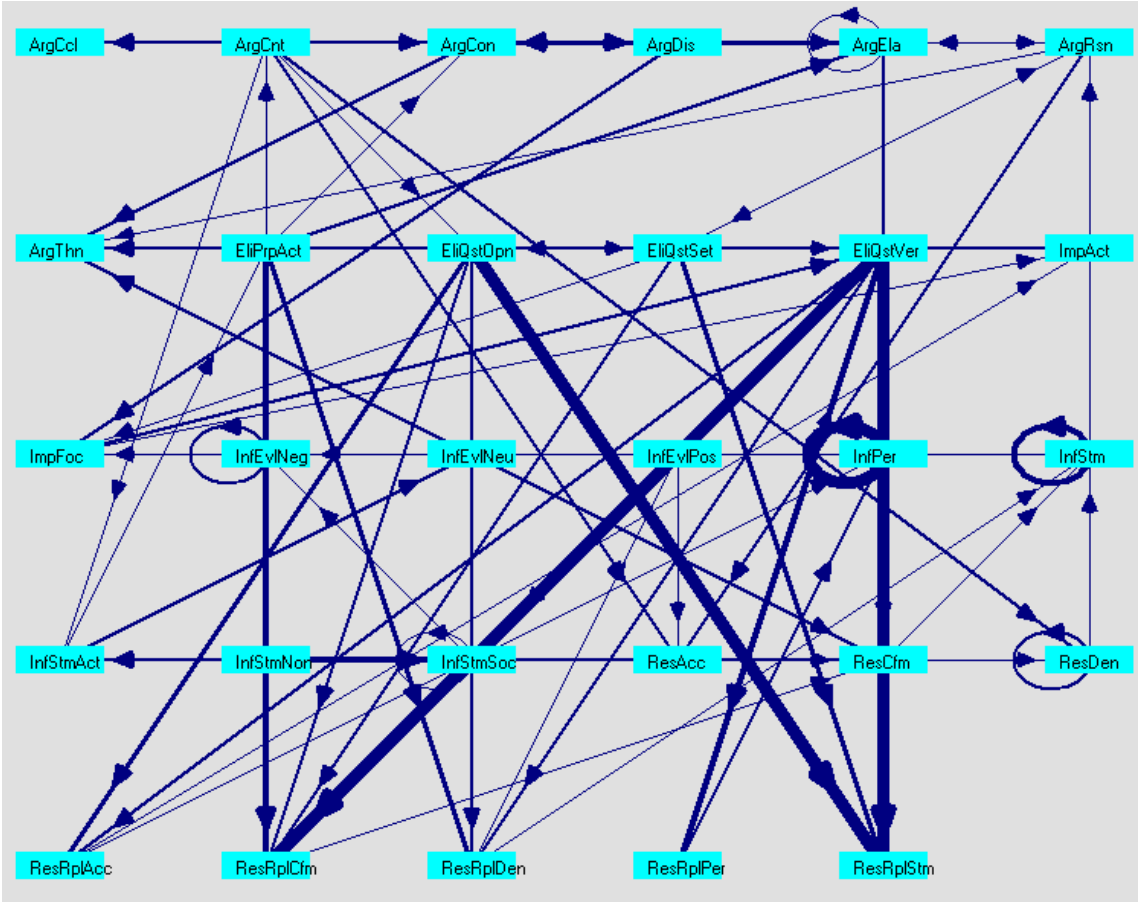

Figure 4 Transition diagram of the five least successful groups.

Conclusions and Discussion

In the present study, the effects of visualization of participation during CSCL were examined. A CSCL-environment was augmented with the Participation Tool (PT). The PT visualizes how much each group member contributes to his or her group's online communication.

The first research question concerned the effect of the PT on students' use of argumentative dialogue acts. Although it was expected that treatment group students would use more argumentative dialogue acts compared to control group students, this expectation was only partially confirmed. On only one out seven dialogue acts a significant effect of the PT was found. The PT had a significant effect on students' use of conditional arguments.

The second research question examined the effect of the PT on the sequences of argumentation group members engaged in. It was expected that the PT would stimulate students to engage in longer sequences of argumentation. Again, this expectation was only partially confirmed. Although treatment group students did not construct more sequences of five, four, and two arguments, they did contruct more sequences of three arguments than control group students did. In sum, the PT partially helped group members to construct longer sequences of argumentation.

The third research question asked whether groups with access to the PT performed better on the inquiry group task compared to control group students. It was expected that, through stimulating argumentation and participation, the PT would peform better on the inquiry group task. The results indicate that this was not the case. Treatment groups did not attain higher performance scores than control groups. It is worth noting that for two subtasks moderate to high effects sizes were found in favor of the treatment group. In conclusion, the effects of the PT on group performance were not as profound as expected.

Finally, the last research question investigated the argumentation patterns of successful versus less successful groups to examine the effects of argumentation on group performance. By comparing the transition diagrams of the five most successful groups to those of the five least successful groups, it became clear that, although both groups engage in cycles of argumentation,

the patterns were different. This suggests that specific argumentation patterns are necessary to perform well on a complex inquiry task.

In conclusion, some effects of the PT on students' use of argumentation were found. However, these results were not as profound as expected. Several explanations may account for this. For example, students were not forced to use to PT. They could open and close it whenever they wanted. Unsurprisingly, some students used the PT very little, whereas others used it a lot. If the PT would have been on students' screens all the time, this might have produced different, perhaps more positive, effects. Second, the PT may focus students more on superficial characteristics of their collaboration, and less on using argumenation during collaboration. Other tools, such as argumentation scripts, may focus students more specifically on adequately using argumentation during online collaboration (Weinberger, Stegmann, & Fischer, 2006).

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