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Learning through synchronous electronic discussion

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Abstract

This article reports a study examining university student pairs carrying out an electronic discussion task in a synchronous computer mediated communication (CMC) system (NetMeeting). The purpose of the assignment was to raise students' awareness concerning conceptions that characterise effective pedagogical interactions, by collaboratively comparing and discussing their analyses of a dialogue between a tutor and a student. To examine whether the use of synchronous CMC could meet this end, students' dialogues are characterised in terms of their constructive and argumentative contributions, and by their focus on the meaning of concepts. In addition, a comparison was made with a control group in which no peer coach was available with two forms of peer coaching. Peer coaches were focussed either on structuring arguments or on reflectively checking arguments in terms of strength and relevance. First, the results indicate that the study of students' learning from electronic discussions requires an analysis of focus in relation to argumentation. Second, the coaching instruction did not fulfil our expectations. In this study, students seem to need support to focus on meaning rather than on argumentation in general, but they may also need support to hold overview, to keep track of their discussion and to organise their interface. Text-based electronic communication seems to be sensitive to such issues that may cause meaningful interaction to be disturbed.

Keywords: Computer-mediated communication; Co-operative/collaborative learning; Distance education; Telelearning; Pedagogical issues; Teaching–learning strategies

1. Introduction

Collaborative learning is regarded as an activity encouraging knowledge construction

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through mechanisms such as belief revision, conceptual change, externalising knowledge and opinions, self-explanations, co-construction of knowledge and reflection (Piaget, 1977; Doise & Mugny, 1984; Voss & Means, 1991; Johnson & Johnson, 1993; Chan, 1995; Dillenbourg & Schneider, 1995; Baker, 1996; Savery & Duffy, 1996; Petraglia, 1997; Littleton & Hakkinen, 1999; Baker, 1999). It is believed that learning is particularly effective when collaborating students encounter conflicts and manage through negotiation to produce a shared solution (e.g. Piaget, 1977; Doise & Mugny, 1984; Baker, 1996; Erkens, 1997; Savery & Duffy, 1996; Petraglia, 1997). In our research, we focus on the relation between knowledge construction and argumentation in collaborative learning situations. This paper presents the results of a research project concerned with argumentation and learning in a task which explicitly focusses on meaning negotiation.

We work with students of Educational Science. In this academic area, students have to deal with unclear, vague and abstract knowledge domains that are considered to be 'discussible' (Golder & Pouit, 1999). Social science domains are not characterised by the presence of many fixed or stable conceptions and statistical evidence and research results can be interpreted from various perspectives, allowing different interpretations and conclusions. Assignments involve problems with more than one acceptable solution and more acceptable ways to reach solutions. Also, many situational factors (e.g. learning context, task design, personal beliefs and values) affect the construction of knowledge and problem solving. To introduce students to deal with this type of knowledge domain significant negotiation is needed; hence, critical discussion seems to be an appropriate instructional means. In argumentation, students can check, challenge and counter each other's disputed information. This can encourage them to produce *constructive activities*, in which they add, explain, evaluate, summarise or transform knowledge for better understanding or problem solving. We propose that these activities can be considered as signals of learning in progress as they seem to be connected with knowledge construction. This issue is pursued in Section 2.

To support and optimise students' engagement in argumentative dialogues for learning purposes, computer mediated communication (CMC) systems provide new educational opportunities. CMC systems are network-based computer systems offering electronic opportunities for group communication, such as Newsgroups, E-mail conferencing systems, Internet relay chat and virtual classrooms. Through text-based communication, CMC offers an 'interpretative' zone that allows participants to share multiple perspectives or attitudes relative to a particular topic or issue. The permanence and explicitness of text together with time-delays in text-based CMC systems provide opportunities to reflect, scrutinise information and to 'think before talking'. Despite these possibilities, not much is known about learning in CMC. The focus of this study is enhancing learning through synchronous electronic discussion.

2. Factors in collaborative argumentation

In effective collaborative argumentation, students share a focus on the same issues and negotiate about the meaning of each other's submitted information. Incomplete, conflicting, disputed or irrelevant information needs to be checked critically, untill a consensus is reached. However, the means and processes for fostering argumentation and generating effective negotiation in educational situations are poorly understood, especially in electronic environments. In Section 2, factors related to support collaborative argumentation are considered. Specifically, focussing and critical argumentation in relation to learning and peer coaching in electronic environments are considered.

2.1. Focussing

In collaborative learning, focussing plays an important role in the interpretation and understanding of communication. Students have to initiate and maintain a shared task-focus. They have to agree on the overall goal, descriptions of the current problem-state, and available problem-solving actions (Roschelle & Teasley, 1995). Failure to maintain a shared focus on themes and problems in the discussion, results in a decrease of mutual problem solving (Baker & Bielaczyc, 1995; Erkens, 1997). Defining more specifically, what kind of focus should be shared and maintained relates to the learning and task goals. For example, when students are supposed to reach insight and understanding of theories and concepts, sharing and maintaining a conceptual focus in the dialogue may be most appropriate. When student pairs are asked to program a computer-based learning system, in some stages it may be best to focus on the practical use of the available programming tools. In this study, students have to develop insight and understanding of a conceptual model. In this situation, we expect that a shared and maintained conceptual focus is best for learning purposes.

2.2. Critical argumentation

In collaborative learning, students need to assess each other's information critically, considering the problem or question under discussion (Erkens, 1997). Various perspectives can be discussed and elaborated upon by the use of critical argument moves defined as *checks, challenges* and *counters* (Veerman & Treasure-Jones, 1999):

- Students can check information when they do not fully understand earlier stated information from one or more discussants (Petty & Cacioppo, 1986). Questions aimed at checking information are, for example: 'What do you mean by ...', 'Can you explain/define/tell me more about...', or 'I do not really understand the difference between...'
- When students doubt about or disagree with one or more persons, they can use challenges or counters. Challenging information means that questions are aimed at triggering justifications. Typical challenges are: 'Why do you think that is important?', 'what sources did you get your information from?' or 'Why do you think Laurillard is right when she says...?'.
- Countering information means that argumentative moves are used for explicit disagreement. Some examples are: 'No, this is not true', 'I do not agree', 'but I think...' or 'On the contrary I think...'

To check, challenge and counter disputed information is assumed to support students' understanding and learning. In the current study, these argumentative 'moves' are considered to be important since they may provoke discussion aimed at reaching insight and understanding of a conceptual model.

2.3. Learning in process: the production of constructive activities

From a theoretical perspective on academic learning, academic education can be framed as an ongoing argumentative process (Petraglia, 1997). It is the process of discovering and generating acceptable arguments and lines of reasoning underlying scientific assumptions and bodies of knowledge. The purpose of collaborative argumentative tasks is to externalise, articulate and negotiate alternative perspectives, inducing reflection on the meaning of arguments put forward by peers as well as experts. However, it is difficult to measure students' learning results in such tasks, since it is hard to judge veracity or accuracy of 'discussible' information with respect to well-established norms. There are not many well-defined conceptions and problem solutions that can be used to define learning or understanding. One of the possible ways to analyse learning is to study the process of negotiation or to investigate the articulation of information as it occurs during discussions. This can be done on many dimensions (Baker, 1999).

We propose to focus on forms of knowledge articulation that seem to be good for knowledge construction. During discussion, some interactions may lead to the construction of new knowledge (Baker, 1999), in which students add, explain, evaluate, summarise and even sometimes transform information. Adding information means that an input of new information is linked to the discussion. Explaining information means that earlier stated information is for example differentiated, specified, categorised, or made clear by examples. Evaluations are (personally) justified considerations of the strength or relevance of already added or explained information. In transforming knowledge, already stated information is evaluated and integrated into the collective knowledge base in such a way that, a new insight or a new direction transpires, that can be used to answer questions or to solve problems. Summarising means that already given information is reorganised or restated in such a way that the main points or (sub) conclusions reflect the discussion.

In this study, we propose to define learning as a set of such non-normative constructive activities. This means that we are not directly concerned with the construction of representations that are accepted as correct from a normative point of view (Baker, 1999). Rather, our aim is to consider forms of knowledge articulation that seem to be good for knowledge construction during students' discussion.

2.4. Coaching collaborative argumentation

Assessing information critically on its meaning, strength or relevance depends on many factors, such as the peer student, the role of the tutor, the type of task, the type of instruction and the selected medium. There are key problems that may inhibit students engaging in critical argumentation (Kuhn, 1991). These include:

- Students tend to believe in one overall correct solution, even in 'discussible' knowledge domains.
- Students exhibit difficulties in generating and comparing counter arguments.
- Students have difficulties in using strong, relevant and impersionalised justiications.
- Students' exposure to critical attitudes can be inhibited because of socially biased behaviour.

For example, students may be afraid to 'lose face' (e.g. in front of the classmates) or go against dominant discussants (e.g. a tutor).

To enhance students' learning through electronic argumentation many support strategies can be thought of. Examples are: scaffolding students, modelling their behaviour, using question asking strategies or structuring arguments. To combat biased behaviour, we decided to deliberately design *peer coaching*: well-prepared students only intervening from the sidelines. The two different coaching strategies we chose, respectively, focussed on argument structures (the structure coach) and on critical assessment and justification of arguments (the 'reflective' coach). The structure coach is focussed on argument building, particularly on generating and comparing alternative and contrasting statements, arguments and elaborations. The reflective coach is focussed on checking information on meaning, strength and relevance and on questioning connections between claims and arguments. In Table 1, the two coaching strategies are described in more detail.

2.5. Computer mediated communication

Text-based and time-delayed communication can be beneficial to keep track and an overview of complex questions or problems under discussion. Text-based discussion is by necessity explicit and articulated. In addition to the chat windows, in which contributions are not interlaced in time, a history of the dialogue can be used to reflect over time on earlier stated information. Contradictions, gaps or conflicts may be revealed through text-based and time-delayed discussion. However, due to the lack of non-verbal cues an immediate and shared interpretation of information sometimes may be more difficult to achieve than in face-to-face situations (see e.g. Moore, 1993). This can be especially harmful for maintaining a shared focus in argumentative dialogues.

The lack of physical and psychological cues such as physical appearance, intonation, eye-contact, group identity, sometimes leads to democratising effects (Short, Willams & Christie, 1976; Kiesler 1986; Rutter, 1987; Spears & Lea, 1992; Smith, 1994; Steeples et al., 1996). It is anticipated that critical behaviour will be less biased towards a tutor or a dominant peer student.

It is unclear how characteristics of specific electronic environments relate to effective collaboration in learning situations. The purpose of this chapter is to analyse the interplay between focussing, argumentation and learning in computer mediated communication. As a general expectation, we expect argumentation while focussing on the meaning of concepts to be positively related to the production of constructive activities. However, we expect that CMC presents some specific obstacles for the attainment of this goal, reflected in problems with maintaining focus and a bias for compromising. The groups with peer tutors allow us to analyse more specific expectations, indicating that a focus on specific types of argumentation may enhance specific constructive activities in the dialogue.

Two main research questions have been addressed. First, how can dialogues, produced by student pairs during the discussion task, be characterised in terms of focussing and argumentation and how does that related to the production of constructive activities? It is expected that a high number of argumentative information exchanges will be positively related

Table 1
Tests and materials

Tests and materials	Description
Knowledge test (*10 minutes*)	Students have to link the concepts of Discursive, Adaptation, Interaction and Reflection (as used and explained by Laurillard) to the 12 activities in the 'conversational framework'. The best students were selected to become peer coaches
Technical instruction NetMeeting (*30 minutes*)	Students have to categorise several sentences using Laurillard's model, open the electronic text-editor Notepad to write their answers in, and adjust the size of Notepad on their computer screen. Then, they open NetMeeting, adjust the chat-box to their identity (adjust the name, email address), and connect to another student in NetMeeting. Finally, they share their Notepads using NetMeeting and practice electronic communication as an exercise
Individual analysis (*10 minutes*)	Students individually start to analyse a short protocol of a tutoring session. In this protocol a tutor and student discuss how to design didactical strategies for a computer based training program. Seventeen sentences of the protocol have to be categorised by using the 'conversational framework'
Peer coach training: (*10 minutes*)	The best 14 students were trained to use coaching strategies to support student-pairs during the electronic discussion task. They were instructed to coach the students only in order to develop their own thinking, and to trigger discussion only in the following situations (listed from high to low priority): (a) the students disagree, but do not explore their differences (b) the students agree, but they do not give explanations or arguments while the expert solution is different (c) the students disagree, but the expert agrees only with one of the students (d) the students agree, but do not give explanations or arguments The peer coaches were randomly divided into two groups, each offering interventions in a different manner: *''Structure' condition* To explore the problem space students have to discuss multiple points of view and elaborate on stated arguments from a positive and negntive perspective. Dependent of the situation (e.g. initial disagreement, agreement) interventions embody question types such as : ''What arguments can you give to support your choice/ opinton?' 'What counter-arguments can you think of?', 'Are there any other solutions...?', 'What conclusions can be drawn?' Of course, peer-tutors are free to reformulate questions to adapt them to the specific situation *Reflective condition* When information is doubted, disagreed or disbelieved it has to be explicitly questioned or countered. Dependent of the (initial) state in the discussion, interventions embody 'check' activities, such as checking arguments on the content, source, factual knowledge, logical reasoning chains etc. Questions are aimed at explicitly linking claims to arguments and arguments to elaborations, for example: ''Can you explain what you mean?'', ''What source have you used?'', ''Do you think this argument is strong or relevant?'', ''Why do think that?''. Again, students are free to reformulate prototypical questions to adapt them to the specific situation

Table 1 (*continued*)

Tests and materials	Description
Discussion rules: (2 minutes)	Before entering the Netmeeting discussion task, all students and peer coaches received 'discussion rules'. Students were instructed to initiate discussions with their peers and not with their peer coach. Peer coaches would only intervene when necessary, and mainly would ask questions instead of giving answeres. All students and peer coaches were instructed to be focused on the task, to be clear, not to be convinced too easily, to develop an argument before accepting doubted or disbelieved information and to show central but " reasonable", behaviour.
Evaluation: (5 minutes)	Both students and peer coaches have to evaluate the electronic discussion they engaged in. They have to state their opinion on a five-point Likert scale (from full agreement to full disagreement) regarding seven statements aimed at task focussing, clearness of the discussion, and breadth, depth and quality of the discussion. When relevant, they have to state whether the peer coach played an essential role

to the production of constructive activities. Student pairs that focus on the meaning of concepts are expected to produce more constructive activities than pairs that focus on the application of concepts. A frequently shifting focus is expected to mitigate against the development of constructive activities.

Second, how can peer coaches support students' argumentative dialogues in order to enhance learning (in terms of the produced constructive activities)? We expect peer coached student pairs to focus more on the meaning of concepts than on the use of concepts. In addition, student pairs guided by the reflective peer coach are expected to emphasise explanations using checks. Student pairs guided by the structure peer coaches are expected to emphasise evaluations using challenges and counters.

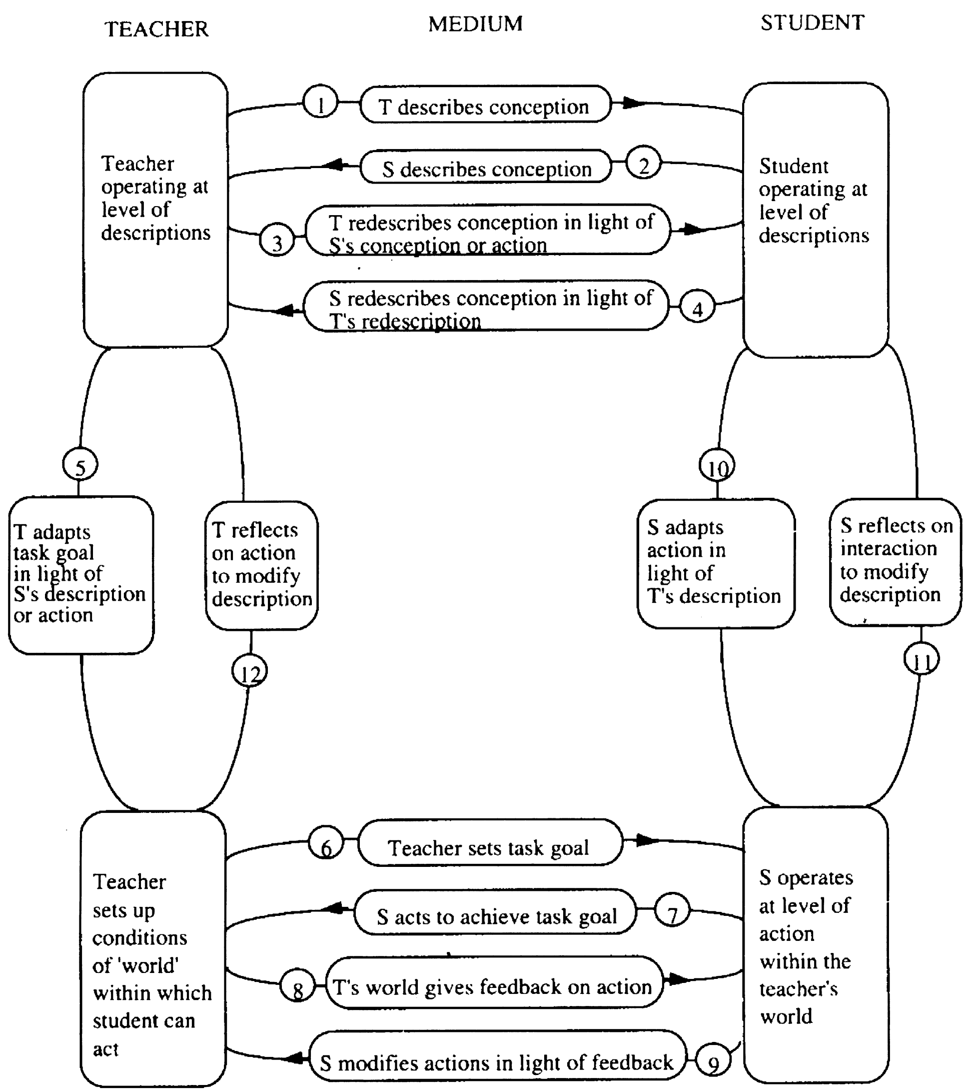
A prior knowledge test was used to select students to be instructed as peer coaches. We asked pairs to judge the quality of their own discussion and of the coach (for future assignments) and we traced the global strategy of all student pairs. There was also an opportnity to use the results to look for individual differences bewteen student pairs.

3. Method

The study was conducted in the context of an undergraduate course in educational technology. One of the learning goals in this course was to reach insight and understanding in the 'Conversational Framework' (Laurillard, 1993; see Fig. 1), a discussible model that one can use for analysing teacher–student interaction (Bostock, 1996). We used the framework only as subject for discussion, not for our own data analyses. We designed an electronic discussion task for considering this framework and assigned student pairs to three different conditions: a reflective peer coaching condition, a structure peer coaching condition (see Section 2.4) and a control group (no coaching).

3.1. Sample and procedure

Data were collected at two subsequent times the course was offered — November 1997 and January 1999. In 1997, we collected data related to 42 upper-level undergraduate student in the coached conditions. In 1999, we collected data related to 26 student in the control group. Across the years, comparable types of students participated in the study (according to their age, sex and knowledge test scores) and the educational setting was identical.



The 'conversational framework' identifying the activities necessary to complete the learning process.

Fig. 1. The conversational framework (Laurillard, 1993, p. 102).

During the second week of the course, students were instructed to use a book to study the 'Conversational Framework' at home. In the third week, the student engaged in our study as part of their educational program. All students initially took a 10-minute knowledge test about the framework. Afterwards, they received 30 minutes of technical instruction on how to use the synchronous CMS system (NetMeeting). In 1997, subsequently, the best sutdents received a 10-minute instruction on peer coaching. They needed sufficient knowledge of the 'Conversational Framework' to adapt specific coaching strategies to students' discussions. In the meantime, the other students individually analysed a protocol of a tutoring session with respect to the 'Conversational Framework'. Their assignment, was to categorise 17 sentences according to this model. In 1999, all students completed this analysis. Subsequently, students were randomly paired in preparation for their use of NetMeeting. They were instructed to come to an agreement in a 45–60 minute discussion (we used flexible time-constraints). It was anticipated that spontaneous discussions would be triggered (Bull & Broady, 1997).

Electronic discussions were logged automatically and post-task questionnaires were used to assess the students' and peer coaches' judgement of the quality of the discussion and, when relevant, the support given by the peer coach. Materials used to test prior knowledge, to instruct the students and to evaluate the discussions are shortly described in Table 1.

3.2. Data analyses

Electronic discussions were automatically logged as text files on the computer. The experimental condition and total time were logged as well as time stamps and names per message. In addition, each protocol was divided into four discussion phases:

1. students introduce themselves and organise the interface.
2. students plan how to carry out the task.
3. students engage into content-related discussion.
4. student either cease working on a task or end the discussion.

The phases of content-related discussion were analysed in-depth on focussing (including focus shifts), information exchanges (including argumentation) and constructive activities (see Table 2). Our main goal was to study the interplay between focussing, argumentation and learning, defined as a set of constructive activities, in order to enhance synchronous electronic discussions.

Focus categories were related to the task goals: the development of meaning of concepts and the use of conceptual knowledge. Two focus categories reflected this: (1) focus on the meaning of concepts, (2) focus on the use of concepts. The focus could also be the task strategy (planning how to start the task, time management, how to carry out the task, keeping an overview of the task, etc.). Two categories of focus shifts were distinguished: focus shifts from understanding to the use of concepts and visa versa, and shifts from the meaning or use of concepts to the task strategy and visa versa.

The categories of information exchange indicated how argumentation was triggered. Considering several approaches to the analysis of educational dialogue (including analyses of dialogue games, exchange structures and communicative acts, argument and rhetorical structure; see Pilkington, McKendree, Pain & Brna, 1999), we decided on six dialogue moves:

Table 2
Categories of data analysis

Discussion phase	Variables	Categories
Content-related discussion	Focussing	Meaning of concepts Use of concepts Task strategy
	Shifting focus	Meaning ⇔ use Meaning or use ⇔ strategy
	Expressions of information exchange	Argumentative information exchanges: • Check. • Challenge. • Counter. Statement Acceptance Conclusion
	Constructive activities	Adding information Explaining information Evaluating information

statements, checks, challenges, counters, acceptances and conclusions. Although these categories can embody elements of argument, we view checks, challenges and counters as argumentative information exchanges.

At the epistemological level, the discussions were analysed on types of constructive activities. We analysed goal-oriented activities in which relevant information was added, explained, or evaluated. Summarising information and information transformations hardly occurred. Inter-judge reliability of the coding system showed a Cohen's kappa of 0.91 for the focus variable, a kappa of 0.89 for information exchange categories and a kappa of 0.74 for constructive activities.

In Fig. 2, we present an authentic example of a content-related discussion fragment analysed with MEPA (Erkens, 1998), a tool developed for Multiple Episode Protocol Analysis. For technical reasons, messages longer than two lines are truncated to two lines in the screen dump.

4. Results

In this section, a description is provided of student variables and how student pairs accomplished the discussion task. An examination is given of the relationships between focussing, argumentative information exchanges and the constructive activities. Differences are identified between the control group, the group with a access to a structure coach and group with acdess to a reflection coach. An initial analysis led to additional analysis in terms of a cluster and discriminant analyses.

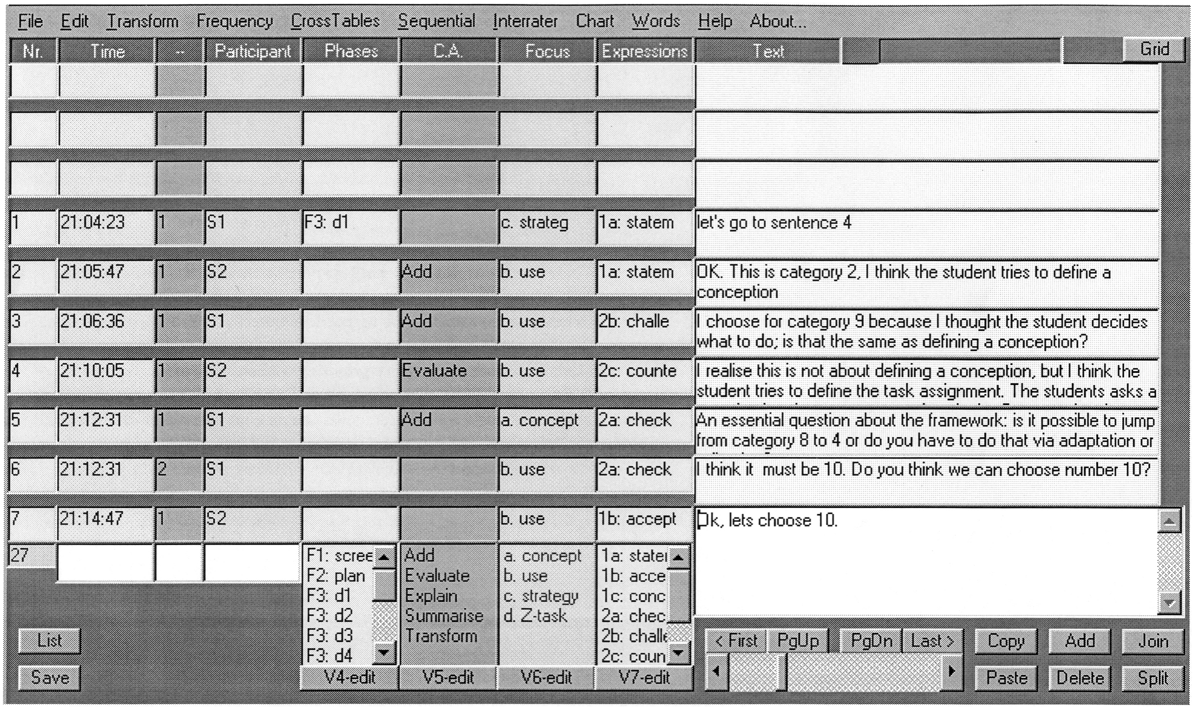


Fig. 2. Example of analysing a discussion (C.A.: Constructive Activity type; Expressions: information exchange type).

Description of the analysis:

1. Student 1 (S1) starts a content-related discussion phase (F3:d1) and proposes to analyse sentence 4 of the protocol of the tutoring session. The focus is on the task strategy (where to start the discussion = c. strategy), the proposal is coded as a statement.
2. Student 2 (S2) agrees and states what category of the Conversation Framework (CF) fits sentence 4. S2 focusses on the use of the CF and adds content-related information ('*student tries to define a conception*').
3. S1 challenges S2 by proposing another category and adds information ('*...student decides what to do'*).
4. S2 then counters S1 and the information is evaluated ('*...the student tries to define the task assignment. The student asks a question but there are no questions in he Conversational Framework! So, the this is not an adaptation towards an earlier action as a consequence of feedback...*').
5. S1 shifts focus towards the meaning of concepts and checks understanding. New content-related information is added (*... to jump from category 8 to 4 or ... via adaptation or reflection*).
6. Then, S1 shifts back to the use of concepts and checks mutual agreement.
7. S2 agrees and accepts the choice for category 10.

4.1. Student variables and task approach

In 1997, 14 discussions were logged on the computer. Two discussions were not considered, because they were coached by students with low scores on the knowledge test. A third discussion was not task-oriented. Of the 11 discussions left for analysis, five were guided by structure coaches; six by reflective coaches. In 1999, 13 discussions were logged on the computer. Four discussions were removed from the analysis. In two discussions, one of the students did not show up; a tutor replaced the student but invalidated the discussions. Another two discussions were not task-related; students did not study the 'Conversational Framework' and decided to discuss the practical use of the electronic tool.

4.1.1. Prior knowledge

All students were tested on their knowledge of Laurillard's 'Conversational Framework'. The results were measured on a 10 point scale (10 = maximum score). In 1997, the mean score of the students pairs left for analysis was 5.8 (s.d. = 2.1), in 1999 this was 6.4 (s.d. = 2.2). The scores of the students across coaching and control groups were comparable. No relationship was found between individual scores on the knowledge tests and the production of constructive activities in discussion groups.

4.1.2. Self-judgement

Students and peer coaches stated their personal opinion by answering seven questions on a five-point Likert scale. Scores run from 1 (low quality) to 5 (high quality). In 1997 and 1999, the quality of the discussion was scored above average with means 3.5 and 3.8, respectively. Coach support was scored as average (mean = 3.0). Reflective peer coaches judged their support for discussions as important, whereas the structure peer coaches did not ($t_{(12)} = 2.4; p < 0.05$). No relationships were found between personal opinions, (self) judgement of the peer coaches and the production of constructive activities.

4.1.3. Task approach

All student pairs started the discussion task by organising the interface (the phase of 'screen building'). This was necessary because they had to use each other's Notepads and the chat box in NetMeeting. Despite technical instruction and exercises, this phase caused problems. On the average, students used 20% of their time to organise the interface, at the start and during the discussion. After the initial phase of screen building each student pair discussed briefly how to carry out the task. All groups proceeded through their assigned task in order of the to be

Table 3
MANOVA on messages sent and time (on task)

	Coach	No. of pairs	Mean	Std. deviation	F	Sign.
Messages sent	Structure	5	120.6	39.4	1.43	0.27
	Reflective	6	121.0	62.7		
	Control	9	78.7	57.7		
Time (s)	Structure	5	3174.4	1513.3	1.56	0.24
	Reflective	6	3273.8	1444.4		
	Control	9	2355.1	367.5		
Time per messages (s)	Structure	5	28.2	17.3	1.16	0.34
	Reflective	6	28.8	10.9		
	Control	9	40.9	21.8		
Not task related (% of the discussion)	Structure	5	3.8	5.9	0.27	0.77
	Reflective	6	2.3	2.0		
	Control	9	3.3	2.2		

categorised sentences. In each condition, more time was spent on categorising the first three sentences than on later ones. None of the student pairs spent much time on closing off the task. Due to the experimental setting and time constraints, all students were forced to quit the task before reaching the end (they discussed at maximum 10 out of 17 sentences). The three conditions did not affect the students' general approach to the task. Across conditions we only found a relationship between the average time spent per message and the production of constructive activities ($r = 0.68; p < 0.01$). Considering time and the amount of messages sent, a MANOVA obtained no significant differences between groups, due to large variations within conditions and across years (see Table 3).

4.2. Electronic discussions

To characterise electronic discussions in terms of focussing and argumentation on the one hand and the production of constructive activities on the other hand, we removed all but the content-related fragments from the discussions. All content-related messages were scored on focus, types of information exchanges (including argumentation) and, if relevant, on focus shift and constructive activities. Considering the high differences we found in means and standard deviations of the time and the number of messages sent per discussion, both between and within conditions, we rendered messages relatively, in *percentages*. After all, our research questions are aimed at the interplay between content-related argumentation, focussing and the production of constructive activities, not at the absolute amount of messages provoked per condition.

First, the relationship between argumentative information exchanges and constructive activities was analysed. Student pairs that checked, challenged and countered information were expected to produce more constructive activities than student pairs that hardly engaged in argumentation. Correlational measures did not confirm our expectations: no significant relationships between argumentation and the production of activities were found ($r = 0.26$; $p = 0.28$).

Second, we analysed the relationship between focussing and constructive activities. Student pairs that focussed on the meaning of concepts were expected to produce more constructive activities than groups that focussed on the use of concepts or the task strategy. Shifting the focus was expected to inhibit the production of constructive activities. Correlational measures partly confirmed our expectations. Focusing on the meaning of concepts in itself showed no significant relationship with the production of constructive activities. However, focussing on the task strategy was negatively related with the production of constructive activities ($r = -0.53; p < 0.05$). In addition, shifting focus between the meaning and the use of concepts showed a positive relationship towards the production of constructive activities ($r = 0.47; p < 0.05$).

Finally, we searched for a combined relationship between argumentation and focussing on the one hand and the production of constructive activities on the other hand. As we expected, correlational measures showed a positive relationship between argumentation while focussing on the meaning of concepts on the one hand and the production of constructive activities on the other hand ($r = 0.48; p < 0.05$).

Table 4
MANOVA for peer coaching (‘structure’ vs. ‘reflective’ vs. no coaching)

	Condition coach	Mean	Std. deviation	*F*	Sign.
Check	Structure	18.1	8.0	2.12	0.15
	Reflective	25.3	4.9		
	Control	22.9	5.0		
Challenge	Structure	14.9	2.4	3.19	0.07
	Reflective	12.3	4.9		
	Control	7.9	6.2		
Count	Structure	8.6	2.9	0.08	0.93
	Reflective	8.2	4.1		
	Control	7.4	8.0		
Argumentation: Σ (check + challenge + counter)	Structure	41.6	8.8	1.87	0.19
	Reflective	45.8	6.6		
	Control	38.2	7.2		
Focus on use	Structure	74.1	12.2	1.57	0.24
	Reflective	57.8	13.3		
	Control	59.5	20.6		
Focus on meaning	Structure	7.88	3.3	1.50	0.25
	Reflective	17.3	10.8		
	Control	17.6	12.9		
Focus on strategy	Structure	18.1	9.6	0.93	0.41
	Reflective	25.0	5.4		
	Control	20.2	9.9		
Focus shift meaning ⇔ use	Structure	6.6	1.8	1.13	0.35
	Reflective	10.2	4.3		
	Control	10.0	5.4		
Focus shift meaning/use ⇔ strategy	Structure	21.4	9.8	0.39	0.69
	Reflective	26.0	9.6		
	Control	22.7	8.6		
Meaning — argumentation	Structure	3.0	2.7	1.8	0.20
	Reflective	8.9	7.0		
	Control	6.4	4.7		
Use — argumentation	Structure	29.5	7.3	1.1	0.36
	Reflective	26.5	6.1		
	Control	22.1	11.5		
Strategy — argumentation	Structure	3.9	3.7	0.68	0.52
	Reflective	8.4	3.8		
	Control	7.3	8.7		
Add	Structure	11.7	4.0	3.41	0.06
	Reflective	9.0	2.2		
	Control	16.2	7.1		
Explain	Structure	4.3	2.6	0.97	0.40
	Reflective	9.2	12.2		
	Control	9.6	3.7		
Evaluate	Structure	13.4	6.9	0.73	0.50
	Reflective	13.0	5.3		
	Control	18.0	11.5		
Constructive activities	Structure	29.3	12.3	1.91	0.18
	Reflective	31.1	12.0		
	Control	43.9	19.0		

4.3. Structure and reflective coaching compared to the control group

Before analysing differences between coaching conditions and the control group we checked to see whether peer coaches acted according to their roles. Confirming to our expectations, we found structure peer coaches to be aimed at the argument structure and asking questions to provoke multiple perspectives and pro- and contra-argumentation. Reflective peer coaches focussed on questioning justifications and connections between claim and evidence. Unfortunately, at some times the coaches made errors. The structure peer coaches sometimes took their task too seriously and pressed students who got stuck in their (shared) understanding to continue the task. At other times the reflective peer coaches engaged shortly into the content of the discussion by checking or countering domain knowledge. This ended a discussion immediately since the students took the coach's opinion as a fact.

The two coaching conditions and the control group were tested on differences in argumentation, focussing, shifting focus, focussed argumentation and the production of constructive activities. Analysis of variance (MANOVA) only showed two small differences when challenging information and adding activities were considered (see Table 4). Challenges were mostly made in the structure condition (mean = 15) and in the reflective condition (mean = 12); the control group (mean = 8) was somewhat lower ($F_{(2.17)} = 3.2$; $p = 0.07$). Additions were most frequently produced in the control group (mean = 16); the structure group (mean = 12) and reflective group (mean = 9) were lower ($F_{(2.17)} = 3.41$; $p = 0.06$). Challenges were mainly produced by the coaches. However, student pairs in coached conditions produced fewer constructive activities. This result did not confirm our expectations (see Table 4).

4.4. Additional analyses

Analysis of variance, unfortunately, revealed less clear differences among the conditions than we expected. To reach more insight into the interplay between focussing, argumentation and the production of constructive activities, we decided to continue our analyses exploratively by executing a cluster analysis to identify relatively homogeneous student pairs on the following six variables (see Section 4.4.1):

- focus on the meaning of concepts related to argumentation (Σ (checks + challenges + counters));
- focus on the use of concepts related to argumentation (Σ (checks + challenges + counters));
- focus on the task strategy related to argumentation (Σ (checks + challenges + counters));
- shifts of focus between the meaning and use of concepts;
- shifts of focus between the meaning or use of concepts on the one hand and task strategy on the other hand;
- sum of constructive activities.

In order to plot and compare clusters of student pairs and to identify underlying functions, we completed a discriminant-analysis.

4.4.1. Cluster-analysis

We explored our data by attempting to reorganise the 20 student pairs in clusters. A K-

Table 5
Student pairs clustered on (*percentages*) of focussed argumentation, focus shifts and constructive activities

Clusters	1	2	3	ANOVA (*F*)	*p*-value
Argumentation on meaning of concepts	4	11	7	3.16	0.07
Argumentation on use of concepts	29	12	33	27.16	0.00
Argumentation on task strategy	5	14	2	8.90	0.00
Shifting focus between meaning and use of concepts	8	10	13	1.77	0.20
Shifting focus to and from task strategy	23	29	16	2.48	0.11
Production of constructive activities	29	36	66	14.83	0.00
Number of student-groups:	12	5	3		

means cluster analysis iteratively classified the groups into three final clusters (see Table 5). We additionally requested analysis of variance *F* statistics to reveal information about each variable's contribution to the separation of the clusters.

As shown in Table 5, most student pairs are classified in the first cluster ($n = 12$). These student pairs are characterised by a high score on argumentation related to a focus on the use of concepts. The ratio of discussing the meaning of concepts to the use of concepts is 1:7 and focus shifts between these two variables do not often occur. In contrast, focus shifts to and from the task strategy are frequent. The production of constructive activities is the lowest compared to the other groups, though not far away from second cluster. This first cluster has been labelled as a group of *Achievers*; student pairs mainly aimed for agreement about the use of concepts.

At first sight, student pairs in the third cluster ($n = 3$) look similar to the student pairs in the first cluster. However, the relative focus on the meaning of concepts versus the use of concepts is higher (1:5 versus 1:7) and the number of focus shifts between these two variables is somewhat higher (13% versus 8%). In addition, the focus of task strategy is not as pronounced (16% versus 23%) and shifts to and from the task strategy are low. But, the most obvious difference is that students in the third cluster produce more than twice as many constructive activities (66% versus 29%). We label this 3rd cluster as the group of *Conceptual Achievers*; student pairs shifting back and forward between discussing the meaning and use of concepts, finally aimed at solving the discussion task.

The second cluster of student pairs ($n = 5$) clearly differs from the other two. Discussing the meaning of concepts and the task strategy are clearly more prominent while discussing the use of concepts is quite a bit lower. The balance between discussing the meaning of concepts and the use of concepts is 1:1 and focus shifts between these two variables occur every now and then. However, discussing the task strategy and shifting focus to and from the task strategy occur most frequently compared to the other clusters. Nevertheless, the amount of produced constructive activities was not the lowest. It appears that this group of *Conceptualisers* positively relates to the production of constructive activities but is 'hidden' behind serious interface problems.

4.4.2. Discriminant analysis

To plot and compare clusters of student pairs on underlying functions, we finally executed a discriminant analysis. Although this method can be used for forecasting cluster membership of

Table 6
Canonical discriminant functions evaluated at group means

Cluster	Function 1	Function 2
Achievers	−1.6	−0.5
Conceptualisers	3.5	−0.9
Conceptual Achievers	0.6	3.6

future cases, we used this method only in a descriptive and explorative way. We included all 20 student pairs, labelled with a cluster membership, and the same six variables as used in the cluster analysis. Discriminant analysis showed us two canonical discriminant functions (see Table 6) that were significantly separable (eigenvalue > 1; Wilks' Lamba = 0.00). In the following paragraph we will describe and explain these functions in a post hoc explorative manner.

The first function can be explained as a dimension of that reflects low content-oriented information is argued about. Referring to the characterised clusters on the six variables (Table 5), we interpret that the larger the positive distance on this dimension, the stronger the cluster of student pairs, is explained by meaningful interaction. Meaningful interaction reflects an emphasis on argumentation focussed on and shifted focus towards the *meaning* of concepts. The negative side of the function can be interpreted as argumentation that is mainly focussed on the *use* of concepts.

The second function can be explained as a dimension representing strategy-oriented discussion. This type of discussion was mainly aimed at interface-related issues such as keeping track of the discussion, holding an overview and sharing focus on the same information. Miscommunication caused discussions to be aimed at aspects of the task strategy: how to handle the task in this electronic environment, what to do and how to start, maintain or continue the electronic communication. The negative side of the function, can be interpreted as a need to overcome such problems; whereas, the positive side reflects no such disturbances. In Fig. 3, a plot presents the clustered student pairs on these functions of meaningful interaction strategy-oriented discussion.

The figure shows that all *Achievers* score negatively on the function on meaningful interaction. In addition, they appear to engage many times in task-oriented discussion (as shown by a negative score on this function). *Conceptualisers* can be explained more positively; they engaged highly into meaningful interaction. However, they also dedicated time to task-oriented discussion. This combination of meaningful interaction interfered by task-oriented discussion may explain the relatively low amount of constructive activities despite the balanced focus and focus shifts towards on the meaning of concepts (see Table. 5). Their constructive power seems to be 'hidden' behind task-related problems, such as organising the task and keeping track of the discussion at the interface. The role of *Conceptual Achievers* is explained less by the function of meaningful interaction than by the function of task-oriented discussion. Thus, the lack of task-oriented discussion appears to mainly explain the highest amount of constructive activities produced among the conditions (see Table 5).

In Table 7, the 20 student pairs are shown in reference to their original (non) coached condition and presented into the three clusters. All five structure coached student pairs belong to the group

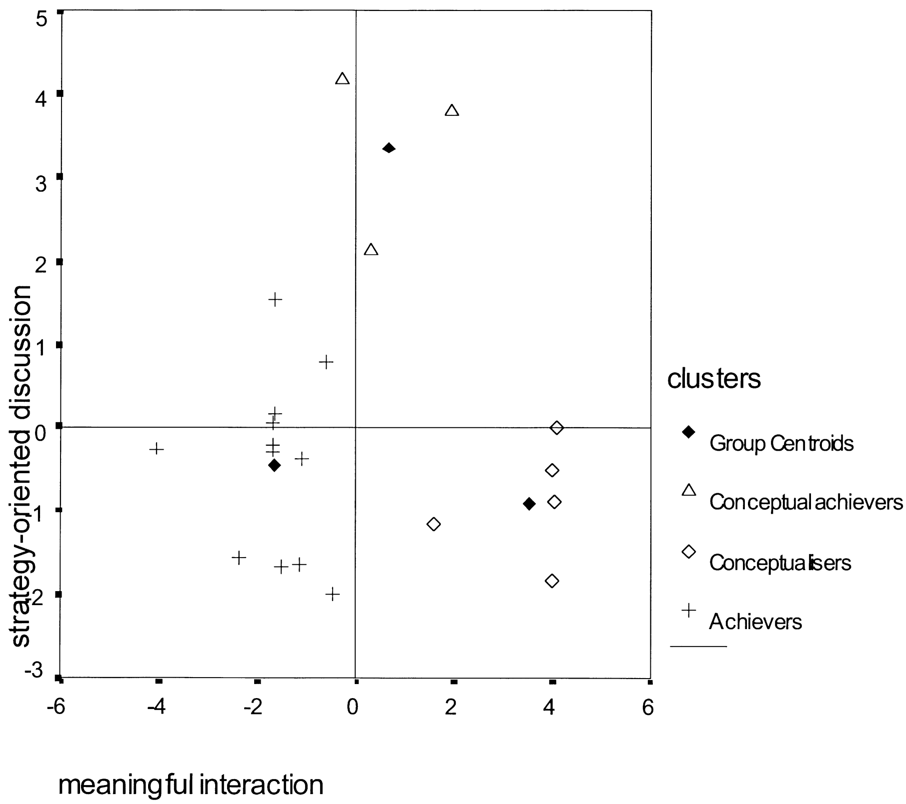


Fig. 3. Canonical discriminant function (plot of nmbered student pairs)

of *Achievers*. Reflective coached student pairs sometimes occur in the conceptual groups. Student pairs from the control group mainly belong to *Conceptualisers* and Conceptual Achievers.

5. Conclusions and discussion

This study offers suggestions on how to enhance learning through electronic argumentation. We researched how student pairs carried out a discussion task in a synchronous CMC

Table 7
Number of pairs in different conditions organised into clusters

Clusters	Conditions		
	'Reflective' coaching	'Structure coaching'	Control group
Achievers	4	5	2
Conceptualisers	1	0	4
Conceptual Achievers	1	0	3

environment (NetMeeting), how they focussed and argued about information and how a structure versus a reflective peer coach influenced their behaviour. Structure peer coaches were instructed to support the structuring of arguments and counter argumentation and to provoke multiple perspective taking. Reflective peer coaches were instructed to aim at checking information on its strength and relevance and on offering support to link claims to evidence. Findings were related to the students' production of *constructive activities*, an alternative measurement to define collaborative learning in process.

The results indicate that, first of all, the study of students' learning from electronic discussions requires analysis with respect to argumentation. Argumentative information exchanges are only related to the production of constructive activities when they are focussed on or shift focus towards the meaning of concepts.

Second, we found student pairs in the control group to challenge information less often than student pairs in coached conditions; however, they produced more constructive activities. These student pairs mainly checked information, which appears to be a more powerful argumentative move than *challenges* or *counters*. Discussing information, therefore, seems to be most effective when information is checked and focussed on and shifted towards the meaning of concepts. Student pairs that can be characterised as *Conceptualisers* and *Conceptual Achievers* (mainly aimed at a meaningful focussed discussion) do not show a strong need for support on this type of meaningful interaction. However, student pairs that can be defined as *Achievers* (mainly aimed at the *use* of concepts and at finishing the task), do need support.

To support meaningful interaction, a reflective coaching strategy appears to be a first small step into the right direction. Reflective peer coaches trigger students to check information. However, this strategy needs to be extended in at least two directions. First of all, emphasis should be placed on providing support to focus on conceptual knowledge and shifting focus from the use of concepts to their meaning. It appears that shifting focus from the use of concepts to their meaning can be triggered in several ways. Both students and coaches can contrast or compare already stated information, ask for definitions, explanations, specifications, justifications or (counter) examples considering concepts, and question the relevance of stated information considering the task- and learning goals. To deliver this kind of support, one of the many options would be to peer coach and track the student's strategy and to explicitly intervene when the focus is strongly aimed at the use of concepts. Technically, a menu-based pop-up window with a checklist of foci could be designed that students have to fill in every few minutes. Thus, the system can track the main focus and focus shifts and provides electronic feedback by making suggestions or asking programmed questions. Another extension of the coaching strategy should be to explicitly avoid inhibiting actions such as pressing students to continue because of time constraints, pressing students to state arguments when a problem is already explored, shifting focus to the task strategy or engaging in the content of the discussion.

Finally, students may not only show a need for support on focussed argumentation. Organising the interface, keeping track of the discussion and holding an overview proved to be problematic and triggered task-oriented discussion, which inhibited or interfered meaningful discussions. One of the reasons may be that in NetMeeting, messages have to be complected before they are sent. For example, if a participant is typing an answer to a certain question, the other person does not see what is going on and may in the meanwhile construct another message that, for instance, triggers a focus shift. The answer finally sent then is not connected to the earlier stated question. This makes it difficult to keep track of the discussion and to maintain an overview. A simple behavioural rule to prevent students from loosing track of the discussion may be something such as 'wait for an answer before sending another message'. However, this type of guidelines may diminish the 'flow experience' of electronic communication, which Csikszentmihalyi (1997) describes as that 'action and awareness is fused, the passing of time is unremarked and the activity itself becomes intrinsically rewarding and deeply engaging'.

Providing students with CMC systems that provide a (graphical) overview of the discussion *online* may be helpful to keep track of the discussion (see also Veerman & Treasure-Jones, in press). Other solutions may be found in providing students with electronic systems that embody multiple spaces for negotiation, such as MUDs and MOOs (Dillenbourg & Baker, 1996).[1] In the NetMeeting system, student pairs only had one negotiation space in which they had to discuss the task strategy, content-related issues and personal information. A system that supports jumping across different spaces of negotiation may prevent students from getting confused or loosing track of the discussion.

Finally, asynchronous communication systems may offer some advantages. First of all, students are not (psychologically) pressed to react in a short unit of time. This may support the production of constructive activities that integrate earlier stated information with new meaning and insights such as knowledge transformations. Secondly, in most systems students can organise their messages by 'branching' them around themes. Thus, despite time stamps questions and answers, arguments and elaborations, statements and counters all can be linked together. However, interface problems related to technical difficulties can trouble asynchronous discussion groups as well as synchronous discussion groups and sometimes take up to 20% of time and communication space (Hansen, Dirckinck-Homfeld, Lewis & Rugelj, 1999). 'This is a large proportion for something that is supposed to help, rather than being object of attention in itself!' (p. 178). Building user-friendly and transparent communication systems indeed seems to be a necessary first step.

It would be interesting to continue this line of research in a structured synchronous or an unstructured asynchronous CMC system. In a structured synchronous system, the effect of turn-taking control, flexible structured menu-based interaction or a graphical overview on a focussed argumentative dialogue can be studied, in relation to the production of constructive activities. In an asynchronous system, relationships can be studied among larger groups of students who organise their discussion differently and have more time to read, think and reflect before contributing to the discussion. An interesting question is how an extended and revised version of the reflective coaching strategy affects the students' meaningful interaction in this 'distanced' mode of communication.

The need for research results specifying how to support student learning through argumentative dialogues in electronic environments is obvious. Technical progress, the interest in the use of CMC systems for education, the ever-increasing need for life-long learning, for

[1] See http://tecfa.unige.ch/edu-comp/WWW-VL/eduVR-page.html for an extensive overview on MUDs, MOOs and educational 2D and 3D virtual reality systems.

collaboration and reflection, for discussion to cope with this complex society, prompt the need for empirical studies designed from a modern, constructivist perspective. Although this type of research is detailed, time-consuming, we hope that in the next decade further studies will be conducted in this area for the benefit of education practitioners who want to make use of this new technology.

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