COMPUTER-SUPPORTED COLLABORATIVE LEARNING THROUGH ARGUMENTATION

Computer ondersteund samenwerkend leren door middel van argumentatie

(met een samenvatting in het Nederlands)

Proefschrift

Ter verkrijging van de graad van doctor
aan de Universiteit Utrecht
op gezag van de Rector Magnificus, Prof. dr. H. O. Voorma
ingevolge het besluit van het College voor Promoties
in het openbaar te verdedigen
op 26 mei 2000 des middags te 16.15 uur.

door

Arja Lammy Veerman
Geboren op 9 februari 1969 te Woerden

Promotor: Prof. dr. G. Kanselaar
Co-promotor: Dr. J. E. B. Andriessen

ico

The research reported in this thesis was conducted at the Interuniversity Center for Educational Research (ICO), accredited by the Royal Dutch Academy of Arts and Sciences.

Arja Veerman

Computer-supported collaborative learning through argumentation

Proefschrift Universiteit Utrecht
ISBN: 90-393-2393-3

Omslag: Elsbeth de Ruiter, Utrecht
Druk: Print Partners Ipskamp, Enschede

ACKNOWLEDGEMENT

This thesis is about computer-supported collaborative learning (CSCL) and that reflects exactly what I have been up to in the last couple of years. It all began in 1996, when my supervisor Jerry Andriessen visited France for two months in the same period that I started to work on this project. We established e-mail contact and that was the beginning of entering a virtual world that could be explored on an overwhelming number of interesting aspects. Ever since, I have browsed the Internet on a daily basis to find information, to connect to people and to sense the smell of cyber fun ☺. Over the years many people offered me support, electronically as well as face-to-face. Since it is impossible to thank them all, I will therefore only mention those without whom this study could never have been accomplished.

Jerry, without your guidance I would have been lost in cyberspace a long time ago. Thank you very much for keeping up the spirit, for your encouragement and help, and for drinking far too many beers with me. Gellof Kanselaar, in your role of professor, head of the department and supervisor, you have given me the opportunity to work on this project. I'm very grateful for your support and trust. Jos Jaspers, without your assistance the computer would have entirely vanished from this research. Your technical support was far beyond duty. I also thank Dan Suthers for his support on the Belvédère computer system throughout the years. Without you, Dan Jones and Jos, I wouldn't have been able to perform any of the Belvédère studies. Gijsbert Erkens, thanks for finishing your thesis in 1997. Without your work, I would not have come to grips with this project in such a short time, if ever. Jos van der Linden, your concern about us, Ph.D.-students, was warm-hearted. Ronny Wierstra, I appreciated your help on solving the methodological problems that occurred over time. Hermi (Tabachneck-) Schijf, in the final year you made my life as a researcher a lot easier and the work much better. Your many helpful comments were worth gold. Elsbeth de Ruiter, you gave this thesis an artistic appearance. Hopefully the groovy outside will stimulate people to also take a glimpse at the inside. Thanks a lot, Yvonne van der Hee, for your language corrections in the final draft of this thesis.

I am grateful to all others who helped me to revise parts of this thesis, particularly at the end of this project: Pierre Coirier, Tamsin Treasure-Jones, Pierre Dillenbourg, Paul Kirschner, Richard Joiner, Else Veldhuis-Diermanse, Yvonne Barnard, Jacobijn Sandberg, Wouter van Joolingen and Eleonore ten Thij, thanks for the many comments and advice.

Anybody who looks at the reference list knows that Michael Baker works way too hard. Lucky me! Thank you for your support and the work on CSCL and argumentation.

I would also like to thank all the students that participated in the studies; particularly Mirjam Brand, Jakko van der Pol and Jurjen van de Groep who were great student assistants. Thanks to the Ph.D.-students at the department, I got fresh air on a daily basis during our many lunchtime walks. In particular, I would like to thank Mariëlle Klerks, Carla van Boxtel, Eline Lankhuijzen and Joris Veenhoven respectively for playing fanatic squash, for interacting about interaction research, for offering ongoing social support and for the pleasant bike rides home.

Finally, I wish to express my love and gratitude to all my family and friends. I'd particularly like to thank my parents Kees and Marianne for never advising me to quit this project. They had more faith in me than could ever be justified by logical argument. Marianne and my big brother Fred corrected the Dutch parts of this thesis. They should also be thanked for being 'paranimfs' during the thesis defence. My little brothers Jitse and Marijn always made me see things in perspective: *this is just a thesis*. Finally, my dearest Joop - you told me the truth about love. If W.H. Auden were still alive, he would be incredibly jealous.

Utrecht, March 2000

Arja Veerman

CONTENTS

Chapter 6

Chapter 7

Chapter 1

GENERAL INTRODUCTION

1.1 Aim of the thesis

In academic education, there has been wide interest in using Internet and web-based communication applications for educational purposes. Such applications not offer only advantages of time and/or place, but also of flexibility of information exchange and options for electronic communication. Information can be easily stored, presented and accessed in multiple formats (e.g. text, graphics). Communication within communities of education (students, teachers, tutors etc.) can be facilitated by the use of computer-mediated communication (CMC) systems (e.g. chat box, e-mail, newsgroups).

In academic education, students have to deal with abstract, ill-defined and not easily accessible knowledge as well as with open-ended problems. Collaborative learning is one of the pedagogical methods that can stimulate students to discuss such information and problems from different perspectives, and to elaborate and refine these in order to re- and co-construct (new) knowledge or to solve the problems. In such situations, argumentation is considered to be one of the main mechanisms that can promote collaborative learning (e.g. Piaget, 1977; Dillenbourg & Schneider, 1995; Baker, 1996; Savery & Duffy, 1996; Erkens, 1997; Petraglia, 1997). However, little is known about the effective use of educational technology to support collaborative learning in academic education, particularly considering the role of argumentation.

In the present thesis, collaborative learning through argumentation in computer-supported collaborative learning (CSCL) environments is examined. The purpose is twofold: to increase knowledge about the effective use of educational technology to support collaborative learning in academic education and to contribute to a better understanding of the role of argumentation as a mechanism for collaborative learning itself.

The research is framed by socio-constructivist learning theory[1], the nature of academic education and current technology. The following general research questions are addressed:

1. How can collaborative learning situations be arranged that *provoke* and *support* students' argumentation, examining contextual aspects affecting argumentation (the role of student, peer student, tutor, task, instruction and medium)?
2. How can student groups' argumentative discussions be characterised in relation to collaborative learning processes in CMC systems?
3. How can students' computer-supported collaborative learning be enhanced by providing pedagogical support or electronic facilitation at the user-interface?

To study the first question, the research started with a search for principles that provoke argumentation in academic and collaborative learning situations. Effects of important contextual aspects were specifically looked at, such as the role of the student, peer, tutor, task, instruction and medium. In addition, a review study was conducted in which features of electronic systems were investigated that provoke or support argumentation in collaborative problem-solving situations. To study the second and third research question, process analyses were applied to assess student groups' argumentative discussions in relationship to collaborative learning in different CMC systems, with and without various forms of pedagogical support.

1.2 Organisation of the thesis

This thesis contains five studies, which are presented in Chapter 2 to 6. Chapter 2, 4, 5 and 6 are all articles of empirical studies that have been submitted to international journals; one has been published, the others are in review. Chapter 3, a review study, has been published as a book chapter. Each chapter stands on itself, but also forms part of an incremental line of argument. The thesis presents the studies in chronological order and thus, theoretical backgrounds described and methods used partly overlap and are sometimes reconsidered or brought up to date when advanced insights are gained over time. Generally, the empirical studies share the following features:

[1] In the remainder of this thesis, the terms 'constructivism' and 'constructivist learning' will be used with regards to socio-constructivist learning theory.

- *Academic education*. All studies are conducted at the Department of Educational Sciences, Utrecht University, The Netherlands.
- *Authentic learning situations*. All studies are designed as authentic collaborative learning tasks in courses on Educational Technology and Computer-based learning. They all include third-year undergraduate students, and contextual features of the educational situations are always considered.
- *Open learning tasks*. The studies include open-ended collaborative learning tasks in which different interpretations of theories and concepts can be acceptable and problems can be solved in many different ways.
- *Collaborative learning*. In contrast to studies that consider individual cognitions and learning results as end products, this research aims at assessing argumentative processes and/or collaborative learning-in-process.
- *Argumentation*. Except for the first study in Chapter 1, all collaborative learning tasks are specifically designed to provoke students to engage in critical argumentation.
- *CMC systems*. Computer support for collaborative learning through argumentation always takes place through text-based CMC systems. In some CMC systems information can also be graphically represented or thematically organised.

With regards to generalisation of the findings, it should be emphasised that all studies are conducted in natural, authentic collaborative learning situations in academic education and not in experimental settings. In addition, most studies are conducted by use of synchronous CMC systems. This does not reflect a preference for such systems, but relates to the research context in which the initial accent is placed on studying short-time interactions and argumentation. Generalisations should be restricted to comparable situations and student groups.

In Chapter 2 a study is reported on how collaborative learning situations can be arranged in order to provoke students' argumentation, examining contextual aspects affecting argumentation (the role of the student, peer student, tutor, task, instruction and medium). Three empirical studies are reported in sequence: two in face-to-face (F2F) situations, with and without a tutor, and a third study using the electronic CMC system Belvédère. The Belvédère system is used both as a synchronous tool for text-based communication (chat box) and as an argumentative diagram construction tool.

In Chapter 3 a review study is reported on how argumentation can be provoked and supported in electronic collaborative problem-solving situations. The review includes five studies on different CMC systems that are all designed for educational tasks and in which argumentation is emphasised as a method for collaborative problem solving or as an end goal for learning. The selected CMC systems include a range of approaches to structuring interaction at the user-interface for supporting communication and argumentation (turn-taking control, menu-based dialogue buttons, graphical argument structures etc.). In assessing the systems' success at provoking and supporting argumentation, characteristics of the task, instruction and structured interaction are researched.

In Chapter 4, 5 and 6 three empirical studies report on student groups' argumentative discussions in relation to collaborative learning processes in different CMC systems, with and without pedagogical support provided by humans or by the electronic system. In Chapter 4 student pairs carry out an electronic discussion task in NetMeeting, a network-based software system that supports synchronous communication and the sharing of computer applications between users. It is analysed how student pairs focus their discussions, engage in argumentation and how different types of peer coaches influence their behaviour. Findings are related to student pairs' production of constructive activities, a measure that was developed for assessing collaborative learning-in-process.

In Chapter 5 student pairs and triples use Belvédère for synchronous chat discussions and graphical argumentative diagram construction. It is assessed how the diagram construction tool supports student groups in keeping track of the main issues under discussion and in engaging in argumentative chat discussion. Chat discussions are analysed on focused argumentation in relation to the production of constructive activities; diagrams are assessed on the organisation of information on the interface. Also, the overlap of information between chats and diagrams is analysed.

In Chapter 6 a study reports on small student groups that engage in electronic discussion assignments by use of the asynchronous CMC system Allaire Forums. In Allaire Forums, information can be organised around themes. Thus, in addition to linear time stamps, messages can be linked together hierarchically. Students' discussions are assessed on focused argumentation in relation to the production of constructive activities, and effects of different task assignments and moderation interventions are studied.

Finally, in Chapter 7 a summary of the five studies is presented and the overall conclusions that emerge from these studies are discussed. Results are put in a broader perspective, considering theories and methods used and some results from parallel studies. Implications for educational practice and suggestions for future research complete this thesis.

Chapter 2

COLLABORATIVE ARGUMENTATION IN ACADEMIC EDUCATION[1]

The central question in this research is how to organise educational situations that provoke students' collaborative argumentation. Entities influencing argumentation are considered (the role of the student, peer, tutor, task, instruction and medium) and specific attention is paid to instructional possibilities. In this article, we report on three studies conducted at our own educational department. In comparing and interpreting these studies, we discovered some principles for provoking collaborative argumentation in academic learning situations. First, to engage in fruitful argumentation students must be committed by and prepared for an open-ended, discussible and argumentative task. Second, by producing their self-defined (competitive) stances and being asked for a joint product, students' commitment to engage in these types of discussions can be strengthened. Third, to support students' multiple perspective taking and elaboration, additional instruction can be given by providing students with basic guidelines for argumentation, competitive instruction on argumentative behaviour and electronic tools to organise arguments graphically.

[1] Veerman, A. L, Andriessen, J. E. B. & Kanselaar, G. (submitted). Collaborative argumentation in academic education. *Instructional Science*.

2.1 Introduction

We start from the assumption that there is an important role for argumentation in academic learning (Petraglia, 1997). This is because academic knowledge cannot be understood as something fixed that can be transmitted from experts to students. To participate fruitfully in academic discourse, it is crucial for students to understand the nature of scientific knowledge as a process of permanent negotiation.

Inspired by such thinking and by the book 'Rethinking University Teaching' (Laurillard, 1993), tutors engaged in the curriculum of Educational Sciences at Utrecht University have recently started to thoroughly rethink their academic teaching. Traditional learning activities such as studying from textbooks for exams and listening to lectures are substituted by more student-centred activities. Tutoring sessions, collaborative learning projects and electronic discussions in which students can actively ask, share, refine, explain and discuss knowledge, are organised as central learning activities in the curriculum.

Our research is about the role of collaborative argumentation in this educational setting. While the above ideas sound plausible and are probably shared by many others, not much is known about the precise ways (considering the task, instruction, media, etc.) argumentation can be used in academic settings, and what the effects are on students' learning. Although our main interest is in the use of electronic media to support collaborative argumentation, we first need more insight about the ways our own students (and tutors) argue in educational practice. In this article, we report the results of three instructional interventions in which students are asked to perform argumentative tasks in different settings; the third situation is an electronic one. These three studies form a temporal sequence. Their main purpose is to discover a number of principles in the first and second study for the use of collaborative argumentation in electronic media.

The remainder of the article is organised in the following way. First of all, we present our perspective concerning the role of collaborative argumentation in academic learning. In addition, possible problems and affordances associated with the roles of the tutor, (peer) students, task design, instruction and the medium in educational situations will be discussed. We will then describe and interpret each of the three studies in sequence, in addition to a description of our system for data analyses. Finally, we will tentatively draw some conclusions on main principles for the use of collaborative argumentation in academic learning.

2.2 Factors affecting collaborative argumentation in education

From a rhetorical perspective on academic learning, 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. In collaborative learning, students can externalise, articulate and negotiate multiple perspectives, inducing reflective behaviour to elaborate on each other's arguments. This process of co- and reconstructing knowledge in relation to specific learning goals can be referred to as 'knowledge transforming' (Bereiter & Scardamalia, 1987).

Our approach is first to analyse argumentative discussions in different educational situations in the context of the curriculum at our department. From this analysis we hope to discover some important principles considering the entities placed around the learner and affecting collaborative argumentation: the (peer) student, the tutor, the type of task, the type of instruction and the selected medium (see Figure 2.1).

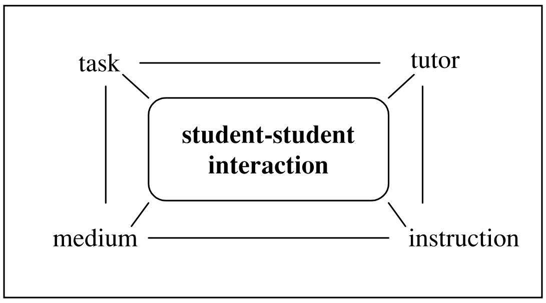


Figure 2.1. The student in collaborative learning situations.

- **The tutor.** In academic education the role of the tutor can be crucial. Tutors may signal misconceptions, model students' behaviour by breaking down a task, making abstract situations concrete or vary the context in which problems occur. In study 1, the tutor acts as an expert trying to discuss the students' conceptual problems.

- **The student.** Research suggests that students argue when doubt or disbelief arises, with respect to their personal attitude strength (Krosnick & Petty, 1995). In argumentation, attitude strength can bias the evaluation of scientific information: evidence supporting one's attitude is seen as more compelling than evidence that disagrees with it (Lord, Ross & Leppler, 1979). The tendency towards favouring a personal position and attacking the opposition, thereby neglecting the possible plausibility of the opposition or flaws in the personal stance has been found in many studies (e.g. Hightower, 1995; Stein, Calicchia & Bernas, 1996). This type of biased behaviour limits the negotiation space and, therefore, hinders knowledge transformation. In the second and third study, we instruct our students to be aware of multiple-sided argumentation and to ask each other critical questions.
- **The peer.** Interacting with fellow students can make learning realistic and relevant, both of which are seen as critical conditions for a learner to seriously consider alternatives (Petraglia, 1997). However, especially in authentic learning situations politeness strategies may inhibit students to engage in critical discussion. To prevent students from being 'too nice' to each other, one of the possible interventions is to give them competitive roles, for example to let them defend (predefined) conflicting positions (Stein & Miller, 1991; Stein, Calicchia & Bernas, 1996). Such an intervention may distance students from routine conversational rules and trigger argumentation more easily. In the second and third study, we considered this aspect in relation to our instructional design.
- **The task.** Learning through collaborative argumentation is more likely to occur in certain educational situations (Coirier, Andriessen & Chanquoy, 1999). Optimal tasks should be open-ended, thus students can share and learn form each other's differences in prior knowledge, experiences, beliefs and values. To arrive at a shared conclusion or solution, collaborative argumentation is a necessary activity.
- **Instruction.** One of our main questions is what kind of instruction is needed to trigger students' engagement in argumentation and to support them in multiple perspective taking and elaboration. In the second study, we choose to concentrate on the concept of 'asking questions'. Question asking is acknowledged as a fundamental component in complex problem solving and learning (Graesser, Person & Huber, 1993; King, 1990). In the third study we examine if competitive roles for students trigger collaborative argumentation.

- **The medium.** Electronic features such as a text-based dialogue history or graphical tools can be used for reflection and structuring text-based interaction (Veerman & Treasure-Jones, 1999). Compared to oral discussion, computer-mediated communication (CMC) is a ’slow’ mode of communication. Time delays allow participants to re-read and reflect on information and to more easily share multiple perspectives and attitudes relative to a particular topic or issue.

In this study, our research question can be generally formulated as: *How does one provoke collaborative argumentation in academic education?* We aim at finding principles for provoking collaborative argumentation in academic learning situations, considering entities that influence argumentation (the role of student, peer, tutor, task, instruction and medium).

2.3 Three studies

In this section, we describe three studies that each involved different groups of undergraduate students who collaboratively worked on short, ’real-time’ tasks as part of an eight-week course in Educational Technology and Computer-based learning (CBL). In each task, students had to work in pairs or triplets on open-ended problems. With or without a tutor present, they had to externalise (incomplete) knowledge, beliefs and values and to use each other as a source of knowledge and reflection in order to reach a (shared) solution. In sequence of admission, the tasks were aimed at the following goals:

(1) evaluating constructed learning goals of a CBL program
(2) developing insight into a theoretical framework
(3) designing didactics for a CBL program

The tasks were respectively conducted as face-to-face (F2F) tutoring sessions, collaborative learning sessions and electronic collaborative learning sessions. In Table 2.1, an overview is given of the main differences considering the entities that affect collaborative argumentation in the three studies (see also Figure 2.1). Before we present and elaborate the studies in sequence of the data collection, we give details and an example of our system for analysing data on collaborative argumentation.

Table 2.1. Main components in the design of the studied learning situations.

		Tutor	Medium	Students' role	Instruction
Study 1:	Tutoring sessions	Yes	F2F	---	--
Study 2:	Collaborative learning sessions	No	F2F	Competitive behaviour	Question asking
Study 3:	Electronic collaborative learning sessions	No	CMC	Competitive versus Consensual behaviour	Basic instruction on argumentation

2.3.1 Data analysis

All F2F sessions were recorded on audiotape (study 1 and study 2). The electronic sessions were logged automatically on the computer (study 3). All sessions were screened on the presence of **argumentative fragments**, defined as oral or written exchanges in which at least some doubt is expressed (in the form of a question or counter-argument) and at least one argument is given (Van Eemeren, Grootendorst & Snoeck Henkemans, 1995). Subsequently, all argumentative fragments were analysed on separated verbal utterances that we defined as single messages exchanged between participants. Based upon the Verbal Observation System (Erkens, 1997), work on analysing argumentative text production (Andriessen, Erkens, Overeem & Jaspers, 1996) and the Question Categorisation System (Graesser, Person & Huber, 1993), each separated utterance was coded as a sort of question or as an argument (see Table 2.2).

Table 2.2. Analysing argumentative fragments on question asking and argumentation.

Categorisation system for separated utterances	Examples
(A1) Question types	
1. Goal-oriented question	*"Why have you chosen this subject?"*
2. Cause-consequence question	*"Why shouldn't the teacher's reactions lead to learning?"*
3. Evaluative question	*"Are you satisfied with the assignment?"*
4. Other open questions	*"Why?", "Can you give me a definition?"*
5. Verification question	*"Is that true?"*
6. Other closed questions	*"Is the student wrong or the tutor?"*
(A2) Question generation mechanisms	
1. Inferring knowledge	*"O yeh, why do you think that?"*
2. Correcting knowledge	*"What operationalisation do you use?"*
3. Monitoring common ground	*"If I understand you correctly, you say that principles are facts?"*
4. Other...	*"Any more suggestions?"*
(B) Argumentation	
1. Neutral argument	*"I don't know if the tutor's feedback is helpful or not"*
2. Positive argument	*"So, I am sure this is true because...."*
3. Negative argument	*"No, that is not correct. When that happens it means that..."*

Since argumentative fragments often start or include questions expressing doubt or disagreement (Van Eemeren, Grootendorst & Snoeck Henkemans, 1995), we were interested in analysing types of questions and their underlying goals as well as different types of arguments. Considering question asking, the Question Categorisation System offered what we looked for. Based upon this system, we could code all questions on two dimensions: (A1) as question types (e.g. 'open' or 'closed' question) and (A2) as question generation mechanisms (underlying goals of questions). Thus, each question should be coded with one code from set A1, and one code from set A2.

Grounded on earlier, exploratory research we reduced the original system from 13 to 6 types of questions and from 20 to 4 question generation mechanisms (Veerman, 1996). Thus, each question could be coded on two dimensions, for example: a verification question ("Is this true?") could be aimed at monitoring common ground ("Is that true?" interpreted as: "Do I understand you correctly?") but also at inferring knowledge ("Is that true?" interpreted as: "Tell me why. I don't believe you"). The coding of question generation mechanisms heavily depends on the context in which questions occur.

Arguments (B) were coded as neutrally, positively or negatively related to the main claim or problem statement. Codings were based upon both content and linguistic features ('but', 'and', 'thus', 'however', etc.). Positive arguments contained justifications, positive examples, specifications or explanations. Negative arguments were stated against or as the opposite of (a part of) the claim or problem statement. Neutral arguments contained continuations ('and...'), disjunctives ('maybe or maybe not') and conceptual statements.

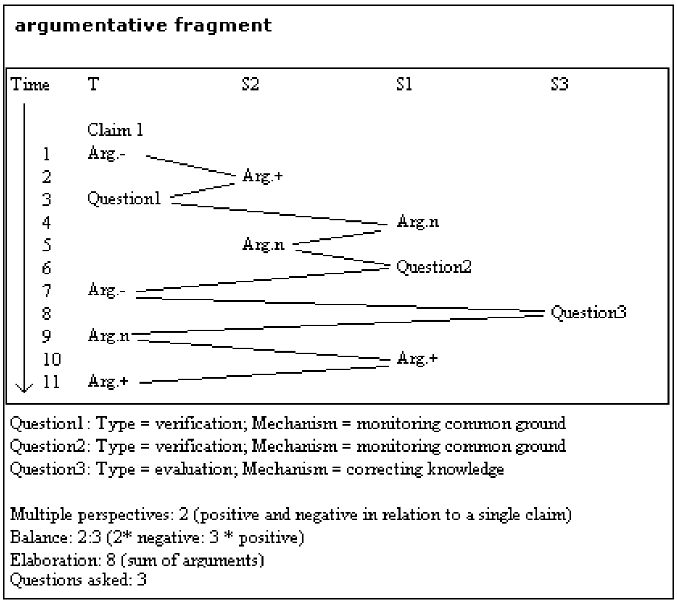
Considering the argumentative fragments as a whole (for each student pair, per argumentative fragment) we measured in addition to the total number of elaborations and questions asked, multiple perspective taking and the balance between positive and negative argumentation (Andriessen, Erkens, Overeem & Jaspers, 1996). Multiple perspective taking means that students state arguments for and against a claim. Considering one claim, a maximum of two perspectives can be discussed (pro and contra). Conflicting claims can be discussed in four ways: for and against Claim 1 and for and against a conflicting Claim 2 etc. Balance is measured between positively and negatively oriented arguments. The highest balance score is 1: there are as many arguments oriented for as against a claim. The lowest balance score is 0: the arguments are all positively or all negatively related towards the claim. The number of elaboration is the sum of all argument types stated. We additionally summed up the number of questions asked.

In the next section, we will show an example of an argumentative fragment analysed on question asking, argumentation, multiple perspective taking and balancing the argument.

2.3.2 Example

To give an example, we present an argumentative fragment collected in the first study on tutoring sessions (see the next page). In this example, three students (S1, S2, S3) and a tutor (T) discuss the issue of offering help in a CBL program. The main claim (Claim 1) under discussion is: “help is offered when the student makes a mistake". The students describe what they think the help system should do, the tutor disagrees. The students finally convince the tutor of their opinion, which can be considered as non-prototypical. Text and explanations of the argumentative fragment are presented and the analysed fragment is shown (Figure 2.2).

The inter-judge reliability score of the Question Categorisation System was found to be 0.94 (based upon the amount of agreement), on both question types and question generation mechanisms (Graesser, Person & Huber, 1993, p.162). For practical reasons, we decided to only measure the inter-reliability score for categorising arguments ourselves (neutrally, positively and negatively oriented) by defining Cohen’s kappa (1968). After extensive training, we could establish a Cohen’s kappa of 0.77. For qualitative data that depends on the interpretation of categories, this score can be regarded as ’substantial’ (Heuvelmans & Sanders, 1993).



Nr.	Text argumentative fragment	Explanations
	CLAIM: "help is offered when the student makes a mistake"	
1	T: (reads from the student's paper) 'Help is offered when the student makes a mistake'. No, I don't think that is true.	Negative statement in relation to the claim
2	S2: Yes, it considers the ideas of Burton, who.....	The ideas of Burton can be considered as a justification for the claim
3	T: Yes? A help system is...., or isn't that true? The help in Word Perfect, that is pressing a help button, isn't it?	The tutor tries to find out what the students mean
4	S1: No, that is uhh..., a help system....is something placed in the menu bar.	Explanation within the argumentative fragment; can be considered as a neutral argument in relation to the claim
5	S2: I made some nice translations (from Burton's arguments), but maybe they are not correct.	Idem
6	S1: Do you really see the help as part of the menu bar?	Checking the other student's utterance
7	T: Yes, yes, that's what I thought. Well..., I don't think you have to copy this literally.	Argument against the claim: Burton does not have to be copied
8	S3: But the help system can have different types of explanations in different ways, can't it?	Evaluating the help of features of the system, aimed at correcting the idea that there may be only one type of help provided by the system
9	T: I mean, in Word Perfect is it obvious that uhh.... The other thing is, when a student makes a mistake, help must be triggered. Uh...	Elaborating, not aimed at choosing a specific point of view
10	S1: (reads Burton aloud) 'In the system help is available on request or during errors.' So, during errors he says uhh...	Using Burton as a justification for the claim
11	T: 'Upon request'? That is what I read first, ...yes. Yes, so that's possible. Yes, uhh... ok. Help is offered when a student makes a mistake.	Agrees, thinks what Burton mentions is possible

Figure 2.2. Example of an analysed argumentative fragment.

2.3.3 Study 1: tutoring sessions

The study on collaborative argumentation in F2F tutoring sessions was implemented as an open-ended problem-solving task as part of an 8-week course on developing CBL programs. After an introduction to the course and a presentation of some principles for instructional design, 23 students organised themselves in 11 units of one, two or three students each (2*1 student; 6*2 student; 3*3 students). They all reached a comparable level in Educational Sciences and had to work together during the whole course. Their first group assignment was to construct learning goals for a CBL program they had to design. To this end they were instructed to use concept map techniques (Novak, 1991) and to construct a plan on paper (size A1/ A2), in which their learning goals were described, interrelated, organised and justified (see Figure 2.3). In the second week of the course, this plan was subject to a one-hour tutoring session, in which a tutor evaluated the feasibility of the learning goals by discussing the students' assumptions. Neither the students nor the tutor were instructed on what to say or how to act during the tutoring sessions. We expected argumentation to occur, provoked by the tutor questioning and critiquing the students' work.

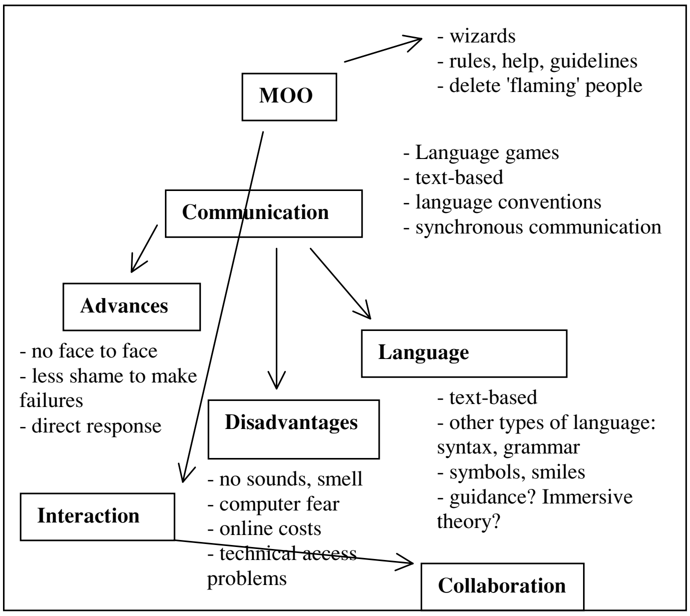


Figure 2.3. Example of a concept map, subject to one of the tutoring sessions.

The data analysis revealed that the tutoring sessions hardly contained argumentative discussion. From the 11 one-hour tutoring sessions analysed, only 25 argumentative fragments (a few minutes each) could be gathered in which in sum 72 questions were asked (mean ≈ 3 questions per fragment) and 767 elaborations were stated (mean ≈ 31 arguments per fragment). In Table 2.3, questions and arguments are split into different categories for analyses. Considering multiple perspective taking, students explored on average 2.1 different perspectives, the balance between positively and negatively oriented arguments was on average 0.4.

Table 2.3. Frequencies of question types, generation mechanisms and argument types in 25 argumentative fragments.

Categorisation system for separated utterances	Tutor	Students	Total
(A1) Question types			
1. Goal-oriented question	5	--	5
2. Cause-consequence question	2	--	2
3. Evaluative question	9	--	9
4. Other open questions	13	--	13
5. Verification question	12	11	23
6. Other closed questions	11	9	20
Total number of questions	52	20	72
(A2) Question generation mechanisms			
1. Inferring knowledge	20	--	20
2. Correcting knowledge	20	--	10
3. Monitoring common ground	7	16	37
4. Other...	5	4	5
Total number of questions	52	20	72
(B) Argumentation			
1. Neutral argument	20	18	38
2. Positive argument	161	183	344
3. Negative argument	203	182	385
Total number of elaborations	384	383	767

In Table 2.3 it is shown that the tutor, who aimed primarily at correcting and inferring knowledge, asked most questions (72%). Students mainly asked verification and other types of closed answer questions, aimed at reaching common ground. Considering argumentation, students and tutors contributed about the same number of neutrally, positively and negatively related arguments. The tutors contributed more positive arguments than negative ones; the students used both types of arguments comparably often.

Within the argumentative fragments (including both student(s) and the tutor), since all categories had a skewness and/or kurtosis > 1, the relationship between question asking and argumentation was measured by Spearman's nonparametric measure of correlation. In

Table 2.4 it is shown that question asking in general and some specific question types and generation mechanisms were significantly related to the incidence of arguments, particularly to negatively oriented arguments. In addition to open questions, verification and cause-consequence types of questions, questions aimed at correcting knowledge and at monitoring common ground showed significant relationships.

Table 2.4. Significant relationships between question asking and argumentation.

Argumentation / Question asking	Elaboration (∑arguments)	Negative arguments
Sum of questions	0.40*	0.46*
Question types:		
- goal-oriented question	---	0.46*
- cause-consequence question	0.41*	---
- open question	0.42*	0.41*
- verification question	0.49*	---
Generation mechanisms:		
- correcting knowledge	0.40*	0.46*
- monitoring common ground	0.57*	0.43*

* $p < 0.05$

In this study, the students and tutor acted according to different roles. The tutor asked most questions, the students tried to find out what the tutor meant and what he wanted the students to do. The students proved to be strongly biased towards the tutor's evaluations and to adopt his plans without engaging in further discussion. This may be explained by the role of the tutor, which was by default to evaluate the students' plans. The students appeared to be not very well prepared to defend their point of view. They only made rough sketches for their conceptual design. It seemed they did not feel highly committed and/or self-confident to defend their work. Our assumption is that the dominant position of the tutor, combined with the insecurity of the students, did not provoke students to critically question ideas and to engage more often in argumentative discussion.

To overcome some of these problems, we decided to organise a more collaborative learning situation (F2F). First, we wanted the students to show a stronger attitude in defending positions. Therefore, we decided not to bring the tutor back on stage and, moreover, we provided the students with predefined conflicting claims and a competitive role (to win the discussion!). Second, students were provided with instruction on critical question asking (particularly asking open questions and verification questions aimed at correcting and inferring knowledge). We expected the students to be encouraged to resist critique, to discuss their positions and to engage in multiple-sided argumentation.

2.3.4 *Study 2: collaborative learning sessions*

Based upon the results of the first study, we developed in this second study two short (open-ended) argumentative discussion tasks as part of an introductory course on Educational Technology for undergraduate students. For several years, this course has focused on the book 'Rethinking University Teaching' (Laurillard, 1993). The book is used as a theoretical framework to discuss affordances of media applications in higher education (hypertext, simulations, CMC, etc.). It centres on a discussible 'conversational framework' (Bostock, 1996) that describes crucial activities necessary to complete the learning process in teaching-learning dialogues.

In order to develop insight into the implications of this framework, we developed two 10-minute argumentative discussion tasks in the third week of the course. Students with a comparable background in Educational Sciences (n = 24) were required to prepare two chapters of 'Rethinking University Teaching' (Laurillard, 1993) at home about the role of (1) feedback and (2) tutoring strategies in tutoring sessions. Before the meeting, they had to take an individual knowledge test, in which they were tested on their knowledge about the concepts and activities mentioned in the conversational framework. During the meeting, they were randomly paired and instructed to competitively discuss a protocol of a tutoring dialogue. In two 10-minute sessions they were asked to defend controversial claims in relationship to the protocol and to win the discussion. The claims were:

(Ad 1) "The tutor provides feedback that improves / does not encourage the student's learning process"

(Ad 2) "The tutor's strategy improves / does not encourage the student's learning process"

In the study 12 student pairs engaged in the first discussion task without additional instruction on question asking. In the second task they switched partners randomly and were provided with additional instruction on question asking, as shown in Figure 2.4

Instruction on question asking

- Ask each other questions
- Don't ask too many questions at once
- Ask questions, such as:
  Is it true that...?
  Why...?
  Can you explain...?
  Can you give an example...?
  Can you give a characteristic...?
  What can you infer on...?
  What do you mean...?
  Is that true...?
  ...

Figure 2.3. Instruction on question asking.

We analysed the data in the same way as in the formerly described study on the F2F tutoring sessions. First of all, we gathered 24 collaborative learning sessions, which could all be considered as complete argumentative fragments. We gathered 13 sessions without instruction on question asking and 11 sessions with instruction. One of the student pairs accidentally did not receive instruction in the second session. Secondly, within these argumentative fragments we analysed separated utterances on question types, question generation mechanisms and argument types. In addition, we measured argumentative fragments on multiple perspective taking, balanced argumentation, the total number of elaboration and the sum of questions asked (see Table 2.5).

Table 2.5. Frequencies, means ($\bar{x}$), standard deviations (s.d.) and p-values considering question types, question generation mechanisms and argumentation in the instructional condition versus the control group.

	Instruction (n = 11)			Control (n = 13)			
	freq.	$\bar{x}$	s.d.	freq.	$\bar{x}$	s.d.	p-value
(A1) Question types							
1. Goal-oriented question*	12	1.1	1.0	10	0.8	1.2	0.28
2. Cause-consequence question*	13	1.2	1.0	7	0.5	1.4	0.04
3. Evaluative question*	1	0.1	0.3	0	0.0	0.0	0.73
4. Other open questions	23	2.1	1.8	18	1.4	1.3	0.39
5. Verification question	25	2.3	1.9	36	2.8	2.3	0.61
6. Other closed questions*	7	0.6	1.0	4	0.3	0.5	0.65
Total number of questions	81	7.4	3.5	75	5.8	4.6	0.41
(A2) Question generation mechanisms							
1. Inferring knowledge*	44	4.0	2.1	32	2.5	3.0	0.04
2. Correcting knowledge *	8	0.7	1.0	14	1.1	1.5	0.87
3. Monitoring common ground	28	2.6	2.3	29	2.2	2.0	0.82
4. Other...*	1	0.1	0.3	0	0.0	0.0	0.73
Total number of questions	81	7.4	3.5	75	5.8	4.6	0.41
(B) Argumentative fragments							
1. Neutral argument*	58	5.3	6.5	41	3.2	3.0	0.46
2. Positive argument	306	27.8	14.7	366	28.2	12.0	0.43
3. Negative argument	308	28.0	15.7	343	26.4	13.9	0.69
Total number of elaborations	672	61.1	30.8	750	57.7	25.7	0.36

* skewness > 1 and/or kurtosis > 1; categories are included in a nonparametric test (Mann-Whitney)

The 24 argumentative fragments included in sum 1422 elaborations (mean ≈ 58 per fragment) and 156 questions (mean ≈ 6 per fragment). Compared to the study on tutoring sessions, twice as many questions were asked and the sessions were twice as elaborated in 1/6 of the time available (10 minutes versus 1 hour). Students asked each other mainly verification questions, but also many open, goal-oriented and cause-consequence questions. Questions were mainly aimed at inferring knowledge and at monitoring common ground.

Considering multiple perspective taking and balancing the argument, an independent T-test showed no differences between conditions ($T_{(df = 22)} = 0.99$; $p = 0.33$ resp. $T_{(df = 22)} = 0.26$; $p = 0.80$). Overall, students explored on average 3.5 different perspectives; the balance between positively and negatively oriented arguments was on average 0.5. This means that on average for every 5 positively oriented arguments, 10 negatively oriented arguments were stated (or the other way around). Some fragments included more positively oriented arguments whereas others contained mainly negatively oriented arguments. This explains why the total number of positive and negative arguments is comparable (672 versus 651) whereas the balance is far below 1. Against expectations, hardly any differences were found between the instructional conditions of question asking (see Table 2.5). Student groups that were not provided with instruction on question asking produced a comparable number of questions and arguments as the instructed student groups. In addition, they also produced comparable types of questions and arguments considering means and standard deviations. Using a nonparametric Mann-Whitney test for measuring differences between groups showed that instructed students only scored higher on asking cause-consequence questions and questions aimed at inferring knowledge. However, means are small and standard deviations are quite high (especially in the control group), therefore, we have to consider these findings as tentative results. Considering the lack of (strong) variation between conditions and our interest in the overall relationship between question asking and argumentation, we continued our analyses by measuring correlations between question asking and argumentation. Categories with a high skewness and/or kurtosis were included in Spearman's nonparametric correlation measurement. Significant results are shown in Table 2.6.

Table 2.6. Significant relationships between questions asked, the number of elaboration and types of arguments across the 24 collaborative learning sessions.

Argumentation / *Question asking*	Elaboration (∑arguments)	Negative arguments	Positive arguments
Number of questions	0.42*	0.44*	---
Question types:			
- goal-oriented question	---	---	0.44*
- verification question	0.43*	0.41*	---
Generation mechanisms:			
- monitoring common ground	0.42*	0.41*	---

In Table 2.6, comparable to Study 1 it is shown again that question asking is related to argumentation. In this study, goal-oriented questions, verification questions and questions aimed at monitoring common ground were related to different types of argumentation. Remarkably, most question generation mechanisms were aimed at inferring knowledge (49%) and another 14% was aimed at correcting knowledge. However, no relationships were found between these types of question generation mechanisms and (types of) argumentation.

We have interpreted the results as follows. Students established a strong motivation to engage in discussion. They focused on winning the argument that started from the predefined conflicting claims. Although the students proved to be able to ask every type of question without instruction on question asking (which suggests they suppressed that ability in the first study), argumentation was not related to the question generation mechanisms of correcting and inferring knowledge, only to monitoring common ground. As a result, it appeared that questions were asked and arguments were given just to keep the discussion going, without arriving at new insights or conclusions. The knowledge tests showed that students did not prepare themselves enough (only 36% of the students passed the test) and the impression was that students just followed the assignment to competitively engage in argumentative discussion, considering the conflicting claims and aiming at winning the discussion.

We concluded that affordances and drawbacks of competitive instruction and providing students with predefined conflicting claims are not yet clear. In order to stimulate students to put effort in critical argumentation, to care for their own learning and to increase commitment to the collaborative learning task, we decided to organise a third study in which the students predefined their own conflicting claims as part of their task preparation. In addition, students were asked to submit a joint product to the tutor as a result of their discussion. We designed the study in a CMC environment in which students could graphically represent and organise arguments generated by themselves and their peers. Instruction on competitive versus consensual behaviour was varied in order to assess effects on collaborative argumentation.

2.3.5 Study 3: electronic collaborative learning sessions

In the third study we questioned how instruction on *competitive* versus *consensual* behaviour affects students' engagement in (a) collaborative argumentation and in (b) argumentative diagram construction. We integrated this study in a course on developing CBL programs (the same course as described in Study 1). After an introduction and the presentation of some principles for instructional design, the students grouped themselves into 7 pairs in order to construct learning goals for a program they had to design. After jointly defining these goals, students were asked to produce conflicting claims on three pedagogical aspects that they thought would meet their learning goals:

- what pedagogical strategies to use
- how to sequence learning activities
- what programming tool to use

The three self-defined conflicting claims then had to be discussed electronically by using the Belvédère system, a synchronous network-tool developed by the Learning Research and Development Center at the University of Pittsburgh (1996). Among many other applications, Belvédère can be used for constructing argumentative diagrams online with individuals or groups of students of any size (see Figure 2.5). The working screen of the program displays private and shared windows. To communicate with a partner the student has a text-based chat box in which multi-line messages can be created and sent. Messages will then be displayed, linked with the writer's name, in the shared chat-history. Adding data into the diagram is constrained; students must use the predefined set of boxes ('hypothesis', 'data', 'unspecified') and links ('for', 'against', 'and'). These are shown in the menu bar in Figure 2.5.

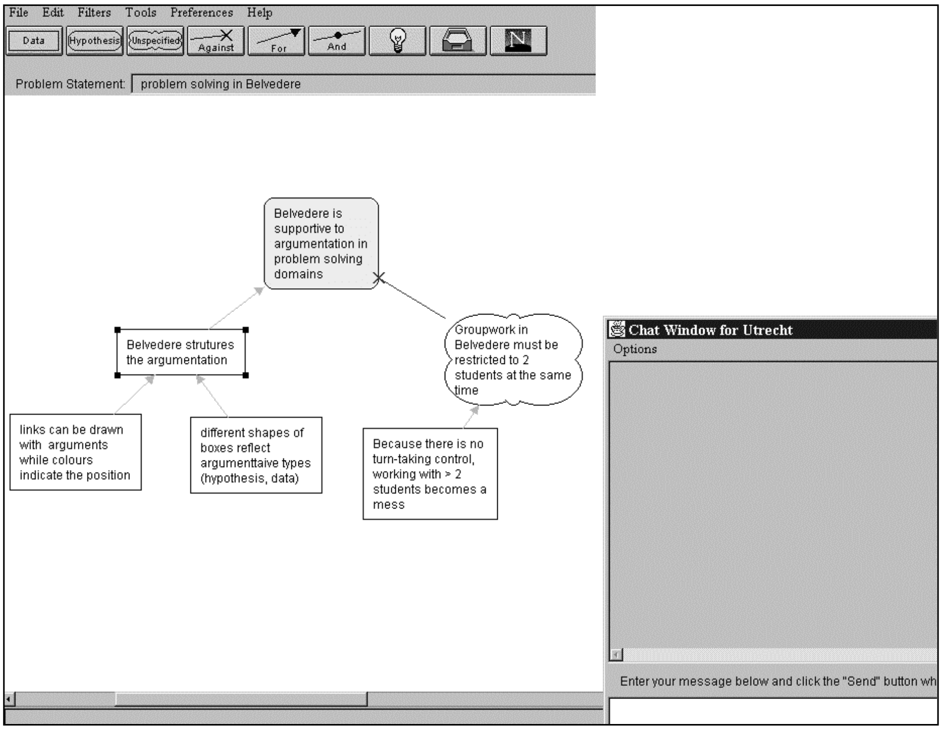


Figure 2.4. Interface of the Belvédère system.

Each Belvédère session took about one hour to complete. Besides basic instruction on the technical use of Belvédère, all students received guidelines on how to engage in argumentative discussions (see Figure 2.6). We figured that perceiving the discussible nature of the task would support students' mental preparation.

Guidelines to engage in collaborative argumentation

- Be critical in argumentation
- Use task-related arguments
- Detect feigned arguments (e.g. based on misinterpretations)
- Be co-operative (e.g. do not use pressure, aggression)
- Use multiple perspectives in argumentation
- Elaborate on arguments
- Ask 'open' and verification question

Figure 2.5. Basic guidelines to engage in collaborative argumentation.

In addition, students were provided with instruction on *competitive* or *consensual* behaviour. In the *competitive* condition students were instructed to behave as competitively as possible, even when they were already convinced by the other party (considering the conflicting claims). They were told to end the argument only when getting stuck or not being able to think of any more (pro or contra) arguments. Then, a (sub) conclusion could be drawn and a next discussion could be provoked. In the consensual condition students were instructed to behave competitively considering the conflicting claims but to arrive at consensus as soon as being convinced by their peer student. We expected the students in the competitive mode of instruction to elaborate more and to take more perspectives into account than students in the consensual mode of instruction. Due to politeness strategies, the latter group was expected to agree on each other too soon, for example when arguments were still doubted or disbelieved.

We analysed the data in the same way as the formerly described studies on F2F tutoring sessions and collaborative learning sessions. In analysing the gathered dialogues and diagrams, it appeared that the third pedagogical aspect for discussion ('What programming tool to use') was not appropriate since students had too little experience in programming. As a consequence, we deleted the (partly) produced chats and diagrams produced on this issue.

Each of the 14 text-based chat discussions left in the study could be recognised as an argumentative fragment (7 student pairs * 2 Belvédère sessions). Within these fragments, we analysed separated utterances on question types, question generation mechanisms and different types of arguments. The chats were subsequently measured on multiple perspective taking and balanced argumentation. In addition, the Belvédère diagrams were analysed on the number of neutrally, positively and negatively oriented arguments in relationship towards the self-defined claims, and on multiple perspective taking and balanced argumentation.

Table 2.7. Frequencies, means ($\bar{x}$), standard deviations (s.d.) and p-values considering question types, generation mechanisms and argumentation within the Belvédère chat conditions of competition versus consensus.

	Belvédère chat discussions Competitive (n = 7)			Consensus (n=7)			p-value
(A1) Question types	freq.	$\bar{x}$	s.d.	freq.	$\bar{x}$	s.d.	
1. Goal-oriented question*	4	0.6	0.8	10	1.4	1.4	0.26
2. Cause-consequence question*	2	0.3	0.5	6	0.9	1.9	0.90
3. Evaluative question*	2	0.3	0.8	3	0.4	0.5	0.54
4. Other open questions*	10	1.4	1.5	12	1.7	1.5	0.71
5. Verification question*	13	1.9	2.0	13	1.9	2.3	0.81
6. Other closed questions*	1	0.1	0.4	4	0.6	1.1	0.62
Total number of questions	32	4.6	2.8	48	6.9	4.9	0.30
(A2) Question generation mechanisms							
1. Inferring knowledge*	14	2.0	1.8	13	1.9	1.7	1.00
2. Correcting knowledge *	8	1.1	2.2	13	1.9	0.9	0.07
3. Monitoring common ground*	6	0.9	1.6	15	2.1	3.0	0.39
4. Other...*	4	0.6	1.1	7	1.0	1.4	0.62
Total number of questions	32	4.6	2.8	48	6.9	4.9	0.30
(B) Argumentative fragments							
1. Neutral argument*	11	1.6	3.3	30	4.3	2.9	0.54
2. Positive argument	117	16.7	14.1	102	14.6	6.9	0.72
3. Negative argument*	102	14.6	15.4	48	6.7	5.0	0.23
Total number of elaborations	230	32.9	28.4	180	25.7	9.5	0.54

* skewness > 1 and/or kurtosis > 1; categories are included in a nonparametric test (Mann-Whitney)

The results showed, first of all, that during the Belvédère chat discussions 80 questions were asked and 410 arguments were stated. Students mainly asked verification questions and open answer questions. They aimed at inferring knowledge, correcting knowledge and monitoring common ground. The students stated more positively oriented than negatively oriented arguments (see Table 2.7). Students explored about two different perspectives (for and against the self-defined claim) and competitively instructed students showed a trend to a higher balanced argumentative chat discussion than students aimed at reaching consensus (mean balance = 0.65 respectively 0.43). However, an additional and independent T-test showed that this difference was not significant ($T_{(df = 12)} = 1.55$; $p = 0.15$).

Considering question asking, hardly any significant differences were found. However, student groups that were instructed to aim at reaching consensus asked more questions (particularly more goal-oriented and cause-consequence questions) than competitively instructed students. In addition to aiming at inferring knowledge, they also aimed at correcting knowledge and monitoring common ground. Competitively instructed students aimed their questions mainly at inferring knowledge. However, they stated more arguments, negatively oriented arguments in particular.

Considering the lack of (much) variation between conditions and our interest in the overall relationship between question asking and argumentation, we continued our analyses by measuring correlations between question asking and argumentation. Categories with a high skewness and/or kurtosis were included in a Spearman's nonparametric correlation measurement. We found an overall and significant relationship between inferring knowledge and the number of negatively and positively oriented arguments triggered ($r = 0.58$; $p < 0.05$ resp. $r = 0.64$; $p < 0.05$). Other relationships found were between open question types and the sum of arguments stated ($r = 0.63$; $p < 0.05$) and between verification questions and the number of neutral arguments ($r = 0.60$; $p < 0.05$).

Looking at both the results triggered between conditions (Mann-Whitney test; T-test) and across conditions (correlation test) leaves us to think that aiming questions at correcting knowledge and monitoring common ground may be less important to provoke argumentation (particular negative types of arguments) than questions aiming at inferring knowledge.

The Belvédère diagrams contained in sum 181 arguments (see Table 2.8). Comparable to the chat discussions, in both conditions the diagrams included about two different perspectives (for and against the claim). We found that, first of all, competitively instructed student groups generated 30% more arguments than student groups aimed at reaching consensus (107 against 74 arguments). Using independent T-test measurements revealed that this could be due particularly to the production of negatively oriented arguments ($T_{(df = 12)} = 2.93$; $p < 0.05$). An interesting finding, which is in line with the results concerning the chat discussions, is that competitively instructed student groups balanced their argumentative diagram significantly better than student groups aimed at reaching consensus (balance = 0.72 resp. 0.53; $T_{(df = 12)} = 2.41$; $p < 0.05$).

Table 2.8. Argumentation in the Belvédère diagrams.

(B) Argumentation	Belvédère diagrams Consensus (n=7)			Competition (n=7)			p-value
	freq.	$\bar{x}$	s.d.	freq.	$\bar{x}$	s.d.	
1. Neutral argument	--	--	--	--	--	--	--
2. Positive argument	49	7.0	3.3	57	8.1	2.5	0.48
3. Negative argument	25	3.6	1.8	50	7.1	2.7	0.01
Total number of elaboration	74	10.6	4.5	107	15.3	4.5	0.08

To summarise, the study showed that students only engaged in argumentation when they were sufficiently prepared for the assignment. Their lack of knowledge about programming inhibited them to discuss the third pedagogical aspect. The argumentative task design appeared to be successful, encouraging students to engage in argumentation based upon their self-defined conflicting claims and the requirement to submit a jointly constructed product (the diagram). The combination of competitive instruction and the graphical overview showed by the Belvédère system may have supported the argumentative process to be multiple sided, balanced and elaborated on different positions. Students provided with competitive instruction produced better balanced argumentative chat discussions than students aimed at reaching consensus: they considered multiple perspectives and elaborated on both positive and negative sides of the argument. Shown as a trend in the chat discussions, these findings were significant in the diagrams: the constructed diagrams showed an even better balanced argumentation than the created chat discussions.

2.4 Conclusions and discussion

Academic education can be viewed as an ongoing process of negotiation in which there is an important role for collaborative argumentation. In collaborative argumentation, multiple perspective taking and elaboration may stimulate learning through knowledge transforming.

The studies described in this article explored the question of how to provoke collaborative argumentation in educational situations, considering contextual features such as the role of the tutor, (peer) student, task, instruction and medium. We conducted three studies in sequence, two in F2F situations, with and without a tutor, and a third study by using Belvédère, an electronic CMC system for synchronous communication and graphical argument construction. Although the studies differed on many aspects such as task design and instruction, in all studies we collected argumentative fragments that were analysed similarly on question asking and argumentation. This allows us to make some comparisons among the three studies.

We found most of our students were not well prepared. Given this situation, we looked for facilitating factors that engaged students in fruitful collaborative argumentation. The results of the studies indicate some principles on how to provoke collaborative argumentation in academic learning sessions. In producing self-defined (competitive) stances and being asked for a joint product, students can be encouraged to participate in collaborative argumentation. To support students' multiple perspective taking and elaboration, additional instruction can be given by providing students with basic guidelines for argumentation, competitive instruction on argumentative behaviour and tools to organise arguments graphically. Belvédère provides students with a shared overview of their arguments. In addition to text-based and permanent argumentation, showing arguments graphically in a 'persistent' window may stimulate students to balance positively and negatively oriented arguments and elaboration.

In general, question asking showed to be important in relationship to collaborative argumentation, specifically considering some types of open answer questions, verification questions and questions aimed at correcting and inferring knowledge and at monitoring common ground. It appeared that open-answer question types aimed more at triggering elaborations and negative arguments whereas verification questions seemed to be more important in order to establish common ground. We think the role of verification questions in particular and the importance of seeking common ground deserve more prominence in today's research about question asking and learning (e.g. King, 1990; Hakkarainen, 1995; Erkens, 1997). Furthermore, we revealed that students were perfectly capable of asking effective question types without additional instruction, as long as this ability was not suppressed by the presence of a tutor.

While the metaphor of education as argumentation points out the importance of focusing on the learner within the educational situation, it also asks us to consider the other party – the educator. Engaging the learner in collaborative argumentation gives the learner an opportunity to articulate his or her understanding and offers the educator the best chance of intervening (Petraglia, 1997). In our first study, however, we found our students to be strongly biased towards the tutor's beliefs and values, which inhibited their argumentation. In our second study no tutor was involved. We found our students to engage in argumentation easily, but not to ask or answer questions in connection to each other. The discussions, as a result of this, were rather superficial. In the third study, Belvédère supported students in discussing questions in relation to their answers or solutions. However, the program only provides students with an overview and is not able to correct students in for instance discussing misconceptions. At some point in the discussion, some sort of tutor support may still be useful.

To support collaborative argumentation for learning purposes, we first of all have to know more about the specific needs students have in different educational situations (both F2F and CMC) considering collaborative argumentation. Secondly, we have to think about how to adapt the tutor's role or other forms of (electronic) support in relationship to the role of entities already provided by the task environment (task features, instruction, electronic characteristics of CMC systems, etc.). The need for research results specifying how to provide effective support increases, especially for collaborative argumentation in electronic environments. Since educators discovered the Internet, CMC systems have increasingly been implemented for educational purposes. We think these systems include promising characteristics to support learning through collaborative argumentation and, therefore, this issue deserves further empirical study.

Chapter 3

SOFTWARE FOR PROBLEM SOLVING THROUGH COLLABORATIVE ARGUMENTATION[1]

In this review study we focus on how to *provoke* and *support* collaborative argumentation in order to optimise open-ended problem solving in network-based learning environments. Taking task characteristics into consideration, support could be designed for the important cognitive processes of collaborative argumentation. Based upon studies of five network-based environments, we propose a framework that considers both characteristics of the task and of structured interaction. Our main finding is that structuring interaction at the interface does not necessarily *provoke* argumentation. The initiation of argument seems to be related to task characteristics, such as use of a competitive instructional task design. However, our review shows that both task characteristics and structured interaction play an interconnected role in *supporting* argumentation during collaborative problem solving.

[1] Veerman, A. L. & Treasure-Jones, T. (1999). Software for problem solving through collaborative argumentation. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 203 - 230). Amsterdam: Amsterdam University Press.

3.1 Introduction

One of the main principles of constructivist learning theory is the negotiated construction of knowledge through dialogue. Understanding is achieved through interaction within an environment in which co-students, tutors, task information and (electronic) tools are available. It is believed that learning is achieved when we are presented with conflicts, which we try to manage through negotiation (alone or in a group) in order to produce a solution:

> *"cognitive conflict or puzzlement is the stimulus for learning and determines the organisation and nature of what is learned"* (Savery & Duffy, 1996).

In Piaget's terms this describes the need for accommodation when current experience cannot be assimilated in existing schema: the socio-cognitive conflict (Piaget, 1977). Such learning through negotiation can consist of testing understanding and ideas against each other as a mechanism for enriching, interweaving and expanding understanding of particular phenomena. Active engagement in collaborative argumentation during problem solving fits this principle by giving prominence to conflict and query as mechanisms for enriching, combining and expanding understanding of problems that have to be solved (Savery & Duffy, 1996). After all, as VonGlasersfeld (1989) has noted, other people are the greatest source of alternative views to challenge our current views and hence to serve as the source of cognitive conflict that stimulates learning.

We consider an argument to be a structured connection of claims, evidence, rebuttals etc. A minimal argument is a claim for which at least doubt or disbelief is expressed (van Eemeren, Grootendorst & Snoeck Henkemans, 1995). Such doubt or disbelief can be expressed by an individual (if working alone) or by a partner in an argumentative dialogue. In response to such doubts a complex structure may be produced potentially including features such as chaining of arguments, qualifications, contra-indications, counter-arguments and rebuttals. Hence the argument is the product, the structure linking claims, evidence and rebuttals. The process by which the argument is produced we refer to as argumentation.

Our interest lies in argumentation structures that are built by groups of students involved in collaborative problem solving. During problem solving we expect students to make various claims about the domain and the potential solutions. It is possible that during the process of problem solving no doubt is expressed regarding claims and solutions and hence no argument emerges in the dialogue. However, such a situation seems unlikely and we believe would not produce the best solution to the problem. Certainly, if the students have not produced reasons to support the claims and solutions during the problem solving process itself, then we have no reason to believe that they will be able to produce such reasons at a later date. Therefore, we believe that students should be encouraged to use argumentation processes to build argument structures during problem solving. The argumentation processes discussed in this review study are:

- argument elaboration — produces support for claims and chains arguments together.
- critical checking — evaluates the strength and relevancy of information, in order to integrate it into the argument structure and/or in order to assess the validity of its current position in the argument structure.
- multiple viewpoints — consideration of alternative claims and counter-arguments in order to choose the preferred claim or solution and to produce rebuttals where necessary.

Our review study addresses how such argumentation processes can be supported in electronic environments. We will consider academic students actively engaged in collaborative argumentation in order to solve open-ended problems such as writing papers, constructing hypotheses or designing computer-based learning programs. These types of problems are characterised by the existence of justifiable beliefs and multiple acceptable viewpoints, as described by Baker (1992). In working on problems together, students first have to establish a (partially) shared focus, which can be changed, maintained or refined during the problem solving process (Roschelle, 1992). The focus determines the concentration on thematic parts (sub-problems) of the problem to be solved. Subsequently, information relevant to the sub-problem must be generated and gathered from mental or material resources. The next phase is to critically check its strength (is the information true?) and relevance (is the information appropriate?) before integrating it in the problem-solving process (for instance by assimilating new information in a writing assignment). Finally, after discussing alternative solutions the strongest and most relevant one must be chosen (Erkens, 1997).

3.1.1 Argumentation in problem-solving assignments

In constructivism, learning is philosophically viewed as enriching understanding in interaction with the environment (Savery & Duffy, 1996). Knowledge is actively constructed, connected to the individual's cognitive repertoire and to a broader, often team-based and interdisciplinary context in which learning activities take place (Salomon, 1997). Constructivism seems to be influenced not only by a Piagetian perspective on individual cognitive development through socio-cognitive conflict, but also by the socio-cultural approach emphasising the process of interactive knowledge construction in which appropriation of meaning through negotiation plays a central role (Greeno, 1997). From a constructivist perspective, collaborative argumentation during problem solving can be regarded as an activity encouraging learning through mechanisms such as externalising knowledge and opinions, self-explanation, reflecting on each other's information and reconstructing knowledge through critical discussion.

Several studies show positive effects of collaborative argumentation during open-ended problem solving (Burnett, 1993; Erkens, 1997). Burnett analysed the dialogues between students engaged in a collaborative writing task, and found that students who became involved in 'substantial conflict' during the writing assignment ended up considering more alternative solutions and finally produced better papers. 'Substantial conflict' not only involved considering multiple perspectives but also a critical evaluation of these alternatives. Students who did not engage in this type of conflict tended to compromise too soon and produced poorer solutions. Another example is the study of Erkens (1997) in which pairs of students solved partly predefined problems. He found that during and after phases of information checking, argumentation significantly contributed to the success of the final problem solution.

In almost every part of the problem-solving process difficulties may arise. Students can fail to understand each other or fail to maintain focus on the same thematic content. They can be biased towards agreement and consequently fail to query or counter doubtful information. Elaboration may not be focused on key concepts and misconceptions may not be recognised. Argumentation might help to minimise some of these problems. In collaborative argumentation it is essential to evaluate new information, to stimulate the number and variety of elaboration and to consider multiple perspectives. This can be achieved by critiquing of information (either through expressing doubt or generating counter-arguments), producing justifications and considering pro and contra arguments in relation to each other. Unfortunately, collaborative argumentation does not always arise spontaneously and does not always include the most important features that contribute to the problem solving process. Several studies (Baker, 1996; Pilkington & Mallen, 1996; Veerman, 1996) have shown that engaging in discussion depends on task characteristics, including the domain, the learning goals, the instructions and the expected product. Therefore, argumentation may have to be provoked, for instance, through task design. In network-based environments structured interaction may encourage students to engage in critical argumentation. Moreover, essential cognitive processes in collaborative argumentation, such as those listed below, could be supported:

- critical evaluation of information
- multiple perspective taking
- (varied) elaboration

3.1.2 Computer-mediated communication

In this review study we will concentrate on students taking part in text-based argumentation via computer-mediated communication (CMC) systems such as chat boxes or newsgroups available on the Internet. Similarly to face-to-face communication (F2F), in CMC participants have to span a transactional distance. This "psychological and communication space to be crossed", is a space of potential misunderstanding between the creation and interpretation of participants' utterances (M.G. Moore, 1993; Pea, 1993). The meaning of an utterance in F2F communication can be conveyed by the use of visual and inflective cues, such as face expression and intonation (Mason, 1992). Most CMC systems do not provide these multi-modal forms of communication and hence there is an increased risk of misinterpretation (M.G. Moore, 1993). Without understanding each other, only feigned arguments occur, not leading to knowledge development.

In addition, printed text appears to encourage a sense of closure. A printed text is often assumed to have reached a state of completion. Subjects are pulled into believing and accepting ideas and statements which they see in print as true, simply because they are in written form (Mason, 1992). It is not clear whether students treat text in a CMC environment in the same manner as printed text or whether it is regarded as an ongoing dialogue. Although students share the same communicational context, they might not be as critical of new information or possible problem solutions as they would be in F2F settings.

To *provoke* and *support* argumentation in CMC systems, text-based interaction can be structured at the interface. Appropriated to task characteristics, students can be provided with dialogue markers, sentence openers and turn-taking control. These options might improve shared understanding, focus maintenance or critical assessment of new information. Additional options for free text interaction could stimulate elaboration whereas careful use of turn-taking control and dialogue rules could guide the interaction without constraining it. In addition, graphic representation of arguments might support exploration of multiple perspectives and identification of misconceptions and gaps.

To examine how to *provoke* and *support* collaborative argumentation in CMC systems, this review study considers first of all the role of collaborative argumentation in problem solving. Important cognitive processes in collaborative argumentation during open-ended problem solving will be discussed. Secondly, the characteristics of open-ended problem-solving tasks, including specific learning goals and instructional design, will be linked to collaborative argumentation. In order to discuss how task characteristics could be related to electronic support for collaborative argumentation in CMC systems, we will review five examples of network-based environments, comparing features of structured interaction intended to provoke or support collaborative argumentation. To conclude this study, we suggest that structuring interaction is marginally effective in *provoking* argumentation but more clearly contributes to its *support*. However, since each experiment has different task and interface characteristics we have to consider these findings as suggestions for future research questions rather than conclusions in themselves.

3.2 Collaborative argumentation during open-ended problem solving

Collaborative problem solving is frequently used to promote learning. Discussion can be particularly productive when problems are characterised by globally defined task goals and incomplete available knowledge (Erkens, 1997). These open problem-solving tasks, for instance answering an essay question, are characterised by participants having incomplete knowledge of the subject and having to use (justified) beliefs and values to work on multiple acceptable strategies, viewpoints and problem solutions (Baker, 1992). Collaborative argumentation allows students to discuss their incomplete or conflicting knowledge and to use each other as a source of information and evaluation. However, engaging in discussion does not necessarily result in good collaboration, argumentation or problem solving. For instance, failure to note a misconception that has been made explicit in the dialogue will not advance the problem-solving process. Also, a compromise solution, proposed and accepted in order to avoid conflict, may be worse than either of the conflicting solutions (Baker, 1996). The questions considered in this study, therefore, are:

(1) In which phases of solving open-ended problems is collaborative argumentation most productive?

(2) What characteristics can be identified (of the task, the instruction and of structured interaction) that:

(a) provoke argumentation

(b) support the following cognitive processes in collaborative argumentation:

- critical checking of new information
- exploration of multiple perspectives
- (varied) elaboration

3.2.1 Focus

In collaborative problem solving, students have to initiate and maintain a shared focus of the problem (Erkens, 1997). They have to agree on the overall goal, descriptions of the current problem state, and available problem-solving actions (Roschelle & Teasley, 1995). Focusing on the thematic content is essential for the global and local level of communication. Through the global level students keep track of the main goals or concepts. Through the local, or direct level students can discuss relations between different features of (sub) goals or concepts. Both 'problem spaces' (Bereiter & Scardamalia, 1987) need to be coherent (Erkens, 1997; Van Wijk, 1995). Because focus plays an important role in the interpretation and understanding of communicative utterances, failure to maintain a shared focus will result in a decrease of mutual understanding and problem-solving quality (Kanselaar & Erkens, 1996; Erkens, 1997).

A range of problems related to focus has been identified in collaborative problem solving (Erkens 1997). Erkens transcribed 30 protocols of 10 to 12-year-old students working in pairs on a problem-solving task called The Camp Puzzle, and analysed seven dialogues in depth. In this task students had to derive personal characteristics of six children by combining given statements. However, the information required to solve the task had been distributed between the two students. Therefore, students had to exchange information and negotiate about their inferences and task strategy. Erkens found that low-performing dyads exhibited greater difficulties in focusing than high-performing dyads. Problems arose because (1) students became confused about the shared focus or (2) students changed their shared focus before reaching a solution to the previous sub-problem. Specifically, focus confusion occurred when students:

- did not elaborate on each other’s utterances
- became fixed upon their own focus and therefore only interpreted incoming information from their own perspective
- did not develop their own viewpoint, did not negotiate about focus and simply followed the focus taken by their partner

Changing focus before solving a sub-problem caused difficulties either because the sub-problem was forgotten or never solved or because students returned to the problem later and repeated their earlier mistakes.

Baker and Bielaczyc (1995) studied students working in C-CHENE, a computerised tool for collaborative problem solving in the domain of physics. They claim that failure to maintain a shared focus is one of the main problems leading to missed opportunities. These are situations in which students could have used each other as a resource for learning, but did not.

Collaborative argumentation might be of help in initiating the problem-solving process. The focus on the task goal and the themes can be determined through argumentation. Collaborative argumentation can support the discussion of what focus to share and maintain. Although this does not necessarily lead to knowledge development, it is an essential precondition for fruitful problem solving. In the next section we will discuss the role of argument checking processes in open-ended problem solving.

3.2.2 Argument checking

Having started the collaborative problem-solving process with a (partly) shared focus, students can progress by generating or gathering information relevant to the current problem. This could be information retrieved from memory or new information from resources such as books or the Internet. Students should be involved in informing, elaborating and questioning at this stage in order to ensure that relevant information is known and understood by all participants. Students should check new information against their existing knowledge. The following are examples of the sort of questions students should use to evaluate the new information: “Is the new information relevant to the current problem?”, “Is the new information consistent with existing knowledge or is there a conflict?” and “How reliable is the new information?”. When new information is considered doubtful or is disbelieved, then students can check the information by means of clarification questions (Bunt, 1989) or (counter)-arguments.

Checking new information does not only involve logical cognitive processes. It also depends on the problem context, prior knowledge, interest, beliefs and values of the individual problem solvers (Toulmin, 1984; Baker, 1994; Stein & Miller, 1991). Therefore, checking information is to some extent subjective. To scrutinise information critically, Petty and Cacioppo (1986) described an approach for argument checking. Their model describes how to check new information along the **central route**, which involves treating it as being ’problematic’. In scrutinising information along the central route, relevant knowledge is used in order to evaluate the information argumentatively on its *strength* and *relevance*. Thus, information can be related to existing knowledge, leading to acceptance, doubt or disagreement. Especially in the case of doubt or disagreement, questions or counter-arguments can be generated to evaluate the information. Although the central route is the most ’objective’ approach, the cognitive effort involved is tremendous. The more complex the problem under discussion, the harder it will be to scrutinise every chunk of new information in this manner. Instead of taking the central route, checking can also proceed along a second, less reliable but easier and faster **peripheral route**. Here, in contrast to the central route, evaluation is the result of associations with affective cues, or the result of making inferences about the probable correctness of information and the desirability of a certain problem-solving strategy or solution. Affective cues such as the source’s expertise, the dominance of a peer student or simply the sum of given arguments can be used as ’evidence’ in checking new information. Scrutinising information along this route requires less cognitive effort, but the problem solving is less 'objective' than when the central route is followed.

Previous research (Chan, 1995; Baker & Bielaczyc, 1994; Erkens, 1997) has identified problems associated with checking information during collaborative problem solving. Chan studied 108 students (54 in grade 9 and 54 in grade 12) learning biological evolution theories, which contradicted their beliefs. Comparisons were made between situations in which conflict was maximised and minimised. The specific goal was to evaluate whether students using problem-centred discourse moves scored better on post-tests compared to students who didn't use such moves. The production of problem-centred moves is comparable to processes of checking information along the central route (Petty & Cacioppo, 1986). Students using problem-centred moves identified problems in their partner's statements and reformulated problems into questions of enquiry. They connected new information to existing information, tested it by countering and looked for inconsistencies. Chan found a significant difference between the average number of problem-centred moves in high-achieving pairs (14) and low achieving pairs (2). Situations in which conflict was maximised were more advantageous for students than situations with minimised conflict.

Baker and Bielaczyc (1995) also found that missed opportunities occur when students are biased towards early agreement and therefore process each other's information before checking it critically. Taking this learning approach, identified as problem-minimisation (Bereiter & Scardamalia, 1993), means that checking processes are aimed at minimising problems or necessary belief revision.

In Erkens' study (1997), the checking processes of low-achieving problem-solving pairs were compared to those used by high-achieving problem-solving pairs. Several problems were identified in the processes used by the low-achieving pairs. Difficulties occurred when transmitted information was doubtful or unclear but was not queried or countered in the dialogue. Even when check questions were asked, elaborations and justifications were not asked for or given. Incorrect inferences were made without checking the resources and no questions were asked to elaborate upon other possible problem solutions. Better problem-solving pairs used more checking procedures and a variety of arguments, they questioned new information and elaborated on justifications.

In processing discussed information, possible problem solutions have to be produced. These solutions have to be evaluated and, for some assignments a final solution has to be chosen (e.g. decision making tasks). When evaluating problem-solving solutions, Erkens (1997) found that low-achieving pairs encountered the same difficulties with checking as when they evaluated gathered information. When a proposed solution was doubtful or unclear, again few check questions were asked and no counter-arguments were produced. Better problem-solving pairs checked their proposed solutions and discussed argumentatively which solution to choose, using a variety of argument types and elaborating on the arguments.

Although argumentation in collaborative problem-solving dialogues can occur in every stage of the problem-solving process, argumentation is crucial during two particular phases (Erkens, 1997). Argumentation can contribute significantly to the problem-solving process when new information is considered. This information should be critically discussed before being integrated into the existing knowledge structures. This is also the case when solutions are evaluated argumentatively before a definitive solution is selected. Argumentation to share or maintain focus results in satisfying preconditions for productive collaborative problem solving; it does not necessarily advance the construction of knowledge.

3.2.3 Exploration of multiple perspectives

In argumentation students have to take into account contrasting points of view. Holding different points of view can result in different evaluations of information strength and relevance, and of problem solution acceptability. In open-ended problem solving, students have to elaborate on multiple perspectives in order to relate, compare and differentiate the effects of various problem-solving activities or possible problem solutions. However, biased behaviour in argumentative discussions can inhibit students in their collaborative problem-solving process. In biased discussions, students do not share information efficiently but focus on only a small amount of information available.

Based upon the 'Biased Simpling Model of Discussion', Hightower (1995) studied students discussing which candidate to choose for a specific job. The Biased Simpling Model of Discussion predicts that students will (1) favour their own positions and attack opposing positions, thus producing imbalance in the argument, (2) accept group preferences, (3) elaborate on shared information rather than distributed information and (4) concentrate on perspectives with a high proportion of information available. In

Hightower's experiment, 93 students working in groups of three were provided with partly shared and partly distributed information about several imaginary candidates for a job. Their task was to discuss and finally select the candidate they thought would be most suitable for the job based upon the information given. Half of the student groups (n = 15) worked using the Electronic Discussion System (EDS), a synchronous tool supporting computer-mediated communication (CMC). The other groups (n = 16) worked in a face-to-face (F2F) condition. Results of the study confirmed the predictions based upon the Biased Simpling Model. Biased behaviour occurred when students defended their own positions and attacking opposing points of view. This phenomenon is strongly supported by several other studies on argumentative discussions (Veerman & Andriessen, 1997; Kuhn, 1991; Voss & Means, 1991; Stein, Calicchia & Bernard, 1996). Independent of the mode of communication (F2F or CMC), Hightower also found that the discussion was more biased when there was a large amount of shared information. Students aimed for consensus by focusing on the most popular information in the group. In addition, it was found that a high information load provoked biased discussions. Most interestingly, Hightower found more biased behaviour in the CMC environment than the F2F setting. She concluded that students have to put more effort into transmitting information in CMC discussions versus F2F discussions. In crossing the 'transactional distance' reaching mutual understanding is more difficult and, therefore, biased discussions occur more easily.

To summarise, using the following processes during the evaluation of new information and acceptable problem solutions can optimise the problem-solving process:

- critical assessment of new information
- exploration of multiple perspectives
- (varied) elaboration

Characteristics of the task, instruction or structured interaction might support these cognitive processes in collaborative argumentation. In CMC systems particular attention must be paid to reaching mutual understanding, critically assessing new information and preventing biased behaviour.

However, whilst it is important to consider the problems students encounter during argument, the first step is to encourage students to engage in argumentative discussions. Several studies (Baker, 1996; Pilkington & Mallen, 1996; Veerman, 1996) have shown that whether students start critical discussions depends on task characteristics, including the domain, the learning goals, the instructions and the expected product. Providing students with predefined and conflicting information or competitive forms of instruction combined with a joint solution can provoke argumentative discussions. This issue will be pursued in the next section.

3.3 Collaborative argumentation and task characteristics

In open-ended problem-solving tasks collaborative argumentation has to be initiated, especially in the phases prior to integrating new knowledge into existing knowledge structures and deciding on the most acceptable problem solution. Discussions do not always start spontaneously and may have to be *provoked*. Spontaneous discussions are likely to arise when doubt is expressed about specific statements, arguments or conclusions. Grouping students with conflicting opinions (Stein, Calicchia & Bernard, 1996) or involving students in preparatory individual work prior to collaboration (Bull & Broady, 1997) increase the likelihood of conflict and hence spontaneous argument. Discussions can also be *provoked* by instructing students about role-playing activities, for example defending or attacking predefined and conflicting stances (Veerman & Andriessen, 1997). In addition, students can be given different goals concerning the 'closure' of arguments. For example, they could be instructed to reach consensus, to win discussions or to stop a discussion when an impasse is reached. Also, students may be asked to create an individual or joint *final product* based upon their argumentative discussion (e.g. an oral presentation or an argumentative text).

Defining learning goals and the expected final product can encourage students to *engage* in argumentative discussions, but this alone cannot overcome the difficulties students have in critical argumentation *during* discussions. However, knowing that the final product will be assessed can act as a motivation, increasing the effort put into the argument evaluation by the students. Besides, although creating a joint product stimulates positive interdependency (Erkens, 1997), students tend to accept each other's information without critical assessment of new information in relation to existing information (Suthers & Weiner, 1995: formative evaluations; Veerman & Andriessen, 1997). Moreover, students tend towards a partial and biased search through the problem space (Hightower, 1995). Therefore, instructions should aim at encouraging a critical, multiple-sided and elaborated argumentative discussion. Two options for effective instructional design will be discussed in the next two paragraphs.

One approach to providing support through instruction would be to advise students to be competitive, critique each other's information and not to accept new information without being convinced of its strength and relevance. In this situation students must be thorough and persuasive, finding as many reasonable arguments as possible in order to convince the other person to accept their point of view. However, if a final joint product is required then students must reach a consensus at the end of their discussion. Instructing students to produce justifications for their position and present it to the other students during an argumentative discussion in which they attempt to refute the other position and rebut attacks on their position can solve this. Finally, they are instructed to drop all advocacies and seek a synthesis that takes both perspectives and positions into account in order to construct a joint product (Johnson & Johnson, 1993; Veerman & Andriessen, 1997).

A second approach is to provide students with predefined stances. By providing predefined stances, the global focus of the discussion is made explicit. Students are aware of each other's stance and thus have fewer problems interpreting each other's utterances and constructing mutual understanding. Since the problem space has been clearly defined, information checking procedures can focus on relevance to the predefined stances within the boundaries of the problem space. However, providing students with predefined stances might not *support* information checking based on critical argumentation. One possible problem is that students will not feel motivated to critique their partner's information. Enforcing predefined stances without making concessions to personal beliefs and values may mean that the student does not feel any responsibility to critically defend a statement. To support critical argumentation, in this setting students could be asked to produce the stances themselves. Thus, students will have personally constructed the stance, and therefore feel responsible for it (Veerman & Andriessen, 1997). Because of the predefined stances the problem space is limited, aiding the process of checking information.

Another issue that is related to the task and its influence on argumentation is the problem-solving domain. Although the domain does not directly affect the quality of collaborative argumentation, it influences methods used to check new information. In rich problem-solving areas including scientific information, students could be instructed to check information critically using scientific theories and empirical or logical evidence rather than personal information. In less rich problem-solving domains, personal-oriented arguments could be valued on the basis of beliefs and values shared by social communities or authorised individuals (Freeman, 1992). When scientific arguments are used, checking on strength can be based upon theories, empirical evidence or logical reasoning chains extracted from verifiable resources. However, 'correct' scientific information resources will not decisively settle all arguments. The interpretation of information can differ and the relevance of information can be a matter of discussion. In academic learning, students aim to check arguments on verifiable resources whenever it is possible. Raising this issue through instruction could be useful.

To summarise, instructional support can be usefully given at the start of the discussion and during the negotiation process of the discussion. Taking into consideration the domain, the goal and content of the task, instruction can be tailored towards optimising checking procedures in collaborative argumentation and towards optimising the scope and variety of elaboration in argumentation. In network-based environments support could be provided for these important but problematic processes by structuring the interaction at the interface.

3.4 Network-based environments for solving problems by argumentation

Five systems have been chosen for this review. The selection of the systems is constrained by focusing on features affecting collaborative argumentation as described in the earlier sections.

First of all, the chosen CMC systems are all designed for educational tasks in which the emphasis is on collaborative argumentation as a method to optimise problem solving or as a final learning goal. Published results are available on the use of all five systems and in particular data related to argument usage. Secondly, the chosen network-based environments are all designed for symmetrical interaction. That means, participants do not have formal differences in power and status (as tutors and students have), and although prior knowledge will vary, students are expected to have comparable cognitive backgrounds. Furthermore, four of the systems are designed for synchronous communication whereas one system is designed for asynchronous communication. In synchronous forms of communication interlocutors have to be both present at the same time, for example when using computerised chat boxes or a telephone. In asynchronous communication, the interaction can be delayed by hours, days or weeks, as happens in e-mail, because the participants do not have to be present and use the system at the same time[2]. The selected CMC systems, including the asynchronous environment, were only used for short task assignments, rather than assignments completed over a period of weeks or months. In addition, we only considered CMC tasks in which a product or closing of the discussion was required. When considering electronic features of the CMC systems, we searched for a range of environments that demonstrated different approaches to structuring the interaction in order to support communication and more specifically, argumentation. In Table 3.1, the selected systems are listed with short remarks on the structured interaction.

For each system, we will briefly describe the mode of communication, the main learning goal(s) and the support for argumentation (aimed at the process or product) provided through structuring the interaction. In discussing the systems success at *provoking* and *supporting* argumentation, characteristics of the task, instruction and structured interaction will be considered.

Table 3.1. Selected CMC systems and characteristics of structured interaction.

CMC system	Structured interaction
Dialab	Rigid turn-taking control Rigid communication rules
Conference MOO	No turn-taking control Mixture of structured communication rules and free input of text
CTP	Semi-enforced turn-taking control in task window No communication rules
CLARE	Asynchronous turn-taking Double-layered rigid communication rules
Belvédère	No turn-taking control Graphically represented communication rules in task window

3.4.1 The Dialab system

The Dialab system (Moore, 1993) is a synchronous communication tool, designed to teach argument and critical thinking skills using a rigid logic-based dialogue game (MacKenzie, 1985). Students use the Dialab system in pairs. The Dialab system mediates argumentative

[2] Although the division between asynchronous and synchronous modes of communication appears to be clear, it must be kept in mind that asynchronous systems can be used for sending messages almost simultaneously, and synchronous systems can be used as asynchronous systems (Dillenbourg & Traum, 1997)

dialogues between students, applying rules from MacKenzie's dialogue game (DG). DG defines a set of dialogue moves (allowable move types), a set of commitment rules (used to monitor the statements each player has committed to during the dialogue) and a set of dialogue rules (which determine which move types can follow each other).

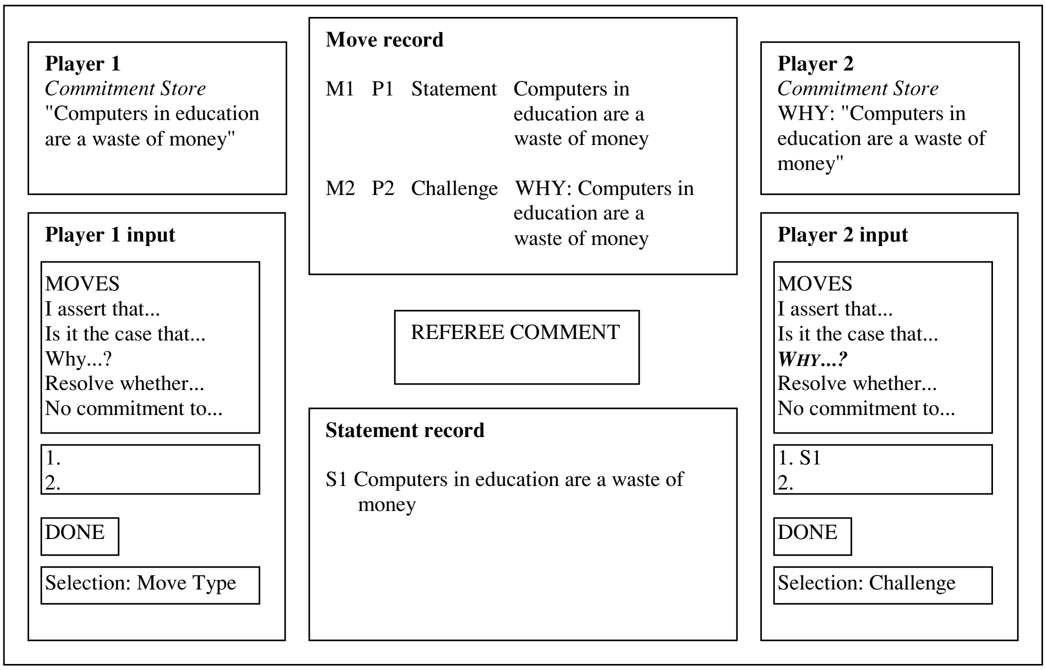


Figure 3.1. Interface of the Dialab system.

When using the system one of the students starts by choosing a move from the set of sentence openers (for example *'I assert that', 'Is it the case that...'*) as shown in Figure 3.1. Each of these sentence openers is represented within the system as a type of dialogue move (for example *Statement* or *Question*). Once the student has chosen a sentence opener, the system displays the selected move type at the bottom of the Input window (see: 'Player 2 Input' window in Figure 3.1). Although the interaction is partly restricted to a menu-based interface, free text can be entered into the system after a move has been chosen. Thus, player 1 is allowed to choose the statement move *'I assert that…'* and put in free text after this utterance *'…computers in education are a waste of money'*. Turn-taking is rigidly enforced and a participant can only make one dialogue move per turn. The opponent will not see this move until they choose to send it, by pressing the DONE button. There is no mechanism for interrupting a turn or for chatting in an unrestricted manner. Following a turn, the computer system updates the sender's commitment store (using the commitment rules) and the move and statement records. Control now passes to student 2 who must choose a move. Based on the preceding move type, the dialogue rules determine which move types student 2 can choose in response. For example, a question cannot be followed by another question. Within the free text entry the student can explicitly refer to a statement in the statement record. Hence by choosing the sentence opener *'Why...'* and pointing at statement 1, the responding student's move will become *'Why are computers in education a waste of money?'* (in the system's internal representation: challenge statement 1).

The commitment rules keep track of each participant's commitment store and these are updated following each turn and are visible to both participants. Besides adding all statements made by students to their commitment store, the system will also add those statements, made by their opponent, which they have neither challenged nor explicitly expressed no commitment to. The interface is shown in Figure 3.1, as it would appear once the updating is complete following the move by student 2. Finally, win-lose rules are applied to the collaborative dialogue identifying situations in which a participant has won or lost the game (for example by showing inconsistency in the commitment store). The dialogue ends once one participant has 'won' the game.

3.4.2 Conference MOO

A Multiple Object Oriented system (MOO) is a synchronous, text-based virtual environment. Multiple users can connect to a MOO at the same time and interact with each other in these two-dimensional virtual spaces, which are divided into text-based buildings, (class) rooms and hallways. They can make appointments arranging where to meet and whom to invite. The flow of communication in a MOO is comparable to that in any synchronous chat. A multiple-line message can be created and not seen by other participants until the writer 'sends' it. Once 'sent', messages then appear in the shared chat history. One difference between an average chat box and a MOO is that participants can perform actions (such as wave to each other, wink, smile, and hence express some of their feelings through recognised non-verbal gestures). In a MOO, participants can have multiple private conversations as well as public group conversations. The flow of different lines of interaction is not structured. The display of private and public messages from different conversations and on different topics is ordered according to the time they were sent.

In this section we discuss a MOO designed specifically for a scheduling task. Pairs of students have to schedule a conference, taking several constraints into account such as the number of talks, different themes and the technical equipment available in each conference room (Jermann & Schneider, 1997). The conference MOO consists of two distinct tools: the first is dedicated to the communication (see Figure 3.2) and the second is dedicated to the problem representation (see Figure 3.3).

The communication tool, which provides two modes for communication, is particularly interesting. It comprises a free mode to fill in text fields and a structured mode for delivering utterances by using buttons. The communication tool is intended for synchronous text-based communication. Students can communicate by pressing buttons, using sentence openers or by entering free text. A dialogue history displays the utterances and allows students to reply to a particular utterance by selecting it. The reply will be indented underneath the utterance to which it refers. When no item is selected in the dialogue history, the new utterance is added to the end of the history list. This structuring method is common in asynchronous web-based discussion systems that use 'threading'. Students can choose to communicate using the 'semi-structured' interface or the 'free-text' mode. Students are allowed to mix both modes in their communication.

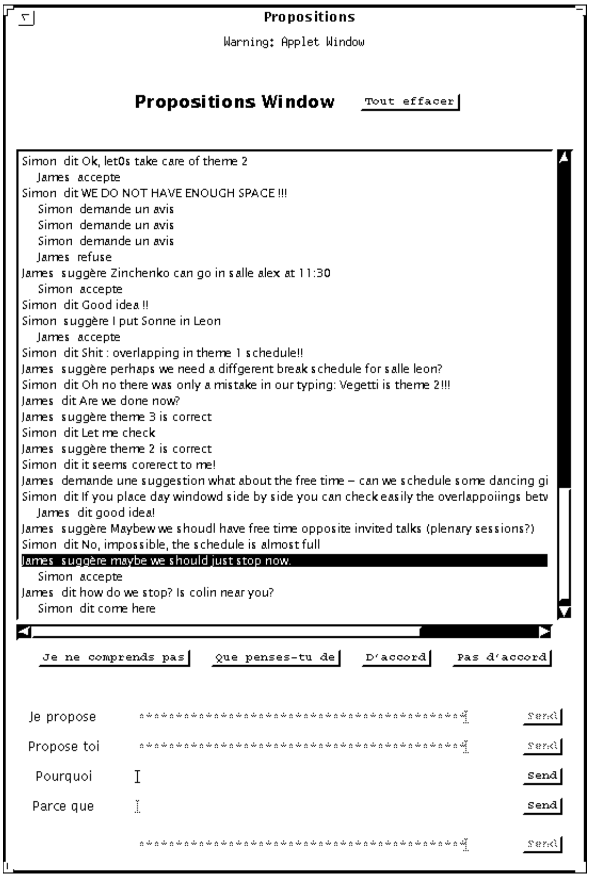


Figure 3.2. Interface of the communication tool of the Conference MOO.

In the semi-structured version of the Conference MOO, four buttons are available, labelled *'I don't understand'*, *'What do you think'*, *'I agree'* and *'I disagree'*. In addition there are four text fields containing the sentence openers *'I propose'*, *'You propose!'*, *'Why'* and *'because'* . Free text can be entered after these sentence openers[3].

[3] In Figure 3.2 and Figure 3.3, the French Conference MOO is used to communicate in English. Translations are made considering buttons and sentence openers.

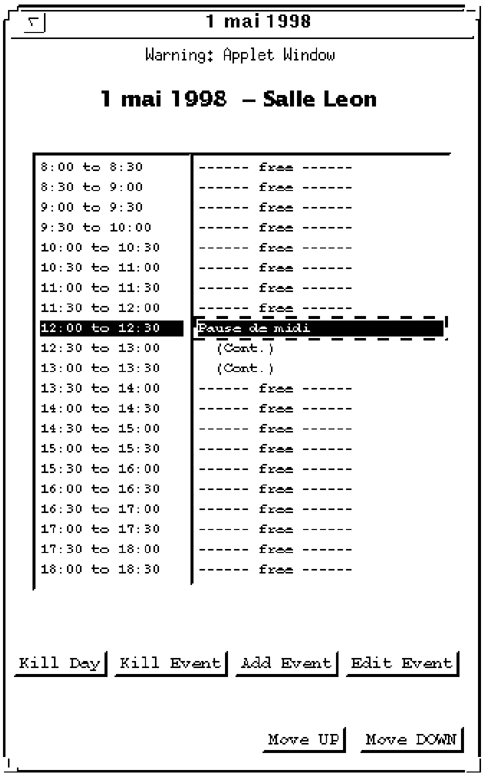


Figure 3.3. Interface of the task window of the Conference MOO.

The task window (Figure 3.3) represents the problem students have to solve collaboratively. In the task window conference rooms are listed with 21 available time slots. Students use this window to create a schedule. Once an event is created, it can be moved up and down and it can be edited. The task is finished once the students have allocated all of the talks a room and a time.

3.4.3 The CTP system

The CTP system (Collaborative Text Processing) is a synchronous network-tool (Andriessen, Erkens, Overeem & Jaspers, 1996). The tool consists of a shared word-processor, a chatting tool and private information resources and is intended to support collaborative distance writing of argumentative texts. In this version of the program the collaboration and the sharing of windows is restricted to pairs of students. The working screen of the program displays several private and shared windows (see Figure 3.4).

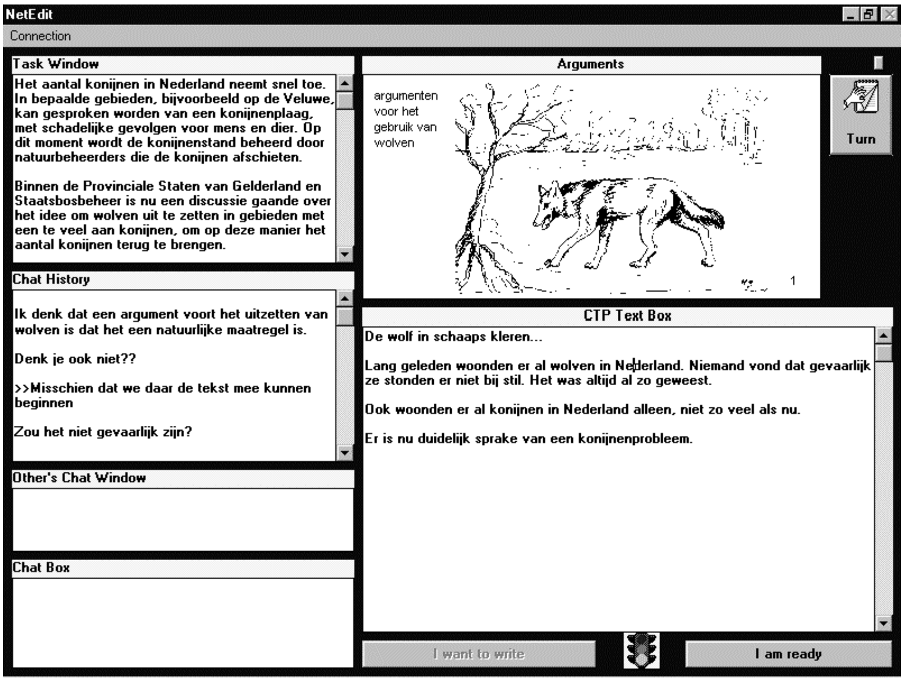


Figure 3.4. Screendump of the CTP system.

Figure 3.4 shows a Task and Argument Window at the top of the screen. The Task Window displays the assignment (in Dutch). The Argument Window displays the supporting information given to individual participants. These task-related arguments (in this example considering the case of encouraging hunting versus increasing the number of wolves to stop the expansion of rabbits ruining Dutch forests) can be presented in text or pictures. Online communication between the writing partners is achieved using a text-based chat box. In the shared text window (CTP Text Box) the participants may enter, edit and revise the text they are currently writing. Here, putting text into the window is neither constrained nor prompted by menu-based interfaces or pre-selected utterances. Participants are free to write what they want and express it in any manner. However, turn-taking control of the shared text window is provided using a traffic light mechanism.

3.4.4 The CLARE system

The CLARE system (Wan & Johnson, 1994) is an asynchronous network-tool, developed in order to facilitate meaningful learning through collaborative knowledge construction. Two main phases of (a) Exploration and (b) Consolidation are involved in the use of the CLARE system. During the Exploration phase students work individually on summarising and evaluating text-based study material. These summaries and evaluations are collected in the system's database. During the Consolidation phase students compare, deliberate and integrate each other's summaries and evaluations. Similarities and differences between each other's work are the input for asynchronous group discussions. The group size in this phase is not constrained, but the larger the number of students the more complex the task of comparing and discussing will become. Finally, based upon the previous activities, students have to integrate their own knowledge with the knowledge of others in order to create a shared knowledge base.

CLARE supports the phases of exploration and consolidation in different ways. The teacher chooses a text and divides it into sections. The text is then included as a hypertext document within the CLARE system (see the left-most window in Figure 3.5). Students can move around this document using standard navigational links (e.g. Next, Up and Previous).

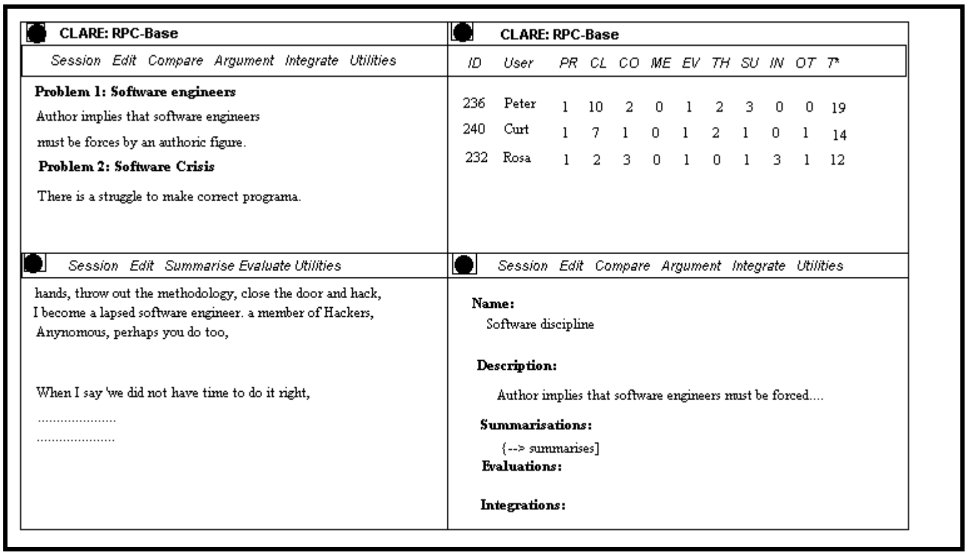


Figure 3.5. Interface of the CLARE system.

Whilst working through the text, students have to summarise and evaluate sections of the text. They are able to highlight parts of the text and use nodes to label the type of section they are summarising or evaluating. Possible nodes include '*Problem*', '*Evidence*' and '*Claim*'. The students' choice of node determines the type of template (Figure 3.5; below right-hand corner) generated, into which they enter their short summaries. A link is automatically added between the highlighted text in the left window, the chosen node and the completed template. Students can now add evaluative remarks to the summary by using nodes such as '*Critiquing*' or '*Question*', which also have associated templates. When the students finish their individual exploration of the text, the group-oriented phase of consolidation starts. The interface changes with this phase. A comparative view of some selected summaries (chosen by matching the node type and text selection) is shown at the top left of the window. Students can add comments and critiques to each other's summaries and evaluations by using the '*Deliberation*' node. Students can add as many comments as they like and build on each other's remarks. In this way, the students engage in a structured asynchronous discussion. Students have access to all the information in the CLARE database including the summaries, evaluations, comments, disagreements or conclusions.

3.4.5 Belvédère system

Belvédère is a synchronous network-tool developed by the Learning Research and Development Center at the University of Pittsburgh (Learning Research and Development Center, 1996). Among many other applications, Belvédère can be used for constructing argumentative diagrams online with individuals or groups of students of any size (see Figure 3.6). Constructing argumentative diagrams by organising arguments according to specific problem statements is believed to be a useful learning activity during the planning phase of an ill-structured problem-solving task.

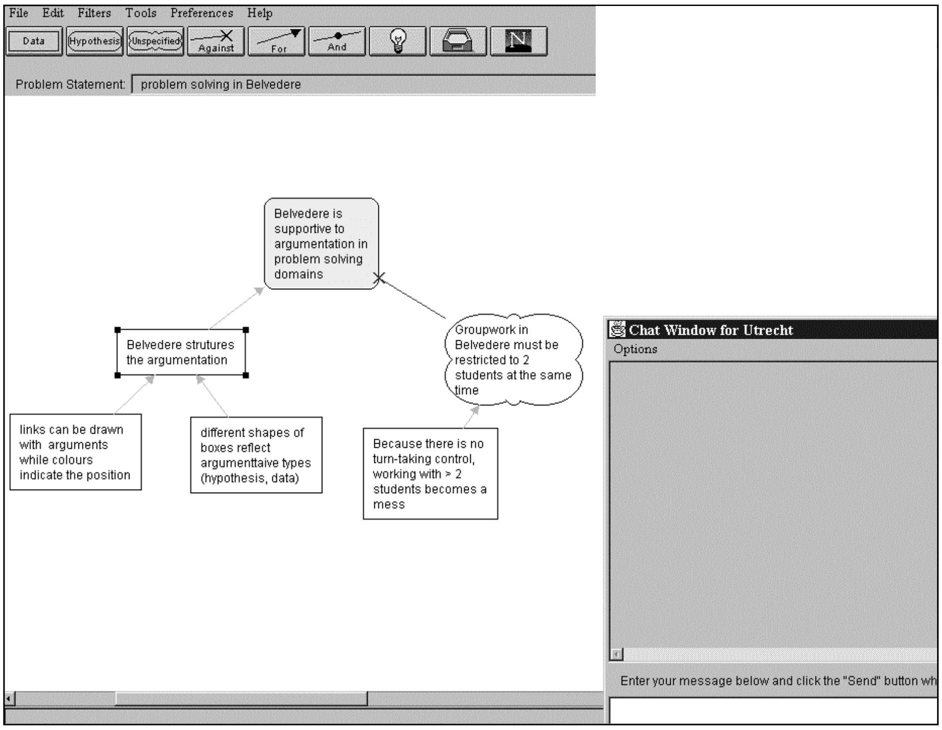


Figure 3.6. Screendump of the Belvédère system.

The working screen of the program displays private and shared windows. To communicate with a partner the student has a text-based chat box as in the CTP system or a typical MOO, in which multi-line messages can be created and sent. Messages will then be displayed, coupled with the writer's name, in the shared chat history. Adding data into the diagram is constrained; students must use the predefined set of boxes (*'hypothesis', 'data', 'unspecified'*) and links (*'for', 'against', 'and'*). These are shown in the menu bar in Figure 3.6. Links can be given a thickness reflecting a participant's confidence in the information. The thicker the line, the more certain the student is about the input. Participants' names can be displayed alongside their contributions. Thus, students can keep track of who is responsible for each component in the argument diagram. An electronic coach (the 'bulb') is available to give help on demand. The coach gives advice on how to improve the argumentative structure of a diagram.

3.5 Discussion of the systems

In every system an effort has been made to structure the interaction through the interface. In some systems the interaction is structured within the communication windows (Dialab), in other systems the interaction is structured within the task screens (CTP, Belvédère) and some structure interactions at both task and communication level (Conference MOO, CLARE). This structure has been provided for several reasons.

Text-based communication can lead to misunderstanding (M.G. Moore, 1993), because non-verbal and paralinguistic cues are not available to support the interpretation of messages. The meaning of utterances must be inferred from the text. To support students in maintaining a shared focus and reaching a shared understanding, interaction can be structured electronically. Turn-taking facilities can help students to keep track of their interactive process. Predefined sentence openers in communication windows such as *'I propose…'* or *'Why do you think…'* and discourse acts such as *'Question'* or *'Critique'* can represent the generation mechanism of an utterance, therefore making explicit the (underlying) goal of an utterance. Buttons, shaped boxes and links, such as those used in the Belvédère system, can also represent discourse acts graphically and ease the interpretation process.

Another reason to structure interaction in network-based environments is to encourage students to focus on specific parts of the communication or problem-solving process. Generally, structuring interaction can lead to an increase of task-oriented behaviour, and a decrease of off-task behaviour (Baker & Lund, 1997). Specifically, by using a defined (sub) set of discourse acts and sentence openers students can be encouraged into certain discourse and problem-solving activities such as argumentation in order to evaluate an alternative solution.

Moreover, students could be supported in problematic activities such as checking arguments before integrating them into the problem-solving process. For instance, in Belvédère students can present their confidence in claims and evidence by annotating the boxes with comments such as *'strongly believe'*.

Structuring the interaction in task or communication windows of network-based environments can help students to understand each other, to share the same focus or to improve their collaborative argumentation. The main question in this section is how interaction can be structured to *provoke* and *support* collaborative argumentation in order to optimise open-ended problem solving. In the next sections this issue will be explored, and related to the task characteristics and instruction provided in the empirical studies conducted with each of the selected systems.

3.5.1 Structuring interaction to provoke *discussion*

All the systems have been used for educational purposes, and a considerable amount of argumentation was generated during their use (Moore, 1993; Jermann & Schneider, 1997; Andriessen et al., 1996; Wan & Johnson, 1994; Veerman & Andriessen, 1997). Table 3.2 shows the proportion of argumentative utterances observed during the studies conducted with each of the five systems. In calculating the proportion of argumentative utterances, the sum of the following utterance types:

- questions triggering arguments
- problem statements
- argument oriented pro and contra statements
- elaborations of arguments

is divided by the total number of utterances produced in the dialogue or in the final product. Studies with the Dialab system and the Conference MOO calculated the argumentative utterances in the dialogues, whereas the study with the CTP system reported only those argumentative utterances present in the final product (the written text). For the CLARE system, the proportion of argumentative utterances refers to those present in the asynchronous database whereas the Belvédère study gives approximate figures for the argumentative utterances produced both in the dialogue and the final product (the argumentative diagram). In the Belvédère study the total number of utterances was not measured exactly. This was because non-task related utterances were mostly counted as one unit, instead of being divided into separate units of utterances. Therefore, we had to estimate the proportion of argumentative utterances based on the rough data available from both the dialogues and diagrams.

Table 3.2. System design, task characteristics and the proportion of observed argument.

System	Structured interaction	Argumentative task	Prop. of observed argument (dialogue)	Prop. of observed argument (product)
Dialab	Yes	Yes	1.00	--
CTP	No	Yes	unknown	0.91
Belvédère	Yes	Yes	ca. 0.90	ca. 0.95
CLARE	Yes	Task problems	0.35	dialogue = product
Conference MOO	Yes	No (information shared)	<0.10	--

In the pilot study using the Dialab system, 7 academic students previously trained in using the dialogue game, used a partially implemented system. The aim of the system was to support students in having a 'fair and reasonable' discussion. An experimenter played the role of the system (as it would have performed if it had been fully implemented). The students communicated using standard chat boxes, but had to identify their move type. The experimenter intervened when they broke the dialogue or commitment rules. The interface provided them with specific argumentative dialogue moves and their task was to engage in discussion and try to win an argumentative about Capital Punishment. Because of the restricted interface, students were forced to use argumentative utterances, though, they could have chosen to make only assertions or confirmations.

In the CTP system, 74 students worked on a collaborative writing task. Each pair was instructed to write two texts (1) considering the problem of the overpopulation of rabbits and (2) considering labour policy. Pairs were randomly assigned to different conditions in order to encourage fruitful discussion as part of the writing process. Students were provided with predefined arguments in a (a) textual format or in (b) graphical representations. Except for turn-taking facilities in the task window, interaction was not structured. Despite this, in each experimental condition the proportion of argumentative utterances in the text ranged from a minimum of 0.87 to a maximum 1.00. The average proportion, as shown in Table 3.2, was 0.91.

Similar studies have been undertaken with the Belvédère (Veerman & Andriessen, 1997) and the CTP system (Andriessen et al, 1996). In the Bélvèdere study 14 students working in pairs produced conflicting stances about three different aspects of a conceptual design task. Each aspect had to be discussed in separate sessions using Bélvèdere. Three argumentative diagrams had to be submitted as the final product. The average proportion of argumentative utterances was circa 0.90 in the dialogues and circa 0.95 in the diagrams. When comparing the proportion of arguments produced in the Bélvèdere system and the

CTP system, no strong difference was found despite the provision of argumentative moves such as *'Hypotheses', 'Data', 'For'*, and *'Against'* in the task window of the Bélvèdere system.

In the study using the CLARE system (Wan & Johnson, 1994) it seemed that the amount of argumentation dropped to a proportion of 0.35 mainly because of problems at the task level. In this study 24 upper-level undergraduates in Software Engineering worked in groups of four. Prior to engaging in a collaborative discussion, they had to identify, individually, the main problem and four major claims in a given text. None of the subjects correctly identified the main problem while summarising the text and only half of the subjects found major claims and connected evidence. As a result, it appeared that students used the wrong kind of dialogue markers to summarise and discuss parts of the text. Because the use of dialogue discourse markers was interconnected (e.g. selecting *'evaluation'* brought up primitives as *'critique', 'question'* and *'suggestion'*) the misappropriation of dialogue markers escalated. These problems, occurring both at the task level and in structuring the interaction at the interface, decreased the possibility of good argumentation occurring in the discussions.

In contrast to the studies described above, little argumentation occurred during the use of the Conference MOO. In the MOO, 10 pairs of academic students had to solve a scheduling task and had flexible access to dialogue acts. An analysis of Jermann and Schneider's rough data shows that less than 10% of the total number of utterances could be coded as argumentative. Argumentative utterances were made mostly by the use of the dialogue acts: *'why', 'I disagree'* and *'because'*. The main difference between the Conference MOO and other studies described is that of **task type**. In the MOO, the problem-solving task was semi-closed. Although the solution could be reached by multiple strategies, all the information needed to solve the problem was provided to all the students. No competitive instruction was given and students worked together without needing to produce argumentative discussions. In this case, little argument occurred despite the provision of argumentative markers.

To conclude, based upon the studies described above it seems obvious that structuring the interaction at the level of the interface does not on its own *provoke* discussion. Task characteristics such as predefined and conflicting information may stimulate the need for discussions when the information is divided among the students. Also, competitive forms of instruction combined with production of a joint solution can stimulate students to engage in argumentative discussions. However, the experiments with the five systems in this review did not compare students given the same task in structured versus unstructured interfaces. Therefore, we need to be tentative about these findings.

3.5.2 Structuring interaction to support *collaborative argumentation*

As discussed in the previous section, structuring the interaction by using dialogue moves, controlling turn-taking or allowing students to indicate their confidence in claims (such as in the Bélvèdere system) does not necessarily *provoke* discussion. However, interaction structuring might *support* collaborative argumentation in order to optimise problem solving. Compared to F2F situations, in CMC systems interaction can be structured electronically, for example by providing students with dialogue markers or turn-taking control. In F2F situations instruction can be given, for example concerning the use of questions or arguments, but this would not directly support the discussions *online*. Providing instruction might not be enough to improve focus maintenance, limit misunderstanding, or support dialogue management (all of which are preconditions for fruitful argumentation). Furthermore, instruction may not be sufficient to support the argumentation processes of critical checking, argument elaboration and the consideration of multiple viewpoints (Veerman & Andriessen, 1997). In CMC systems, electronic support through structuring interaction could be focused on important preconditions and on cognitive processes essential during collaborative argumentation. In Table 3.3 we summarise the main mechanisms used in the five systems reviewed and the activities they are supposed to support in collaborative argumentation during problem solving.

Table 3.3. Mechanisms of structured interaction to support activities in collaborative argumentation.

Mechanism	Activity support
Turn-taking	- Dialogue management - Social aspects: handle interruptions and dominance
Dialogue moves / sentence openers	- Shared understanding due to explicit goal of the message - Use of argument moves - Specific problem-solving activities
Graphical argument structure	- Shared understanding - Use of argument moves - Visual identification of gaps and conflicts in the argument - Consideration of multiple perspectives and balance
Explicit use of dialogue history in new moves	- Dialogue management - Focus and shared understanding
Confidence ratings	- Checking of weak claims

In this section, we will discuss the five systems, consider which argumentative dialogue moves were supported, what methods were used to structure interaction and whether these approaches appear to *support* collaborative argumentation. Our findings are offered as suggestions for improvement of collaborative argumentation through structuring interaction in CMC systems. Systems designed using these suggestions can then be used to test their validity.

3.5.2.1 Dialab system / CLARE

In the Dialab system, students are forced to use specific types of argumentative dialogue moves. Also, students are forced to enter one speech act (move) in one turn. The argumentative move types are connected to specific sentence openers. These include sentence openers for information checking, including question asking or countering arguments. For example, the dialogue move '*Challenge*' is connected to the sentence opener '*Why…*'. The dialogue history is explicitly used to select new moves. Since communication is restricted it is likely that there will be few problems concerning the focus of the argument and shared understanding. Moreover, dialogue management is rigidly structured and can hardly be misunderstood. The results of the study showed that students could be trained to use the dialogue game properly. They were able to identify their move types accurately and followed the dialogue rules. The argument produced was fair and reasonable. However, the 'win-loss' design of Dialab may mean that students are tempted to shift focus when they realise that their argument is losing with the current focus. This would lead to unresolved (sub) arguments, undermining critical checking along the central route in argumentative discussions. This would not necessarily cause problems for the task the system was designed for, but if it were to be used for collaborative problem solving, then this issue would need to be addressed. In open-ended problem solving a strict rule set combined with rigid turn-taking control is inappropriate when students are trying to solve a problem for which they do not yet have the full and unquestionable information. Specifically, allowing students to enter only one move in a turn cannot encourage elaboration. The study with the CLARE system (Wan & Johnson, 1994) supports this claim. In this study it is found that such restricted input mechanisms can actually inhibit elaboration.

3.5.2.2 Conference MOO

In the Conference MOO the use of structure at the interface and the free text input are combined. In Jermann and Schneider's study, results indicated that the use of the free versus the structured interface depends on the content type of the utterance. From the total number of utterances (n=1039) 58% concerned task *category*, 22% task *strategy* and 20% task *management*. Contributions concerning the task *category* and the task *strategy* are expressed more often through the structured section than through the free section. Management contributions are expressed mostly by using free text entry. This interface shows how interactivity can be structured at the interface, providing both restricted and unrestricted input modes. Admittedly little argumentation occurred during the use of this system, but this has been previously explained in terms of the chosen **task** rather than the interface design. Students worked together *without* a specific need for producing argumentative discussions. In collaborative argumentation students may have the same kind of preferences as in the MOO Conference system, using restricted or free input modes for different types of contributions. Allowing free input could, for instance, stimulate task management whereas collaborative argumentation could be enhanced by providing specific sentence openers representing check questions and counter-arguments at the interface. Additionally, the interface could also include dialogue moves and sentence openers designed to prompt exploration of multiple viewpoints, and elaboration.

3.5.2.3 Belvédère system

In the Belvédère system graphical dialogue moves are implemented in the task window and unrestricted communication takes place in the text-based chat box. By using predefined graphical boxes representing argumentative dialogue moves, students can identify information serving as claims and evidence. Arguments can be connected as preferred by using graphical links defined as *'For'*, *'Against'* and *'And'*. Electronic advice on argument structure is provided on request. This is largely based on the argument structure defined by Toulmin (1958). The study with Belvédère (Veerman & Andriessen, 1997) involved 7 pairs of students who produced conflicting stances and then argued about the conceptual task of designing specific learning goals. Comparing the 14 dialogues to the 14 diagrams produced (7 pairs * 2 tasks) shows that producing argumentative diagrams increases task-oriented argumentation and balancing positively and negatively oriented arguments in relationship to the claim.

3.5.2.4 CTP system

The study of the CTP system (Andriessen et al., 1996) showed that, in the written product, students explored multiple viewpoints and elaborated upon their arguments, despite the fact that no dialogue moves or turn-taking control was available in the communication window. Improved elaboration could be related to some of the task characteristics, in particular the fact that students were provided with pictorial information. The pictorial information gave rise to a greater number and variety of elaborations in the written products than did the textual information. The only turn-taking control within CTP was in the task window; this regulated the co-ordination between students creating a final product rather than affecting the argumentation processes.

In conclusion, providing a combination of structured and unrestricted interaction modes within both the task and communication windows might *support* argumentation during collaborative problem solving. In the communication window, combining free text entry with well designed argument dialogue moves or sentence openers can stimulate critical checking procedures in collaborative argumentation without restricting the argumentation or problem solving. In the task window, graphic argumentative dialogue acts improve consideration of multiple viewpoints and elaboration. However, task characteristics such as providing students with predefined stances also play an important role in improving the exploration of different viewpoints. Further research is needed to explore how these graphic dialogue acts produce improved viewpoint exploration and elaboration. In addition, turn-taking control in the communication window must be designed carefully, so that it does not inhibit elaboration. Controlling turn-taking in the task window regulates the co-ordination in producing a final product. Therefore, although it provides no direct support for the processes of collaborative argumentation this may support the problem-solving process.

3.6 Conclusions and discussion

In this review study we considered how to provide computer-based support for argumentation during collaborative problem solving. We found that, in specific phases of the collaborative problem solving, information checking (along the central route), exploration of multiple viewpoints and elaborations are important processes. Taking into account the problem-solving domain, learning goals and the final product, instruction can be tailored towards optimising checking procedures, consideration of multiple viewpoints and the variety of elaboration in collaborative argumentation. The choice of domain, the characteristics of the final product (individual or joint) and the mode of interaction (competitive or co-operative) all form part of the 'instruction'. Electronic support, provided by structuring the interaction, can also be designed to encourage and support the main cognitive processes involved in collaborative argumentation. In order to discuss how task characteristics in open-ended problem-solving tasks might be related to electronic support for collaborative argumentation, we reviewed five examples of network-based environments and compared their approaches to structuring the interaction and supporting argumentation.

The central question addressed was how to structure interaction in order to *provoke* discussion and *support* collaborative argumentation in order to optimise open-ended problem solving. First of all, we found that mutual understanding and focus maintenance are essential for engagement in fruitful discussions. These preconditions can be facilitated not only by task characteristics (e.g. instructing students to construct conflicting stances as an input for discussion), but also by structuring interaction (e.g. use of explicit sentence openers, dialogue moves, graphical argument or dialogue history). Secondly, we found that structuring the interaction does not necessarily provoke argumentation. This seems to have to do more with task characteristics such as competitive instructional design of the task. Notably the provision of argument moves in the Belvédère system did not produce more argument than the unstructured CTP interaction interface. However, the task chosen for the Conference MOO system appeared to have a negative effect on the production of argument despite the provision of argument moves at the interface. Tasks that do provoke argument appear to have at least some of the following characteristics:

- multiple acceptable solutions exist
- competitive instructions
- role-playing or predefined conflicting stances are used
- required information is split between the group members
- students with conflicting original beliefs are grouped together
- an initial individual work stage in which students construct their own stance or solution
- a joint product is required

Such task characteristics appear to provoke collaborative argumentation. Support can be provided through structured interaction at the interface (Dialab and Belvédère both used this approach), although our review suggests that this may have a negative effect if the structure is not well designed or is not suitable for the current task. Considering the interaction, structuring dialogue acts in a hierarchical manner (as was done in CLARE) and thus making them interdependent was clearly disadvantageous. A mistake in choosing the first dialogue move can result in a whole sequence of inappropriate dialogue acts or sentence openers being used and hence cause problems in the discussion. In addition, control of turn-taking can discourage elaboration when it prevents multiple moves being made in one turn. Therefore, it is preferable to place no restrictions on turn-taking control in the communication window or on the use of dialogue moves, so that any dialogue act can be used in combination with and following any other dialogue act (this includes dialogue moves, sentence openers and free text). Hence, a richer set of interactional moves is available that may be suitable for different interactive contexts. Enabling communication using built-in argumentative dialogue acts, sentence openers **and** free text input can stimulate critical checking procedures without inhibiting students' argumentation and problem solving. In addition, graphic argumentative dialogue acts in the task window can add value to the exploration of multiple perspectives and elaboration. Finally, turn-taking control can be used in the task window, regulating the co-ordination process needed to create the final product.

It is obvious that when designing environments to *provoke* discussions and to *support* argument in collaborative problem solving, both task characteristics and structured interaction at the interface must be taken into account and the interaction between the two must be considered thoroughly. However, our framework is tentative because further research is needed in this area. It is our aim to suggest the directions in which research might usefully proceed. Encouraging the important argument processes of information checking along the central route, exploration of multiple viewpoints and elaboration of the arguments is affected by the choice of problem-solving domain, the task characteristics and choice between asynchronous or synchronous modes of communication in network-based environments. Further research could be done comparing students working on the same task in structured versus unstructured interfaces, taking into account graphic or text-based dialogue moves, sentence openers, the availability of free text entry and turn-taking control in both task and communication windows. Also we need to have a stronger idea of how certain task goals can be supported by structuring the interaction. In the evaluation of the selected systems mismatches were observed between the task goals and characteristics of structured interaction. This seems to suggest that software may have to be written specifically for a range of problem types, rather than attempting to build one generic system for all.

The importance of continuing this line of research is obvious considering the increase of network-based learning environments in the last decade. The need for research results detailing how to provide effective support for electronic discussions during collaborative problem solving has increased, yet the answers are not easily forthcoming. Hopefully, during the next decade further studies will be conducted in this area and the results will be made available to the many education practitioners who want to make use of this new technology.

Chapter 4

LEARNING THROUGH SYNCHRONOUS ELECTRONIC DISCUSSION[1]

This article reports a study examining university student pairs carrying out an electronic discussion task in a synchronous computer-mediated communication 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, we compare a control group in which no peer coach is available with two forms of peer coaching. We instruct peer coaches to be centred either on structuring arguments or on reflectively checking of arguments on strength and relevance. The results indicate that, first of all, the study of students' learning from electronic discussions requires analysis of focus in relation to argumentation. Secondly, 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 also may 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.

---

[1]Veerman, A. L., Andriessen, J. E. B. & Kanselaar, G. (2000). Learning through synchronous electronic discussion. *Computers & Education, 34*(2-3), 1-22.

4.1 Introduction

An important issue in learning research is the construction of knowledge through negotiation. Some of the ways in which students negotiate the meaning or interpretation of knowledge have been found to enhance their learning. Collaborative learning is regarded as an activity encouraging knowledge construction 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. The purpose of this contribution is to present results pertaining to argumentation and learning in a task that explicitly focuses on meaning negotiation.

We work with students of Educational Sciences. 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 dealing with this type of knowledge domain hefty negotiation is needed. Hence, critical discussion seems an appropriate instructional means. In argumentation students can check, challenge and counter each other's doubted or disbelieved 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.

To support and optimise students' engagement in argumentative dialogues for learning purposes, computer-mediated communication systems (CMC) 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.

4.2 Factors in collaborative argumentation

In effective collaborative argumentation students share a focus on the same issues and negotiate the meaning of each other's information. Incomplete, conflicting, doubted or disbelieved information needs to be critically checked, challenged or countered on the basis of strength (is the information true?) and its relevance (is the information appropriate?), until finally an accepted or shared belief arises according to the discussed information. However, provoking argumentation as well as generating effective negotiation in educational situations is not guaranteed and poorly understood, especially in electronic environments. In the following sections we will consider the subsequent factors of collaborative argumentation: focusing (4.2.1) and critical argumentation (4.2.2) in relation to learning (4.2.3), to implications for peer coaching (4.2.4) and to electronic environments (4.2.5).

4.2.1 Focusing

In collaborative learning, focusing plays an important role in the interpretation and understanding of communication. Students have to initiate and maintain a shared focus on the task. 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.

4.2.2 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 persons (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 doubted or disbelieved information is assumed to support students' understanding and learning. In the current study, we consider these argumentative 'moves' to be important since they may provoke discussion aimed at reaching insight and understanding of a conceptual model.

4.2.3 Learning-in-process: the production of constructive activities

From a rhetorical 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 argumentation tasks is to have students 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 centre on forms of knowledge articulation that seems 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.

4.2.4 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 (Veerman, Andriessen & Kanselaar, submitted).

Key problems that may inhibit students to engage in critical argumentation are those in which:

- students tend to believe in one overall correct solution, even in ’discussible’ knowledge domains
- students show difficulties to generate and compare counter-arguments to arguments
- students experience difficulties to use strong, relevant and impersonalised justifications
- students’ exposure of a critical attitude can be inhibited because of socially biased behaviour. For example, students may fear to lose face (e.g. in front of classmates), to go against dominant persons in status or behaviour (e.g. a tutor), or for what other people think (e.g. that you are not a nice person)

(see also: Treasure-Jones, submitted thesis, p.13; Kuhn, 1991):

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 focused on argument structures (the ’structure’ coach) and on critical assessment and justification of arguments (the ’reflective’ coach). The ’structure’ coach is focused on argument building, particularly on generating and comparing alternative and contrasting statements, arguments and elaborations. The ’reflective’ coach is focused on checking information on meaning, strength and relevance and on questioning connections between claims and arguments. In Table 4.1 (see p. 77) the two coaching strategies are described in more detail.

4.2.5 Computer-mediated communication

Text-based and time-delayed communication can be beneficial to keep track and keep 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 be achieved than in face-to-face (F2F) situations (see e.g. Moore, 1993). This can be especially harmful for maintaining a shared focus in argumentative dialogues.

On the other hand, considering socially biased behaviour, in CMC systems the lack of physical and psychological cues such as physical appearance, intonation, eye contact, group identity etc. sometimes leads to democratising effects (Short, Willams & Christie, 1976; Kiesler, 1986; Rutter, 1987; Spears & Lea, 1992; Smith, 1994; Steeples et al., 1996). Critical behaviour, therefore, is expected to 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 focusing, argumentation and learning in computer-mediated communication. As a general expectation, we expect argumentation while focusing on the meaning of concepts to be positively related to the production of constructive activities. However, we expect that the situation of computer-mediated communication 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 coaches allow us to analyse more specific expectations indicating that a focus on specific types of argumentation may enhance specific constructive activities in the dialogue. We address the following questions:

(1) *How can dialogues, produced by student pairs during the discussion task, be characterised in terms of focusing and argumentation and how does that relate to the production of constructive activities?* First of all, we expect a high number of argumentative dialogue moves to be positively related to the production of constructive activities. Secondly, 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. Finally, frequently shifting focus is expected to be negatively related to the production of constructive activities.

(2) *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

produce particularly explanations through the mediation of checks. Student pairs guided by the ’structure’ peer coaches are expected to produce particularly evaluations through the mediation of challenges and counters.

In addition, we used a prior knowledge test to select students to be instructed as peer coaches, we asked students pairs to judge the quality of their own discussion and interventions of the coach (for future assignments) and we traced the global strategy of all student pairs. Out of practical opportunity and curiosity, we decided to use the results to look for some individual differences between student pairs affecting the production of constructive activities.

4.3 Method

We integrated an experiment in an actual undergraduate course on Educational Technology. One of the learning goals in this course was to reach insight and understanding in the ’Conversational Framework’ (Laurillard, 1993; Figure 4.1), 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 and a control group (no coaching).

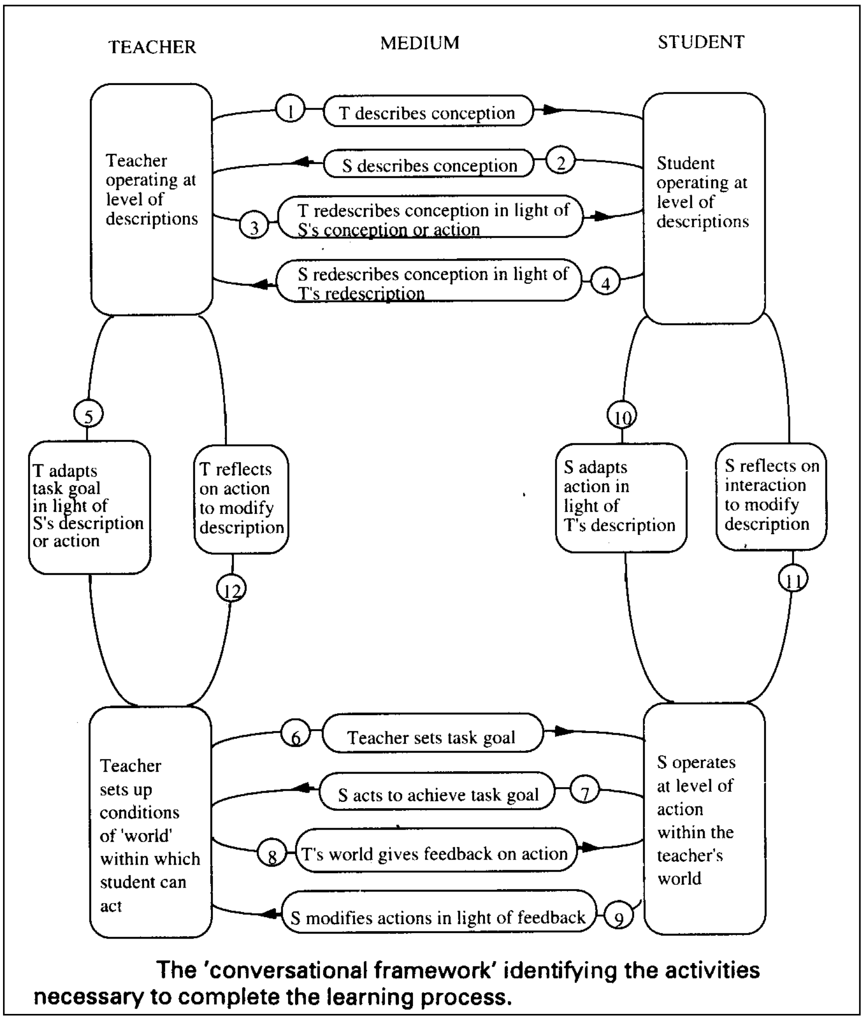


Figure 4.1. The Conversational Framework (Laurillard, p.102; 1993).

4.3.1 Sample and procedure

Restricted by the limited numbers of students subscribed to the course on Educational Technology, we collected data in two subsequent times the course was offered: in November 1997 and in January 1999. In 1997, we collected data of 42 undergraduate students in the coached conditions. In 1999, we studied 26 students 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.

During the second week of the course students were instructed to study by book the 'Conversational Framework' at home. In the third week, the students were engaged in our study as part of their educational program. All students first took a 10-minute knowledge test about the framework. Then, they received 30 minutes of technical instruction on how to use the chat tool and to share an application by the synchronous CMC system *NetMeeting*. In 1997, subsequently the best prepared students (determined by a factual knowledge test) received a 10-minute instruction for peer coaching. They needed sufficient knowledge of the 'Conversational Framework' to adapt specific coaching strategies to situated students' discussions. In the meantime, the other students analysed individually 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 made these analyses. Subsequently, students were randomly paired and confronted with each other's differences when starting to analyse the same protocol together, using *NetMeeting*. Instructed to reach shared answers in a 45 to 60 minute discussion (we used flexible time-constraints), spontaneous discussions were expected to 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 4.1.

Table 4.1. 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 twelve 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, e-mail 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. 17 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 negative perspective. Dependent of the situation (e.g. initial disagreement, agreement) interventions include question types such as: "What arguments can you give to support your choice/opinion?, "What counter-arguments can you think of ?", "Are there any other solutions…?", "Are there any arguments for or against 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 include '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.
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 would mainly ask questions instead of giving answers. 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 critical 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 5-point Likert scale (from full agreement to full disagreement) regarding seven statements aimed at task focusing, 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.

4.3.2 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) students are not task-related or end the discussion. Phases of content-related discussion (3) were analysed in depth on focusing (including focus shifts), dialogue moves (including argumentation) and constructive activities (see Table 4.2). Our main goal was to study the interplay between focusing, 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. In addition, the focus could be (3) on the task strategy (planning how to start the task, time management, how to carry out the task, keeping an overview of the task, etc.). In addition, two categories of focus *shifts* were distinguished: focus shifts from understanding to the use of concepts and vice versa, and shifts from the meaning or use of concepts to the task strategy and vice versa.

The categories of dialogue moves indicated how argumentation was triggered. Considering several approaches in the field of analysing Educational Dialogue (including analyses of Dialogue Games, Exchange Structures and Communicative Acts, Argument and Rhetorical Structure; see Pilkington, McKendree, Pain & Brna, 1999; Treasure-Jones, submitted), we decided on six dialogue moves: statements, checks, challenges, counters, acceptances and conclusions. Although these categories can contain elements of argument, we view checks, challenges and counters as *argumentative* dialogue moves.

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 *dialogue move* categories and a kappa of 0.74 for *constructive activities*.

Table 4.2. Categories of data analysis for content-related discussion.

Variables	Categories
Focusing	- Meaning of concepts - Use of concepts - Task strategy
Shifting focus	- Meaning ⇔ use - Meaning or use ⇔ task strategy
Dialogue moves	- Statement - Acceptance - Conclusion *Argumentative* dialogue moves: - Check - Challenge - Counter
Constructive activities	- Adding information - Explaining information - Evaluating information

Example of analysis

In Figure 4.2 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 2 lines are truncated to two lines in the screen dump. A description of the analysis is provided at the next page.

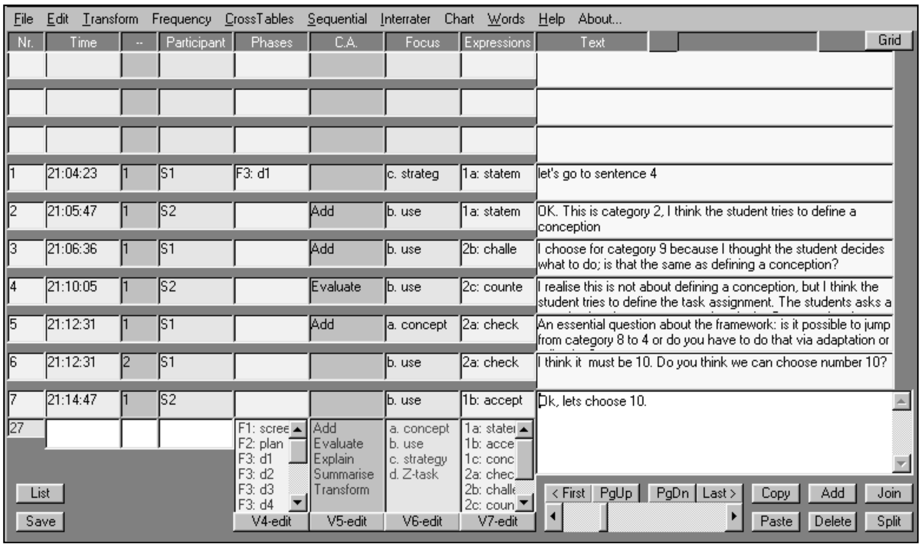


Figure 4.2. Example of analysing a discussion (C.A. = Constructive Activity type; Expressions = dialogue moves).

<u>Description of the analysis:</u>

(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 focuses 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 the Conversational Framework! So, 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.

4.4 Results

In section 4.4.1, we will globally describe student variables and how student pairs accomplished the discussion task. In section 4.4.2 we will report on the examined relationships between focusing, *argumentative* dialogue moves and the constructive activities. In section 4.4.3 we will present differences found among student pairs in the three conditions. In section 4.4.4 we will summarise our first findings that subsequently lead to some additional analyses. Presenting the results of a cluster analysis and discriminant analysis will close this section.

4.4.1 Student variables and task approach

In 1997, 14 discussions (2 students and 1 peer coach each) were logged on the computer. Two discussions were removed from the analysis since two students with low scores on the knowledge test accidentally peer coached these discussions. A third discussion was not task-oriented: students spent their time on imitating Beavis and Butthead. Of the 11 discussions left for analysis, 5 were guided by 'structure' coaches; 6 by 'reflective' coaches. In 1999, 13 discussions (2 students per discussion group) 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.

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 groups' production of constructive activities in discussion groups.

Self-judgement. Regarding the quality of the discussion and the coach, both students and peer coaches stated their personal opinion by answering questions on a 5-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 (mean = 3.5 respectively mean = 3.8). 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 ($T_{(10)} = 2.4$; $p < 0.05$). No relationships were found between personal opinions, (self) judgement of the peer coaches and the production of constructive activities.

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 briefly discussed how to carry out the task. All groups proceeded through their assigned task in order of the sentences that were to be categorised. In each condition, more time was spent on categorising the first three sentences than on subsequent ones. None of the student pairs spent much time on closing off the task. Due to the experimental setting and flexible 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 positive relationship between the average time spent per message and the production of constructive activities ($r = 0.68$; $p < 0.01$). Considering time and the number of messages sent, a MANOVA obtained no significant differences between groups, due to large variations within conditions and across years (see Table 4.3).

Table 4.3. MANOVA on messages sent and time (on task).

	Coach condition	Nr of pairs	Mean	Std. Deviation	F	P-value
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 in seconds	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 (in sec.'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		

4.4.2 The relationships between focusing, argumentation and constructive activities

To characterise electronic discussions in terms of focusing 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 dialogue moves (including argumentative moves) 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, focusing and the production of constructive activities, not at the absolute number of messages provoked per condition.

First, the relationship between argumentative dialogue moves 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 constructive activities were found ($r = 0.26$; $p = 0.28$).

Second, we analysed the relationship between focusing and constructive activities. Student pairs that focused on the meaning of concepts were expected to produce more constructive activities than groups that focused 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, focusing 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 focusing 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 focusing on the meaning of concepts on the one hand and the production of constructive activities on the other hand ($r = 0.48$; $p < 0.05$).

4.4.3 '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 our expectations we found 'structure' peer coaches to be aimed at the argument structure and at asking questions to provoke multiple perspectives and pro and contra argumentation. 'Reflective' peer coaches focused 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 briefly engaged 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.

Table 4.4. MANOVA for peer coaching ('structure' versus 'reflective' versus no coaching).

Categories	Coach	Mean	S.D.	F	P-value
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		
Counter	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	1.80	0.20
	Reflective	8.9	7.0		
	Control	6.4	4.7		
Use * Argumentation	Structure	29.5	7.3	1.10	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		

The two coaching conditions and the control group were tested on differences in argumentation, focusing, shifting focus, focused argumentation and the production of constructive activities. Analysis of variance (MANOVA) only showed two small differences considering challenging information and adding activities (see Table 4.4).

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.

4.4.4 Added analyses

Analysis of variance, revealed less clear differences among the conditions than we expected. To reach more insight into the interplay between focusing, argumentation and the production of constructive activities, we decided to continue our analyses exploratively by executing a cluster analysis (see 4.4.4.1) to identify relatively homogeneous student pairs on the following six variables.

- 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 finally executed a discriminant analysis (see 4.4.4.2).

4.4.4.1 Cluster analysis

We explored our data by attempting to re-organise the 20 student pairs in clusters. A K-Means Cluster Analysis iteratively classified the groups into three final clusters (see Table

4.5). We additionally requested analysis of variance F statistics to reveal information about the contribution of each variable to the separation of the clusters.

Table 4.5. Student pairs clustered on mean percentages of focused 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-use 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		

As is shown in Table 4.5, 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 balance between discussing the meaning of concepts and 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 cluster 2. We label this first cluster 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 quit 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 task strategy is not as much focused on (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 third cluster as the group of *Conceptual Achievers*; student pairs shifting back and forth 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 quit 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 frequent compared to the other clusters.

Nevertheless, the number 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.

4.4.4.2 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 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 4.6) 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.

Table 4.6. Canonical discriminant functions evaluated at group means.

CLUSTER	Function 1	Function 2
1: Achievers	-1.6	-0.5
2: Conceptualisers	3.5	-0.9
3: Conceptual Achievers	0.6	3.6

The first function can be explained as a dimension that reflects *how* content-oriented information is argued about. Referring to the characterised clusters on the six variables (see Table 4.5), 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 focused on and shifted focus towards the *meaning* of concepts. The negative side of the function can be interpreted as argumentation that is mainly focused 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 Figure 4.3, a plot presents the clustered student pairs on these functions of meaningful interaction and strategy-oriented discussion.

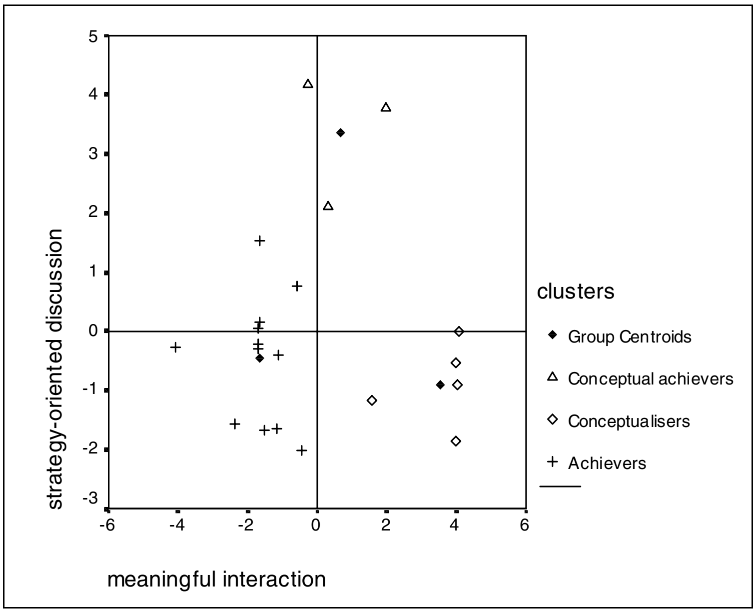


Figure 4.3. Canonical discriminant function (plot of numbered student pairs).

Figure 4.3 shows that the *Achievers* score negatively on the function of meaningful interaction. In addition, they appear to engage many times in strategy-oriented discussion (as shown by a **negative** score on this function). *Conceptualisers* can be explained more positively; they engaged highly in meaningful interaction. However, they also spent their time on strategy-oriented discussion. This combination of meaningful interaction interfered by strategy-oriented discussion may explain the relatively low number of constructive activities despite the balanced focus and focus shifts towards on the meaning of concepts (see Table 4.5). Their constructive power seems to be 'hidden' behind strategy-related problems, such as organising the task and keeping track of the discussion at the interface. *Conceptual Achievers* are less explained by the function of meaningful interaction than by the function of strategy-oriented discussion. Thus, the lack of strategy-oriented discussion appears to mainly explain the highest number of constructive activities produced among the conditions (see Table 4.5).

In Table 4.7, 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 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.

Table 4.7. Number of pairs in different conditions organised into clusters.

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

4.5 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 the synchronous CMC environment (NetMeeting), how they focused and argued about discussible 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 analysing focus in relation to argumentation. Argumentative moves are only related to the production of constructive activities when they are focused on or shift focus towards the meaning of concepts.

Secondly, 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 focused on and shifted towards the meaning of concepts. Student pairs that can be characterised as *Conceptualisers* and *Conceptual Achievers* (mainly aimed at a meaningful focused 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 especially from the use of concepts to their meaning. In reference to the protocols, 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 focused argumentation. Organising the interface, keeping track of the discussion and holding an overview proved to be problematic and triggered **strategy-oriented discussion**, which inhibited or interfered meaningful discussion. One of the reasons may be that in this specific synchronous CMC system messages are sent as a whole. 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 losing 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 (1977) 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, 1999). Other solutions may be found in providing students with electronic systems that comprise multiple spaces for negotiation, such as MUD's and MOO's (Dillenbourg & Baker, 1996)[2]. 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 losing 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 can all 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 of a focused 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

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

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 evident. Technical progress, the interest in the use of CMC systems for education, the ever-increasing need for life-long learning, for collaboration and reflection, for discussion to cope with this complex society, ask for empirical studies designed from a modern, constructivist perspective. Although this type of research is detailed, time-consuming and answers are not easily forthcoming, we hope that in the next decade further studies will be conducted in this area to reach insight and understanding that can be applied to software for future education.

Chapter 5

CO-CONSTRUCTING MEANING THROUGH DIAGRAM-MEDIATED ELECTRONIC DISCUSSION[1]

The aim of this research is to provide suggestions for computer support to enhance collaborative learning through argumentative discussion. We focus on small groups of academic students engaged in electronic discussion using the Belvédère environment, a networked software system for synchronous chat discussion and argumentative diagram construction. We are specifically interested in the relationship between chat discussion and argumentative diagram construction. Our approach is to characterise chat discussions on focused argumentation and constructive contributions and to analyse the diagrams on organisation and selected information from the chat discussion. The results show a complex interplay between chat discussion, diagram construction and student groups' characteristics, which partly overlaps with some earlier findings (Veerman, Andriessen & Kanselaar, 2000). We discuss our results in the light of guiding the development of support for effective student interaction.

[1] Veerman, A. L. & Andriessen, J. E. B. (submitted). Co-constructing meaning through diagram-mediated electronic discussion. *Journal of Artificial Intelligence and Education*.

5.1 Introduction

Computer-supported collaborative argumentation (CSCA) is concerned with problems such as how computer-mediated situations for argumentative interaction should be designed in order to support learning. For some it has been well attested that under certain conditions, specific forms of communicative interactions can be vehicles for learning (e.g. Baker, De Vries & Lund, 1999). Such 'epistemic' interactions focus on meanings of terms and concepts in a domain, and characteristically involve argumentation and explanation (Ohlsson, 1995; Baker & Bielaczyc, 1995; Baker, 1999). In CSCA, one of the conditions relates to the role of the communication interface and the learning environment. The main issue is how the communication interface should be designed in order to provoke and support epistemic interactions to facilitate learning and problem solving with computers (Veerman & Treasure-Jones, 1999). Research on interface design has taught us that such questions cannot be easily answered by systematically varying interface characteristics. Indeed, the affordances of an interface design interact with aspects such as the knowledge domain, the task, types of instruction, the type of learners and the mode of communication (Veerman, Andriessen & Kanselaar, submitted). This is why we prefer to talk about an environment, instead of a system or an interface.

Baker et al. (1999) propose three general conditions favouring the production of epistemic interactions, two of which concern the interface. First of all, to focus discussion, the interface should display the ideas under discussion as well as students' opinions with respect to them (e.g. Suthers & Weiner, 1995). Secondly, the effort to produce a message and to manage the communication should be minimised (see also Baker & Lund, 1996). Finally, the topic of discussion should be debatable (Golder & Pouit, 1999), and participants should have well elaborated views and clearly expressed and mutually recognised opposed attitudes with respect to the subject of debate. It should be noted that with respect to learning, the third constraint presents a paradox: a characteristic of the knowledge of students engaged in debates for learning purposes is that it is not always well elaborated. With respect to the second condition, despite serious attempts to design an interface befitting their requirements, Baker et al. (1999) still report a high degree of effort by students needed for interaction management.

The current work concerns the first condition. We present a study on the relationship between synchronous chat discussion and argumentative diagram construction using the Belvédère environment, a networked software system that supports these facilities (Suthers & Weiner, 1995). We focus on students collaboratively trying to reach understanding and insight into concepts relevant to a design problem at stake. Specifically, our focus is on meaning co-construction through epistemic interaction. The term 'co-construction' implies that new meaning or understanding does not necessarily arise as a function of individual activities but may be constructed in interaction, particularly during argumentation (Baker, 1996; Baker, 1999). We aim to characterise and evaluate students' discussions in terms of interaction and argumentation, collaborative learning and use of the environment.

The remainder of the article comprises two sections. In the first section, the Belvédère environment is described on its pedagogical affordances, also in reference to an earlier Belvédère study we conducted. Then, the educational context is described and subsequently, the main research variables are presented. These variables are explained in close relationship to the so-called NetMeeting study, a study we carried out in the same line of research. However, the NetMeeting system was only used as a basic tool for synchronous chat discussion and not for argumentative diagram construction. In the second section, the present Belvédère experiment is discussed. The method of analysis is presented before describing the results in detail. Finally, some conclusions are drawn and perspectives are offered for future research.

5.2 Background issues

5.2.1 The Belvédère environment and its pedagogical affordances

The Belvédère environment is a synchronous networked software system developed by Dan Suthers and others at the Learning Research and Development Center at the University of Pittsburgh (Suthers & Weiner, 1995; Learning Research and Development Center, 1996; Suthers, 1998). Belvédère was originally developed as a tool for secondary school students (age 12 - 15) to reconstruct scientific arguments by constructing argumentative diagrams on the basis of scientific information. To communicate, each student has a text-based chat box in which multi-line messages can be created and sent. Messages, coupled with the writer's name, are displayed in a shared chat history. Students can only add data into the diagram by using a predefined set of text boxes ('*hypothesis*', *'data'*, *'unspecified')* and links (*'against'*, *'for'*, *'and')*. Boxes and links with different functions have different shapes or colours. These are shown in the menu bar of Figure 5.1.

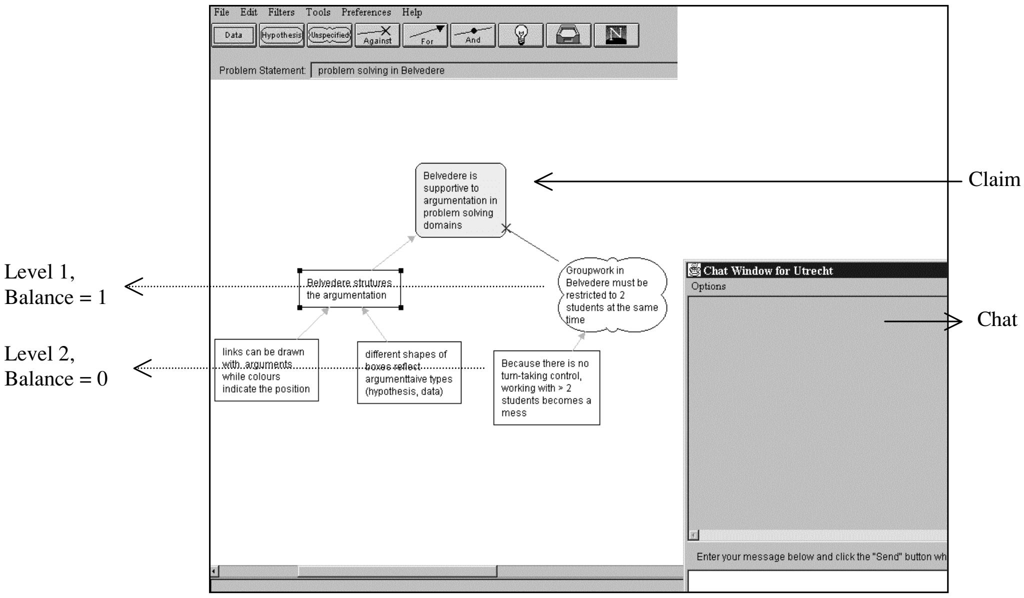


Figure 5.1. The Belvédère system.

In this contribution, we examine the idea (not necessarily the opinion of its developer) that Belvédère forms an appropriate and dedicated interface for organising and understanding argument in collaborative learning tasks. Literature on graphical representation and comprehension generally shows that such representations foster comprehension when they support a focus by transparency on salient and important features of a task (Ghyselink & Tardieu, 1999; Reimann, 1999). In its most basic form, an argument can be seen as an organised structure of a claim and evidence oriented for and against the claim. This structure is essentially not linear (McCutchen, 1987; Adam, 1992; Coirier, Andriessen & Chanquoy, 1999). Hence, linear interfaces may not be optimal for supporting and representing such a structure. In addition, linearisation is considered to be one of the most important problems for coherent argumentative text production. To put an argument onto paper, strategic mental effort is required, and considerable linguistic competence needed (Coirier, Andriessen & Chanquoy, 1999). Hence, non-linear representation of argumentation might facilitate learning and understanding, because it may be easier to construct than a linear argument, thereby leaving more room for attention to other aspects of a learning assignment. In addition, a diagram as a representation of argumentation may be easier to understand and serve as a better source for further debate than linear text. The diagram could be particularly supportive if it is used in a manner closely linked to the chat and serves to trigger discussion about arguments that are still unclear, or not yet stated, discussed or justified (Veerman & Treasure-Jones, 1999). The diagram construction tool, therefore, may help students to organise their argument and to keep track of the main issues under discussion.

Input into the Belvédère diagram construction tool is constrained by a labelled set of argument boxes and links. Students, nevertheless, are free to fill in boxes with any information they like. A general expectation is that students will be cued by the labelled argument boxes and links, which correspond to the input of arguments that can be oriented and organised for and against a claim (Kozma, 1991). In other words, they will use the tool to represent the content of arguments and not procedural matters. A first study with the Belvédère system confirmed this expectation (Veerman, Andriessen & Kanselaar, submitted). The study took place in the context of an academic course on Computer Based Learning (CBL). Small groups of students were instructed to use the Belvédère system for a discussion about learning goals and pedagogical aspects concerning the design of a CBL program. The students produced 14 dialogues and corresponding diagrams (7 pairs * 2 assignments). The number of statements and arguments expressed (pro and contra) in both the chat discussions and the corresponding diagrams were measured and compared. The results showed that the diagrams contained a higher proportion of content information (statements, arguments, elaborations) and a better balance between positively and negatively oriented arguments.

The Belvédère environment may enhance the process of collaborative learning through diagram-mediated argumentative discussion. The diagram construction tool may support students in organising their arguments and keeping track of the discussion by representing (discussed) information. This may trigger new discussion in the chat, about issues raised by the organised representation, maybe in the form of elaboration of discussed content or as arguments that have not yet been discussed or justified. In addition, use of a diagram may affect task approaches, in the sense that the argumentative orientation of the discussion may be fostered, displayed by a focus on meaning negotiation. The question whether such support fosters a focus on important features of a task should be reformulated in this light. In this research we discuss data pertaining to some of the conditions under which meaning negotiation may emerge. The main question can be generally formulated as: *What is the relationship between ongoing chat discussion and the produced argumentative diagrams?* The next paragraphs serve to explain the manner we wish to attack this question.

5.2.2 Educational context

The participants in our experiments are undergraduate students in Educational Technology. In this academic area, students have to deal with open-ended, ill-structured, vague, abstract and complex concepts or problems. Conceptual understanding and problem solutions may legitimately vary with prior knowledge, general opinions and personal beliefs and values (Petraglia, 1997). While the main thrust of the curriculum can still be taken as transmission-based (Andriessen & Sandberg, 1999), there are attempts at introducing more open tasks, such as writing and discussion, including collaborative learning and the use of electronic means.

In collaborative learning, students can externalise and discuss the meaning of concepts and problems to compare and contrast different ways of understanding or handling them. This can be particularly effective when students encounter conflicts and manage to produce a shared meaning or problem solution through negotiation. Argumentation may trigger students to rethink their understanding of a problem and to revise conceptual knowledge, beliefs and values (e.g. Piaget, 1977; Doise & Mugny, 1984; Baker, 1996; Erkens, 1997; Savery & Duffy, 1996; Petraglia, 1997). The educational objective of using the electronic collaborative learning tasks that we focus on is for students to co-construct meaning in order to promote understanding and insight into conceptual knowledge, not to learn argumentation or debate strategies. Our research focuses on creating the appropriate environments to foster such collaborative learning, especially through argumentative discussion.

Not all collaborative assignments lead to argumentation and not all argumentative discussions foster learning (Baker, 1996; Veerman, Andriessen & Kanselaar, submitted). To understand and support students' argumentative discussions so as to facilitate learning, we have to be more detailed than that. The problem is, where to look and what to look for. Full insight into collaborative learning tasks is a long-term goal to strive for, but at this moment, we have to look for interesting observations in large amounts of data. In our research we have established a limited set of variables, which seem to be important in this respect (Veerman, Andriessen & Kanselaar, 2000). These variables are derived from collaborative learning research, and will be discussed in the next sections.

To understand the role of argumentation in the process of collaborative learning in electronic situations requires characterising sequences of interaction as to their relation to the learning and task goals. In open tasks, such as writing or discussion about meaning, it is hard to characterise learning as the result of completion of a single assignment. Approaches to discourse analysis do not seem to support the openness and complexity of our educational setting and the unpredictable unfolding of the discussion itself. Many approaches require well defined concepts or problems that can be divided and subdivided until an 'atomic' level has been reached (e.g. Katz, O'Donnel & Kay, 1999). Others are content-free but based on formal dialogue classifications, such as speech act pairs (e.g. Question/Answer; Argument/Counter-argument), or strict dialogue rules (e.g. Moore, 1993). Flexible systems, such as the DISCOUNT scheme (Pilkington, 1999), aim at levels and categories to describe properties of dialogue in detail.

For our purpose, the examination of the relationship of argumentation to collaborative learning in Belvédère discussions and diagrams, we present a limited approach with respect to the number of selected variables and categories. This does not allow us to model the dialogue as a whole, but may give us the opportunity to characterise the relationships between the variables. The variables we choose are based on previous research. Another restriction of the research should be noted: we do not want to tutor our students. Hence, we are not looking for correct answers or flawed arguments on the part of the students but we focus on the collaborative learning processes themselves.

5.2.3 Research variables

In this section, our main research variables are presented in close relationship to an earlier study, in which we assessed collaborative learning through argumentation by using the NetMeeting system (Veerman, Andriessen & Kanselaar, 2000). NetMeeting is a networked software system, allowing synchronous chat and sharing of applications between several users over the Internet. The NetMeeting study was integrated into an academic course on Educational Technology and aimed at students' development of reaching insight and understanding in the 'Conversational Framework', a theoretical model for analysing tutor-student interaction (Laurillard, 1993). In this study, 20 student pairs were given a 45-60 minute discussion task, in which they were instructed to analyse a protocol of a tutoring session according to the 'Conversational Framework'. Student pairs were peer coached 'reflectively' (aimed at triggering justifications), 'structured' (aimed at counter-argumentation and multiple perspective taking) or not at all.

The analysis we undertook aimed at discovering to what extent effective chat discussions were related to argumentation and collaborative learning activities in these circumstances. In addition, we wanted to find out what effects the coached support would have in this respect. We looked for variables relating task approach to collaborative learning activities and argumentative moves in dialogues. As far as we know, such a combination of variables has not yet been studied explicitly. Based on research on collaborative learning and argumentation (Baker, 1996; Baker, 1999; Erkens, 1997) we analysed the NetMeeting discussions on the variables of (1) focusing, (2) checks, challenges and counter-arguments and (3) the constructive activities produced. In the next sections, each of these variables will be elaborated.

5.2.3.1 Focus

Focusing refers to the way the participants maintain the same topic in their dialogue. In collaborative learning, students have to initiate and maintain a shared focus on the task at hand. In order to achieve this, they generally have to agree on their interpretations of the overall learning goal, descriptions of the current problem-state, and available problem-solving actions (Roschelle & Teasley, 1995). Shifting focus, defined as failures to maintain a shared focus during the discussion, can result in less effective learning (Baker & Bielaczyc, 1995; Erkens, 1997).

Defining exactly what kind of focus should be shared and maintained is determined by the learning and task goals, as set by instructors or by the students themselves. In the NetMeeting study, students were supposed to reach insight and understanding of theories and concepts while discussing conceptual information in order to solve problems as set by the task. We identified three types of focus categories and two types of focus shifts:

(F1) focus on understanding the meaning of concepts (semantic level)

(F2) focus on the application of concepts (pragmatic level)

(F3) focus on task strategy or non-task related issues (procedural level)

(F4) focus shifts between conceptual issues (F1 + F2) and task-strategy / non-task related issues (F3)

(F5) focus shifts between understanding the meaning of concepts (F1) and the application of concepts (F2)

5.2.3.2 Argumentation

Critical assessment of each other's knowledge and inferences is considered by many to be a characteristic of effective collaboration and learning (Petty & Cacioppo, 1986; Erkens, 1997; Buckingham Shum, MacLean, Bellotti & Hammond, 1997). Through argumentation, strengths, weaknesses and the understanding of information can be questioned and discussed. For our purposes, we are not (yet) interested in the effects of argumentation, as changes in beliefs or acceptance of positions. Our concern is the incidence of argumentation, when and how often it happens in terms of task focus, and whether or not it is related to learning activities.

In the NetMeeting study, we first selected all messages that were focused on understanding the meaning and the application of concepts (F1 and F2). Considering several approaches in the field of analysing Educational Dialogue (including analyses of Dialogue Games, Exchange Structures and Communicative Acts; see Pilkington, Treasure-Jones & Kneser, 1999), we subsequently categorised each of these messages as a general dialogue move (D), such as a 'statement' or 'other' (acceptances, conclusions etc.), or as one of the following *argumentative* dialogue moves:

(Da1) checks

(Da2) challenges

(Da3) counter-arguments

Checks were verification questions aimed at reaching understanding (e.g. "Do I understand it correctly... ", "Do you mean that... ", "What do you mean by... "). Challenges were questions that expressed at least doubt and aimed at provoking justifications (e.g. "How do you know that... ", "Why do you think that.... "). Counter-arguments expressed disagreement (e.g. "I don't agree... ", "I think it is the opposite/ something else... "). Statements could include opinions, ideas, new claims etc. However, they were not aimed at expressing doubt or disagreement.

It should be noted that focusing and argumentation could be seen as co-ordination processes in discourse essentially dealing with content matters. The incidence and the nature of these co-ordination mechanisms are contingent on characteristics of the knowledge being constructed. Our concern here is still with the incidence of such activities, not their content.

5.2.3.3 Constructive activities

Learning can be the result of sudden insights, brought about by prolonged reflection, problem solving or passive leisure. The learning results in open tasks depend to a great extent on prior knowledge, beliefs and values of the learner and what is expected to be learned. It is hard to precisely assess this knowledge beforehand. In addition, because of the unpredictable nature of discussions, reliable post-tests are even more difficult to conceive. This does not mean that this is impossible, simply that the domain should be well researched and may have to be restricted on content before adequate tests can be developed. Interesting examples of such studies for the analysis of writing tasks can be found in Alamargot (1997) and Dansac and Alamargot (1999).

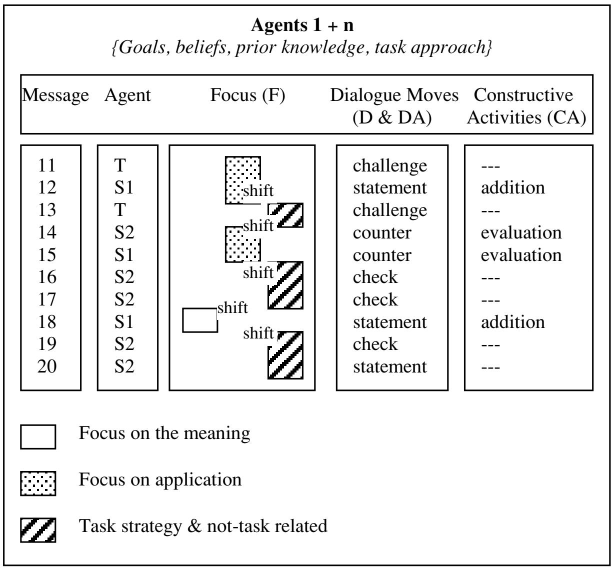
To examine collaborative learning, the option we put forward is to look at what happens with knowledge during the dialogue. Knowledge-building discourse can be viewed as an externalised and collective information network that is dynamic and in which content can grow or change by explicit constructive activities, such as additions of information, explanations, evaluations, summaries and transformations. Additions contain new information that cannot be linked to earlier chat messages. Explanations are linked to earlier chat messages, and 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. Information transformations are based upon evaluations and lead to new insights or directions for further discussion. In summaries, already stated information is (re) organised in such a way that selected points of the discussions are put in relation to each other and reflect the main content of the discussion. Some researchers speculate that in knowledge-building discourse 'explaining' is the major constructive activity (Scardamalia & Bereiter, 1994; p.274). We regard the production of constructive activities as signals of potential support for collaborative learning-in-process as they appear to be connected with knowledge-building discourse to co-construct meaning.

In the NetMeeting study, students tried to co-construct meaning by knowledge-building discourse in which they could produce constructive activities. Chat messages that focused on the meaning or application of concepts, therefore, were subsequently analysed on the production of constructive activities in addition to argument analyses (see Table 5.1).

Table 5.1. Categories of focusing, argumentation and constructive activities

Focus	Dialogue moves, including argumentation (F1 & F2)	Constructive activities (F1 & F2)
F1: Meaning of concepts F2: Application of concepts	D : statement, other Da1: check question Da2: challenge Da3: counter-argument	CA1: addition CA2: explanation CA3: evaluation CA4: summary CA5: transformation
F3: Task strategy / non-task related issues	---	---
F4: Shifts between the meaning and application of concepts	---	---
F5: Shifts between conceptually oriented discussion (F1 & F2) and task strategy / non-task related issues (F3)	---	---

In Figure 5.2, an example is shown of a NetMeeting chat discussion in which single messages (11-20) are analysed on respectively focusing, dialogue moves (including argumentation) and constructive activities. In this example, two students (S1, S2) are engaged in a chat discussion in order to analyse a protocol of a tutoring session. They try to analyse utterances by using the ’Conversational Framework’. The framework offers a scheme with 12 categories that can be used for labelling single utterances. An instructed peer coach provides support on collaborative argumentation in order to enhance collaborative learning processes (T). Text and explanations are given below the analysed fragment in Figure 5.2.



Text	*Explanations*
10. (...)	*(...)*
11. I think I get it. But Maria, why are still at the bottom of the scheme?	*In other words: "why do you want to apply these categories to the sentence?"*
12. I mean category 7 *(student acts to achieve task goal),* which is at the bottom of the scheme. I think sentence 2 is interactive. The student asks a question.	*Justification of choosing category 7; addition of new information to the dialogue*
13. Jeroen, what is your response?	*T challenges S2 to respond to S1*
14. Well, it is possible but I think sentence 2 is not interactive. It is a kind of structured question and if there is a good answer to it, I think the communication between the tutor and student is closed. I would say it is category 3.	*Countering the application of category 7 to sentence 2, followed by an evaluation of earlier stated information ('It is...closed)'.*
15. I think category 3 is the tutor's response. Thus, it can never be a sentence of the student. It should be category 4. But I think this question does not trigger any new concepts.	*Countering the proposal, evaluating why it is not possible to choose category 3 and stating another proposal.*
16. Yep, I have to read it again, ok?	*Strategic action checking agreement*
17. I mean, I am going to read it again, ok?	*Idem*
18. Ok, that's an argument. Uhhh, I think that questions are at all times interactive, but I may be wrong. Expert?	*Conceptual talk about characterising questions; adding new information ('questions... interactive').*
19. Ok, a response of the expert is possible, or do we need to ask other types of questions?	*Strategic talk*
20. I think the expert can't type very fast or we are not allowed to ask such questions.	*Strategic talk*
21. (...)	*(...)*

Figure 5.2. A NetMeeting chat discussion analysed on focus, argumentation and constructive activities.

In the NetMeeting study[2], students engaged in a fast flow of communication, in which they produced multiple messages per minute. They argumentatively checked, challenged and countered each other's information and produced constructive activities

[2] See for detailed results and statistics: Veerman, Andriessen and Kanselaar (2000).

(mainly additions and evaluations). Argumentation, related to a focus on the meaning of concepts, proved to be important for the production of constructive activities.

To what extent epistemic interactions were related to argumentation and collaborative learning activities was further explored by executing a cluster analysis. Student pairs' discussions were grouped on the interplay between focus, argumentation and constructive activities. The cluster analysis revealed that student pairs could be characterised as either (a) Conceptualisers: student pairs that engaged in meaning-oriented discussion; (b) Achievers: student pairs that engaged in product-oriented discussion, focusing on the application of concepts and aiming at finishing the task, or (c) Conceptual Achievers; student pairs that used a mix of meaning-oriented and application-oriented talk. Compared to product-oriented discussions, meaningful discussions could be characterised by focus shifts between the meaning and the application of concepts, argumentation and constructive activities. Thus, epistemic interactions appear to be particularly related to conceptually oriented argumentation and the production of constructive activities.

Conceptually oriented student pairs (a + c) did not profit from support offered by instructed peer students, however, the Achievers (b) did when 'reflective' support was aimed at checking information on strength and relevance. Finally, we concluded that the 1995 version of NetMeeting (2.0) was not an ideal system for synchronous discussion since many student groups encountered synchronisation problems. To establish an argument, students had to discuss information in the same communication interface as in which they had to discuss technical problems, planning issues and co-ordination aspects with respect to the task assignment. Conceptually oriented discussions were significantly interfered with focus shifts towards such types of task-strategy related interactions, which hindered the students to keep track of their discussion and to structure and organise their arguments.

In the present study, the Belvédère chat discussions are comparably analysed to the NetMeeting chats. Focusing, argumentation and the production of constructive activities showed to be functional variables in relationship to epistemic interaction, collaborative learning and the optimal use of the electronic system. The Belvédère environment, however, additionally provides students with a graphical tool for argumentative diagram construction. Therefore, additional diagram analyses are conducted and, three more variables are added: student groups' preparation time, judgement of the usefulness of the

Belvédère sessions and group size. These variables are particularly of interest for next year's implementation of the Belvédère sessions in our educational program: to plan when and how to prepare, group and engage students in the Belvédère discussion. For practical purposes, we use the results to look for some individual group differences affecting the production of constructive activities. The research questions are:

1. How can chat discussions, produced by student groups during argumentative diagram construction, be characterised in terms of focus, argumentation and the production of constructive activities?
2. How can argumentative diagrams, produced by student groups during chat discussion, be characterised in terms of organisation and to the correspondence of information from the chat discussion?
3. What is the relationship between ongoing chat discussion and the produced argumentative diagrams?
4. What is the relationship between student preparation time on the one hand and the chat discussions and constructed diagrams on the other hand?
5. What is the relationship between students' group size on the one hand (2 or 3 students) and the chat discussions and constructed diagrams on the other hand?

5.3 Method

5.3.1 Subjects and method

In 1998, we integrated the Belvédère study in a regular eight-week undergraduate course on Computer-based learning (CBL), which involved 20 undergraduate students. They all had reached a comparable level in Educational Technology. During the introductory meeting of the course, the students formed eight small groups of their own choosing (4 * 2 students; 4 * 3 students).

Prior to the study, the first week assignment for all student groups was to construct learning goals for an educational computer program. All student groups could choose their own theme, nevertheless, they were asked to aim their program at the population of students and tutors within Educational Sciences. After a brainstorm session in week 2, student groups presented their ideas to the tutor in a face-to-face session. Ideas were evaluated on strength and relevance by discussing the students' assumptions. Then, the student groups defined the learning goals and were subsequently asked to produce conflicting claims on two pedagogical aspects (1) what pedagogical strategies to use in order to reach the learning goals and (2) how to sequence learning activities. In week 3, the next step was to discuss these claims in organised Belvédère sessions (60 - 90 minutes per session). Thus, each student group produced argumentative diagrams that were subsequently submitted as final products to the tutor. In week 4, these were used as input for face-to-face tutoring sessions in which student groups had to defend their conceptual plan before proceeding with a more detailed design.

Before entering the Belvédère sessions, the students received basic instruction and exercises on the technical use of Bélvèdere. A list of ground rules for critical argumentation was distributed, such as “be critical but co-operative”, “detect feigned or flawed argumentation” or “ask questions to verify information you are in doubt with”. We based these ground rules on Grice’s co-operative principles for communication (as discussed in Levinson, 1983), pragmatic ground rules for exploratory talk (Wegerif, Mercer & Dawes, 1998) and pragmatic discussion rules and fallacies (Van Eemeren, Grootendorst & Snoeck Henkemans, 1995), and see also the guidelines in Veerman, Andriessen & Kanselaar (submitted; 2000).

The eight student groups produced 13 chat discussions and 13 diagrams in total, which were automatically logged on the computer. Two student groups only engaged in one Belvédère session whereas another group chose a theme for which the second claim was not relevant (’how to sequence learning activities’). Questionnaires were used both to evaluate the time students invested on the subject the week before they engaged in the Belvédère sessions and to assess the students’ judgement of the usefulness of the electronic discussions. The students stated their opinion (using a 5-point Likert scale from full agreement to full disagreement) on eight statements about task focusing, multiple perspective taking, raising new ideas and decision-making.

5.3.2 Data analyses

Chat discussions and diagrams produced were automatically logged as text files and pictures on the computer. Names were logged per message. Chat discussions were subsequently analysed on focusing, argumentation and constructive activities. Diagrams were analysed on thematic organisation and on the overlap of selected information from the chat discussion. Both chat discussions and constructed diagrams were then separately grouped by a K-Means cluster analysis to iteratively identify and classify relatively homogeneous groups of chats and diagrams before relationships were further explored (Everitt, 1974). Finally, we gathered student groups' preparation times, post-hoc evaluations and group size and related them to the clustered chats and diagrams. Below, we explain these analyses in greater depth.

5.3.2.1 Chat discussion analysis

First, all chat discussions were analysed on the focus of messages. Compared to the NetMeeting study, this time students not only had to co-ordinate their text-based discussion but also the building of a diagram. The following focus categories reflected this: (1) technical / off-task talk, (2) planning talk and (3) thematic talk.

Technical talk contained talk about the electronic connection established, about beeps and bleeps, about how to draw diagrams, boxes and links etc. Off-task talk contained talk about the weather but also about the Belvédère system on a meta level ("I am going to use this tool in my classroom, great!", “I do not see the use of such a program"). Off-task talk hardly occurred, therefore, the categories of technical talk and off-task were merged. Planning talk included discussion about how to start, continue or close the task, about discussion roles (for or against the statement), about time management and about proposals to put information into the diagram. Thematic talk included discussion in relation to the claim and statements and was divided into two categories: a focus on the meaning of concepts and a focus on the application of concepts. Focus shifts were all analysed in relationship to thematic talk, and included shifts back and forth between sections of:

1. Thematic talk and planning talk
2. Thematic talk and technical / off-task talk
3. Thematic talk focused on the meaning of concepts and a focus on the application of concepts

Messages focused on thematic talk (3) were subsequently analysed in more detail on types of (a) dialogue moves, including argumentation (statements, checks, challenges and counter-arguments) and on the presence of (b) constructive activities. Dialogue moves included an additional category called 'others', in which small numbers of acceptances, conclusions etc. were put that could not be coded as one of the main categories. Constructive activities only included messages in which information was added, explained, or evaluated since summaries and transformations hardly occurred.

5.3.2.2 Diagram analysis

All diagrams were analysed on the number of themes (different issues that students talked about), statements and links, the organisation of thematic information and on information put into the boxes that overlapped with the content of chat messages. The number of themes was defined as the number of boxes that directly started from the claim. The number of statements included all boxes except the main claim and links were counted. We analysed the organisation of thematic information as follows.

Each information box is (in) directly linked to the claim. The minimal number of steps to go from an information box towards the claim is 1. An information box that is 2, 3 or 4 steps away is always linked to a box that is just one step nearer to the claim. At each step in the diagram {1,2,3...n}, we can measure the balance between positively and negatively oriented information boxes in relation to the claim by division. Zero balance means that students oriented their arguments only for or only against the claim. A balance of 1 means that students oriented as many arguments for as against the claim. The higher the number between 0 and 1, the better balanced an argument is (see Figure 5.1). Finally, the diagrams were analysed on overlapping information. Overlap between information that was expressed in the chat messages and put into information boxes was coded as a dichotomous variable: overlap / no overlap. Overlap was coded if (a) an information box literally overlapped with a chat message, (b) an information box partly overlapped with a chat message but kept the same subject and meaning, (c) an information box contained a paraphrased chat message but kept the same meaning.

5.4 Results

We analysed 13 chat discussions and 13 argumentative diagrams. Inter-judge reliability showed a Cohen's kappa of 0.74 for the *focus* variable, a kappa of 0.83 for *statements and argumentative moves*, and a kappa of 0.78 for *constructive activities* (Cohen, 1968). There was a perfect agreement on organisation measurements; the kappa for *overlapping* information was 0.82. In qualitative data analysis, a Cohen's kappa between .61 - .80 can be considered as 'substantial'; a kappa between .81 - 1.00 is 'almost perfect' (Heuvelmans & Sanders, 1993; p. 450).

5.4.1 Chat discussions: results

As shown in Table 5.2, of all messages sent in the chat discussions (mean = 99 messages) a small majority was focused on technical / off-task issues and planning aspects (mean = 29 respectively 28 messages). The rest were thematic (mean = 42 messages), of which more messages were focused on the meaning of concepts than on the application (mean = 24 versus 18 messages).

Most focus shifts occurred between thematic talk and planning talk (mean = 12 shifts). More than half of the thematic messages were coded as argumentative moves (mostly checks, then counter-arguments, then challenges). Half of the thematic messages could also be coded as types of constructive activities (mean = 20; mostly additions, then evaluations, then explanations). Constructive activities comprised about 20% of the total number of messages sent in the chat discussions; however, it is 48% of all thematic messages sent.

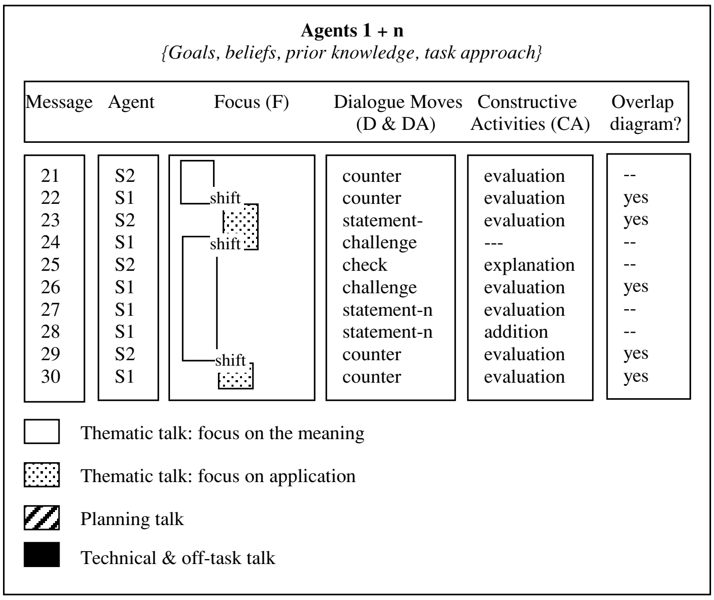
Before executing a K-Means Cluster Analysis, we deleted three categories (counter-arguments, 'others' and focus shifts between concepts and planning) because of a high skewness (> ± 1) and kurtosis (> ± 1.5). The cluster analysis then iteratively classified the 13 chat discussions into three final clusters. We additionally requested descriptives and an analysis of variance F statistics to reveal information about each variable's contribution to the separation of the clusters.

As shown in Table 5.2, first of all it is obvious that significant differences between the three clusters are partly due to the total number of (thematic) chat messages sent. Nevertheless, the clusters can additionally be described and explained on specific characteristics. In Cluster 1, two chat discussions are classified. These chats are characterised by a high frequency of thematic messages (mean = 87), which are focused almost twice as much on the meaning of concepts than on the application of concepts (mean = 56 messages versus 31). Most focus shifts occur between thematic talk and technical issues (mean = 20 technical shifts versus 11 conceptual shifts). Within thematic discussion, checks are made almost twice as much as challenges (mean = 19 versus 10 messages). The production of constructive activities is high (mean = 38 messages), but only for additions and evaluations (mean = 16 and 17). No summaries or transformations occurred. We label the chat discussions in this first cluster as *meaning-oriented:* elaborated and mainly focused on the meaning of concepts. An example of a meaning-oriented chat discussion fragment is shown in Figure 5.3.

Table 5.2. Descriptives and cluster analysis of the 13 chat discussions.

Chats (N=13)	Mean	s.d.	*'Meaning-oriented'* Mean cluster1 (n=2)	*'Pragmatic'* Mean Cluster2 (n=6)	*'Product-oriented'* Mean Cluster3 (n=5)	ANOVA (F)	P-value
∑ All messages sent	99	50	168	117	49	20.47	.00
∑ Thematic messages sent	42	29	87	49	14	26.68	.00
Focused messages (∑ all messages)							
- Technical and off-task issues	29	18	43	37	13	4.75	.04
- Planning aspects	28	16	38	31	22	0.82	.47
- Thematic talk: meaning of concepts	24	20	56	29	4	31.11	.00
- Thematic talk: application of concepts in relation to the claim	18	12	31	20	10	3.36	.08
Focus shifts (between sections of messages sent)							
- Shifts between thematic talk (meaning + application) and planning aspects*	12	11	--	--	--	--	--
- Shifts between thematic talk (meaning + application) and technical / off-task issues	9	7	20	10	3	10.06	.00
- Focus shift between the meaning of concepts and the application of concepts	6	6	11	9	2	4.07	.05
Dialogue moves (∑ thematic messages)							
- Statements	16	11	31	20	7	10.83	.00
- Checks	9	7	19	11	2	22.01	.00
- Challenges	4	4	10	6	1	6.89	.01
- Counters*	8	7	--	--	--	--	--
- Others*	5	4	--	--	--	--	--
Constructive activities (∑ thematic messages)							
- Addition of information	9	5	16	11	5	8.60	.01
- Explanation of information	3	3	5	5	1	4.78	.04
- Evaluation of information	8	6	17	9	4	6.24	.02

* Skewness > ±1 and/or kurtosis > ± 1.5: category will not be used in the cluster analysis



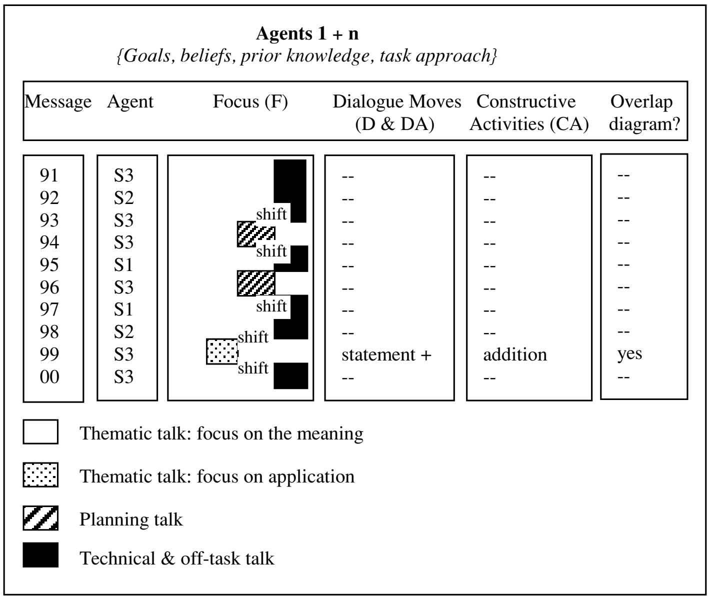
Text	*Explanations*
20. (...)	*(...)*
21. Nonsense, in real life well-organised discussions about developmental issues also exists. For example, you discuss policy issues to develop policy. That's is not just for fun.	*'Nonsense' does not refer to the claim but counters something said earlier in the discussion, which is subsequently evaluated in this message.*
22. Discussions organised to develop policy are organised. Discussions between people about policy without the goal to develop policy; that is what I am focusing on. In other discussion types, there are moderators, such as a chairman.	*Message 21 is countered by clarification ('that's what I am focusing on') and evaluated '(in other types of discussions...').*
23. Ok, that is right, but in education there are also learning situations about certain themes. Mostly, such discussions are not moderated. I think it is also not wishful to have someone who regulates the discussion.	*Earlier stated information is evaluated (yes, but there are also ....not moderated'); information is explicitly used to state a - negative - opinion in relationship to the claim ('...also not wishful to have someone who regulates the discussion.').*
24. Such as?	*Challenge to provoke an example.*
25. Discussions about certain claims a tutor provides. Can't you think of such situations?	*Focus shift to conceptual issue: learning situation. Example and information check.*
26. But what kind of learning effects are we then talking about? We don't come to an overview very often, do we?	*Challenge in which earlier stated information is countered ('but...') and evaluated.*
27. Unless the tutor provides us with an overview, but then he is a kind of a moderator.	*Description of a situation; not an opinion in relationship to the claim.*
28. Think about the electronic claims we discussed a couple of weeks ago through the Internet. I did not have the feeling I learned a lot.	*Input of new information: example of their own negative experience, not directly linked to the claim.*
29. But to get an overview does not have to be the goal. Discussions can be organised to confront people with different points of views. It is not necessary to reach always consensus.	*Evaluation of the goal of discussions by expressing a counter statement ('but...goal').*
30. But a moderator is needed to confront people with each other's different points of view because the moderator can give an overview of different perspectives.	*Information is explicitly used to state a - positive - opinion in relationship to the claim ('...a moderator is needed...')*
31. (...)	*(...)*

Figure 5.3. Example of a meaning-oriented chat discussion fragment.

In Figure 5.3 two students discuss their self-defined claim “Every discussion needs a moderator”. They focus on the meaning of concepts and partly on application. All messages are thematically oriented in the context of the claim. Messages categorised as focused on application explicitly support the claim. In Figure 5.3, text and explanations are given.

Considering the distribution of messages across the categories of focusing, argumentation and constructive activities, the chat discussions in cluster 2 (n = 6) look quit similar to cluster 1. The main difference is that chat discussions in cluster 2 contain less thematic messages (mean = 49). In addition, messages tend to focus on the application of concepts as well as on the meaning of concepts (mean = 29 versus 20 messages). The difference in balance between these two categories is not as high as in cluster 1. We label the chat discussions in this second cluster as *pragmatic*: focused on both the meaning and application of concepts in order to finish the task.

The third cluster of chat discussions (n = 5) clearly differs from the other two since there is hardly any thematic discussion. Chat discussions are mainly focused on planning aspects (e.g. how to construct a diagram together) and on technical issues. The few thematic messages (mean = 14) are mainly focused on the application of concepts, hardly on the meaning of concepts (mean = 10 versus 4 messages). We label these chat discussions as *product-oriented*: not aimed at a process of conceptual discussion but at finishing the task. An example of such a discussion fragment is shown in Figure 5.4, in which three students discuss their self-defined claim “The department needs a website". The discussion is mainly focused on planning and technical issues in relation to diagram construction. In Figure 5.4, text and explanations are given.



Text	*Explanations*
91. Throw it away, Julia.	*This message concerns a diagram box*
92. Really?	*"*
93. YEHHHHH	*"*
94. Will you give me a sign when you are finished drawing the hypothesis?	*Planning issue*
95. Suit yourself.	*Off-task talk*
96. I am finished.	*Explicit reference to the state of work*
97. Don't touch it!	*Technical talk*
98. Where is it?	*Referring to the diagram box*
99. People come back because the website will contain useful information considering their work.	*Explicit thematically oriented message positively related to the claim.*
00. Julia, I don't know how to open another diagram.	*Technical issue*

Figure 5.4. Example of a product-oriented chat discussion fragment.

5.4.2 Diagrams: results

All information boxes put into the diagram window contained thematic information (mean = 15 boxes) and were linked to different themes (mean number of thematic issues = 6) at a maximum of 4 steps away. The mean number of links was 21. The mean percentage of selected information from the chat discussion that overlapped with the information boxes was 58% (see Table 5.3).

Before executing a K-Means Cluster Analysis, we deleted one variable (number of themes) and three categories (balance step 2, 3 and 4) because of a high skewness (> ± 1) and kurtosis (> ± 1.5). A cluster analysis then iteratively classified the 13 diagrams into three final clusters. We additionally requested descriptives and an analysis of variance F statistics to reveal information about each variable's contribution to the separation of the clusters.

Table 5.3. Descriptives and cluster analysis of the 13 constructed diagrams.

Diagrams (N=13)	Mean	Std. Dev.	*Generative* Mean cluster1 (n=2)	*Deliberative* Mean Cluster2 (n=6)	*Adaptive* Mean Cluster3 (n=5)	ANOVA (F)	Sign.
Sum of statements made (except the claim)	15.46	9.54	33	16	9	14.72	0.00
Themes*	6.00	2.12	--	--	--		
Levels	2.62	1.12	4	3	2	4.88	0.03
Links	20.62	11.22	39	22	11	12.61	0.00
Organisation of information 2 (positive : negative statements per level)							
Balance level 1 (N=13)	0.55	0.36	0.50	0.66	0.43	0.55	0.59
Balance level 2 (N=11)*	0.33	0.28	--	--	--		
Balance level 3 (N=6)*	0.29	0.27	--	--	--		
Balance level 4 (N=4)*	0.78	0.15	--	--	--		
Overlapping information (percentage)	57.73	31.28	1.50	54.17	84.50	28.44	0.00

* skewness > ±1 and/or kurtosis > ± 1.5; not used for the cluster analysis

As shown in Table 5.3, two diagrams are classified in cluster 1. These diagrams can be characterised by a high number of information boxes and links (mean = 33 respectively 39), a high number of steps (mean = 4) and hardly any overlapping information (2%). This means that almost all information put into the diagram boxes is new (98%) and not mentioned in or selected from the chat discussions. We label this cluster as a group of *generative* diagrams, containing a large amount of information that is generated and expressed directly into the diagram window. A typical example is shown in Figure 5.5a.

Diagrams in the second cluster (n = 6) contain just half as many information boxes and links as the diagrams in cluster 1 (mean = 16 respectively 22). The mean number of steps is 3. The information boxes overlap with the chat messages for 54%. In these diagrams, overlapping information is combined with generated information directly expressed in the information boxes. We label this cluster as *deliberative* diagrams, containing moderately organised information boxes that overlap with chat messages on the one hand, and are newly generated on the other hand.

Diagrams in the third cluster (n = 5) are characterised by the low number of information boxes, steps and links (mean = 9 boxes, 2 steps and 11 links). However, they include a huge amount of overlapping information (85%). We label this cluster as *adaptive* diagrams in which a small number of chat messages is selected and organised into the diagram window. A typical example is shown in Figure 5.5b.

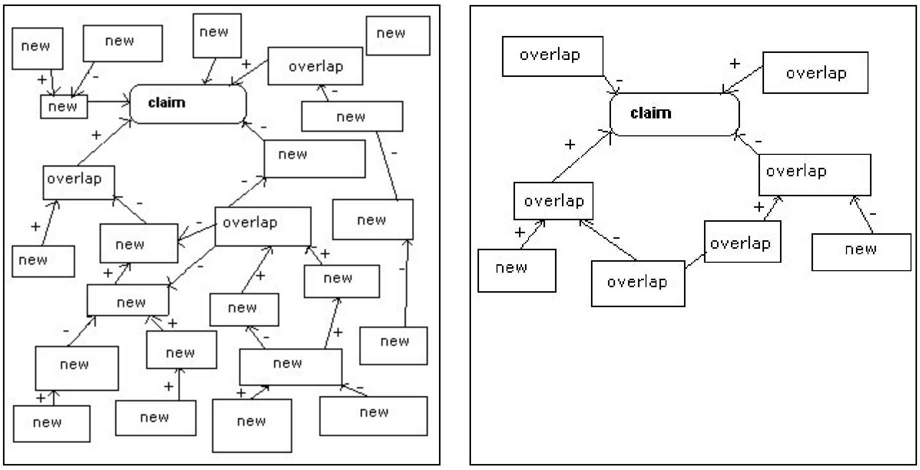


Figure 5.5. Typical examples of a generative diagram (left: 5a) and an adaptive diagram (right: 5b).

5.4.3 *Chat discussions in relation to the constructed diagrams: results*

To explore the relationship between chat discussions and constructed diagrams, we linked the clustered chat discussions to the clustered diagrams. Crosstabs showed no significant relationships (see Table 5.4). However, we can see that meaning-oriented and pragmatic chat discussions only relate to adaptive and deliberative diagrams. On the other hand, product-oriented discussions mainly relate to deliberative and generative diagrams (4 out of 5 times).

Table 5.4. Clustered chat discussions linked to clustered diagrams.

Chats: Diagrams:	Meaning-oriented	Pragmatic	Product-oriented	Total N
Adaptive				
- observed	1	3	1	5
- expected	0.8	2.3	1.9	
Deliberative				
- observed	1	3	2	6
- expected	0.9	2.8	2.3	
Generative				
- observed	0	0	2	2
- expected	0.3	0.9	0.8	
Total N	2	6	5	N = 13

$\chi2(df=4)$ = 3,99; p = 0.41

For each of the clusters distinguished, we took a closer look at overlapping information between chats and diagrams. We traced overlapping information from the diagram boxes back into the chat discussions, and explored it on being (a) only stated, (b) argued about (c) argued about at multiple points in the discussion. In Figure 5.6 and Figure 5.7, two examples show some of the possible (contrasting) relationships between chats and diagrams.

Our exploration on the overlap of information indicated that overlapping information was most thoroughly discussed in meaning-oriented chat discussions and occurred most often in adaptive diagrams (see Table 5.2 and Table 5.3). In product-oriented discussions, information was sometimes stated but not discussed, as was also the case in generative diagrams. Across chats and diagrams, correlation measurements showed that overlapping information in the diagrams was significantly related to the number of constructive activities produced during the chat discussions ($r = 0.63$; $p < 0.05$).

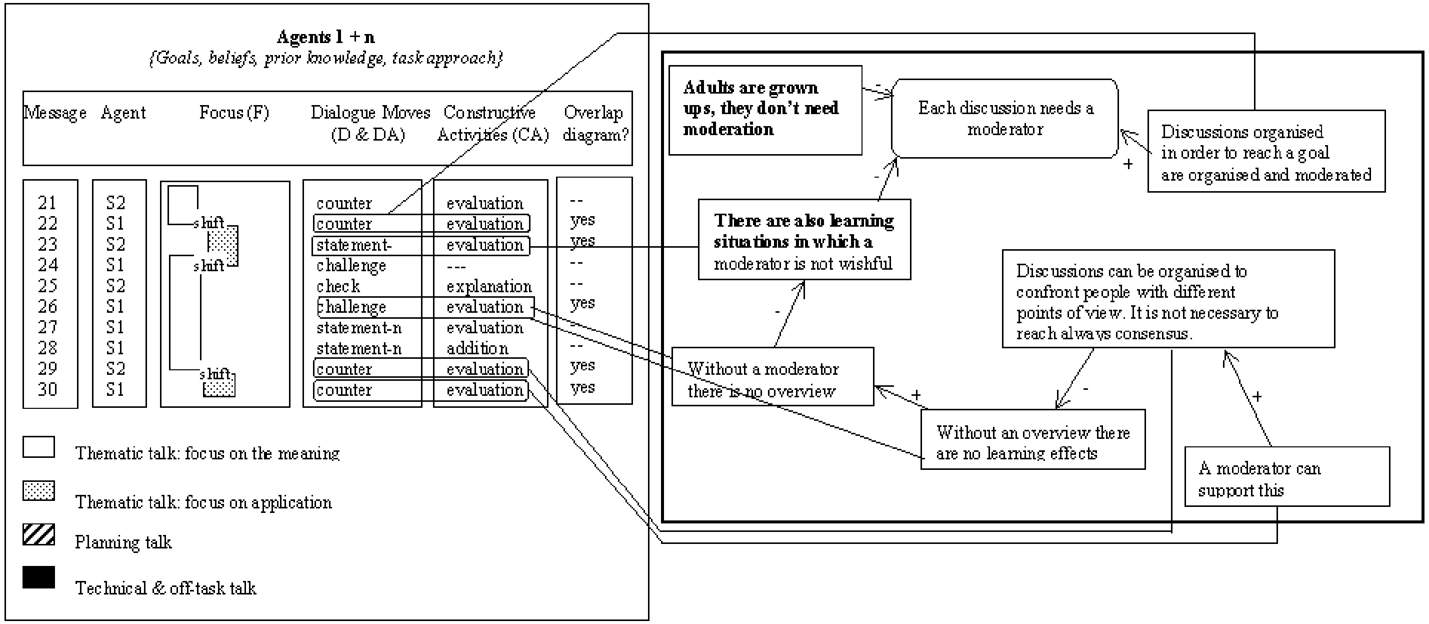


Figure 5.6. Example of an attached diagram to a meaning-oriented chat discussion about the claim “Each discussion needs a moderator".

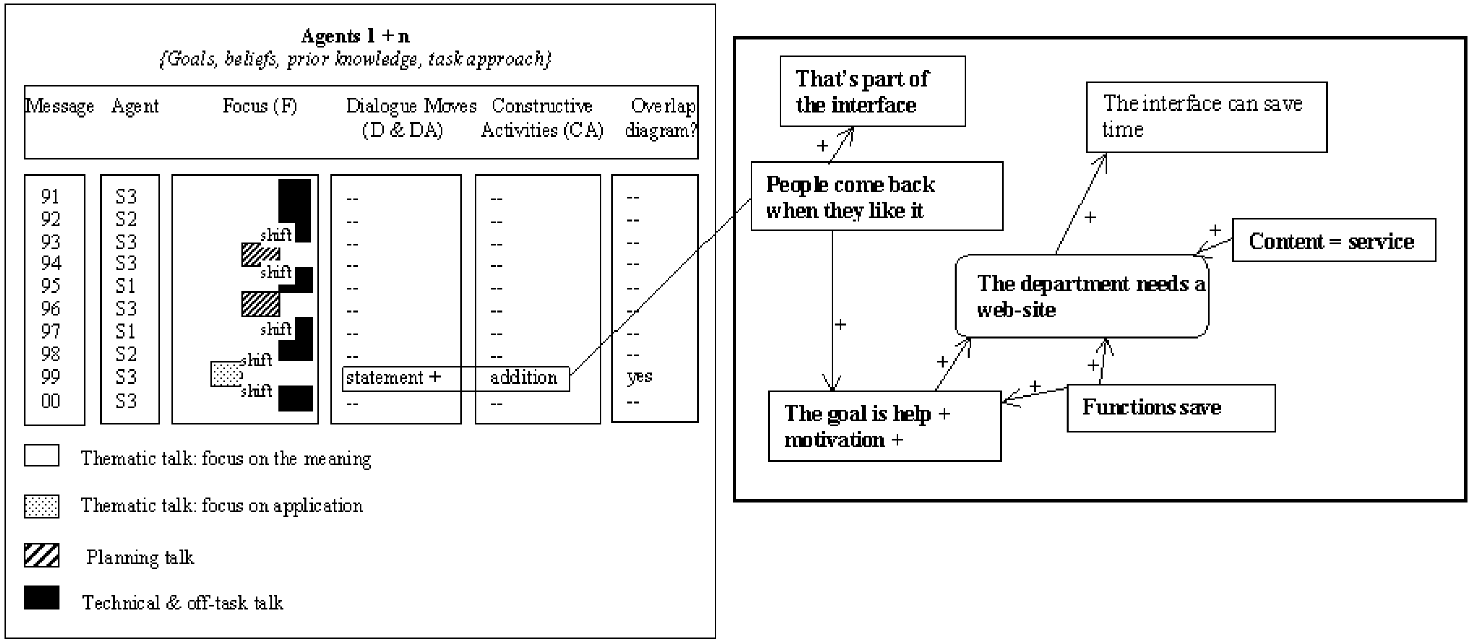


Figure 5.7. Example of a detached diagram to a product-oriented chat discussion about the claim "The department needs a website".

5.4.4 Student group variables

We used student groups' evaluations to look for explanations of the approaches found in chat discussion and diagram construction. We included the students' estimation of their time investment in the subject just before they engaged in the Belvédère sessions and their judgement of the usefulness of the electronic discussions. We also looked at effects of group size (2 or 3 students).

None of the variables showed a relationship to the clustered chat discussions. However, in relationship to the clustered diagrams significant differences were found considering the variables of time investment ($F_{(2,10)} = 13.88$; $p < 0.00$) and judgement of the discussion ($F_{(2,10)} = 6.54$; $p < 0.05$). Generative diagrams were produced by student groups that invested the highest amount of time in preparation activities (mean = 8.0 hours) and judged their sessions below average as 'not very effective' (mean score = 2.0). Deliberate diagrams were produced by student groups that invested the lowest amount of time for preparation activities (mean = 2.3 hours) and judged their sessions as 'effective' (mean score = 3.3). Adaptive diagrams were constructed by student groups that invested a medium amount of time (mean = 3.3 hours) and judged their sessions also as 'effective' (mean score = 3.2).

To summarise, we analysed 13 chat discussions and corresponding diagrams, produced by eight student groups in the Belvédère environment. The chat discussions were analysed on the variables of focusing, argumentation and constructive activities; diagrams were analysed on organised arguments and information that overlapped with the chat discussion. Despite the fact that about half of the messages in the chat discussions was focused on technical/ off-task talk and planning talk, the other half was thematically focused and aimed stronger at the meaning of concepts than at their application. Most focus shifts were found between technical/ off-task talk, planning issues and thematic talk. Thematic messages mostly contained statements, then checks, counter-arguments and then challenges. About half of these messages could be coded as constructive activities. The chat discussions could be clustered into three groups, which were labelled as (a) meaning-oriented, (b) pragmatic and (c) product-oriented discussions. Meaning-oriented discussions contained most thematically focused talk on the meaning of concepts, argumentation and constructive activities. The Belvédère diagrams could be clustered into groups of (a) adaptive, (b) deliberative and (c) generative diagrams. Adaptive diagrams were small and contained most overlapping information. The results suggested that meaning-oriented chat discussions primarily relate to adaptive and deliberative diagrams and that product-oriented chats relate to generative diagrams. Considering students' task preparation, time investment appears to be an important factor for student satisfaction as well as for diagram construction.

5.5 Conclusions and discussion

The present work concerns the issue of diagram-mediated argumentative discussion in electronic environments. We studied how small student groups co-constructed meaning during electronic chat discussion in which they had to justify claims in relation to a to be designed Computer-based learning (CBL) program. Students engaged in electronic discussion by using the Belvédère environment, a networked software system for synchronous chat discussion and argumentative diagram construction. We were specifically interested in describing and evaluating the relationship between chat discussion and argumentative diagram construction. We conducted the research in line with an earlier study about the NetMeeting system, a software system for synchronous basic chat discussion (Veerman, Andriessen & Kanselaar, 2000). Although tasks and assignments differed, considering the chat analyses on focusing, argumentation and the production of constructive activities, some comparisons can be made.

The Belvédère study points out that the interplay between chat discussion, diagram construction and students' group characteristics is not straightforward and difficult to understand. First of all, the results showed that student groups spent half of their messages to technical issues and planning aspects, mainly considering the co-ordination of actions in order to construct a diagram The other half was aimed at thematic talk, and was subsequently coded on talk about the meaning and application of concepts, argumentation and the production of constructive activities. Through argumentation, information could be critically assessed by checks, challenges or counter-arguments. Constructive activities were messages in which thematic information was added, explained, evaluated, summarised or transformed. These messages were regarded as signals of collaborative learning-in-process as they appear to be connected with knowledge-building discourse to co-construct meaning.

Overall, the Belvédère chat discussions contained thematic messages that were focused on the meaning of concepts or on their application. Most focus shifts were found between technical/ off-task talk, planning issues and thematic talk. Thematic messages mostly contained statements, then checks, counter-arguments and then challenges. About half of these messages could be coded as constructive activities. The chat discussions could be subsequently clustered into three groups, which we labelled as: (a) meaning-oriented, (b) pragmatic and (c) product-oriented discussions. Meaning-oriented chat discussions were most elaborated, focused mainly on the meaning of concepts and included particularly checks and constructive activities. Pragmatic discussions focused on both the meaning and application of concepts, included less arguments and constructive activities, and aimed stronger at finishing the task. Product-oriented discussions aimed mainly at finishing the task.

The Belvédère diagrams could also be clustered and were characterised as (a) adaptive, (b) deliberative and (c) generative diagrams. Adaptive diagrams were small and mainly contained an overlap of information from the chat discussion. Generative diagrams were three to four times as large and, on the contrary, hardly contained any overlapping information. Deliberative diagrams fell in between: they were moderately big and contained information that partly overlapped with the chat discussions and was partly new.

To benefit from the Belvédère environment, students had to link their chat discussions closely to their diagrams. A significant relationship was found between the amount of overlapping information between chats and diagrams, and constructive activities produced. However, student groups varied in linking information between chats and diagrams. This appeared to depend heavily on student groups' task approaches and preparation activities.

Considering students' task preparation, time investment also appears to be an important factor for student satisfaction as well as for diagram construction. Weakly prepared students revealed to find the Belvédère sessions useful and produced pragmatic and adaptive diagrams. In contrast, well prepared students were not satisfied and produced generative diagrams. Perhaps the well prepared students had not enough open-ended, vague, abstract or complex issues left for discussion - which would simply leave the Belvédère task to filling in blank diagram boxes.

Considering the interplay between focus, argumentation and constructive activities, the Belvédère chats were more strongly focused on the meaning of concepts, more information was countered and a higher percentage of information was found to be constructive than in the NetMeeting discussions. The NetMeeting discussions could be clustered on similar variables but contained more product-oriented discussions (12 out of 20) than the Belvédère study (5 out of 13). In both studies, epistemic interactions appeared to be related to a meaning-oriented focus in combination with argumentation (in particular information checking) and the production of constructive activities.

Comparable to the NetMeeting system, student groups needed a high amount of effort to co-ordinate their communication. About half of their messages were focused on and shifted focus to technical issues, off-task talk and planning talk. However, the Belvédère environment provided students with separate windows for linear chat discussion and argumentative diagram construction. Whereas the chat discussion tool was used for all sorts of interactions, students used the diagram window solely for organising thematic information and argument construction. Thus, despite the many focus shifts, students did not tend to lose track of their thematic discussion and arguments.

To conclude, our research indicates that the Belvédère environment offers specific features that can support epistemic interaction, argumentation and collaborative learning. However, real advantage appears to depend heavily on student groups' task approaches and preparation activities. We should realise that we do not only deal with software and interface design but also with academic goals and students' orientation towards academic knowledge and technology (Andriessen & Sandberg, 1999). Although studies about interaction are complex by nature, particularly in open-ended knowledge areas, we found our level of analysis to be reliable and promising, meaning that some results were found and could be interpreted. A more global level of analyses may have resulted in the disappearance of distinguishing individual group differences (e.g. Järvelä & Häkkinen, 1999), whereas a more fine-grained level may have triggered more detailed but increasingly complex and difficult to interpret results (e.g. Katz, O'Donnel and Kay, 1999). In the future, we hope to continue this line of research to gain more insight into and better understanding of group characteristics, educational and technological issues in order to favour the types of activities, tasks and tools that may develop students' collaborative learning.

Chapter 6

COLLABORATIVE LEARNING THROUGH ARGUMENTATION IN ELECTRONIC ENVIRONMENTS[1]

We report a study on collaborative learning through argumentation in an asynchronous computer-mediated communication (CMC) system, called Allaire Forums. We studied 28 two-week discussions of 9 - 12 academic students each, involved in a course on Educational Technology. Student groups discussed meaning and application of theory and technology in relation to educational practice. They engaged in different types of task assignments and were 'reflectively' moderated or self-regulated. We analysed the discussions on focused argumentation and the production of constructive activities, a measure we used to define collaborative learning-in-process. This is in line with two earlier studies conducted on student discussions in synchronous CMC systems, the so-called NetMeeting and Belvédère system respectively. The results show that students' asynchronous Allaire Forums discussions were highly task-oriented. They focused on both the meaning and application of concepts and regularly shifted focus between these categories. Students did not engage much in argumentation, especially not in 'direct' forms. However, they produced a high number of constructive activities. Moderation techniques and differences in discussion assignments hardly affected the discussions. Compared to the studies on synchronous CMC systems, the discussions could be characterised as being different, which may be due to time-delays used for focus maintenance, organisational structures of information at the interface and user-friendliness of the software system.

[1] Veerman, A. L., Andriessen, J. E. B. & Kanselaar, G. (submitted). Collaborative learning through argumentation in electronic environments. *Educational Technology, Research & Development*.

6.1 Introduction

In social sciences students need to gain insight into backgrounds of theoretical constructs and social phenomena (Laurillard, 1993). They have to make sense of ill-defined theories and concepts that can be interpreted in different ways, such as 'constructivist learning theory', or 'phenomenography'. This does not only have to do with factual information but also with contextual features in which the learning takes place and students' prior knowledge, beliefs and values (Baker, 1994). Education therefore, should promote collaboration in which knowledge and understanding can be negotiated and the coming together of various perspectives can be facilitated (Petraglia, 1997). This concerns processes such as grounding, belief revision, conceptual change, self-explanations, appropriation and argumentation (Piaget, 1977; Pea, 1993; Baker, 1996; Baker, Hansen, Joiner, Traum, 1999; Dillenbourg, 1999). Argumentation is considered to be one of the main mechanisms to support co-construction of knowledge in collaborative learning situations (e.g. Baker, 1996; Savery & Duffy, 1996; Petraglia, 1997).

Electronic systems for computer-mediated communication (CMC), such as newsgroups, e-mail conferencing systems, Internet relay chat and virtual classrooms provide new opportunities for collaborative text-based negotiation and argumentation. In synchronous CMC systems students can work from different places in real-time. In asynchronous systems work is independent of time and place. Time-delays between messages can take up for hours, days, weeks or even longer[2]. There is a general assumption that any possible networked-based interaction is educationally valuable (e.g. Bonk, Supplee, Malikowski & Dennen, 1999). However, the value of using CMC systems often lacks theoretical grounding in contemporary learning theory. Repeatedly, research emphasises issues such as access to the system, technical issues, attractiveness and fun (Järvelä & Häkkinen, 1999). Current networked-based education can even bring us back to times of programmed instruction: to read text from screens and to fill in empty slots (Van Merriënboer, 1999; Jermann, Dillenbourg & Brouze, 1999).

[2] It must be kept in mind that asynchronous systems can be used for sending messages almost simultaneously, and that synchronous systems can be used as asynchronous systems (Dillenbourg & Traum, 1997).

Our interest is in the theoretical grounding of the value of the use of CMC systems for collaborative learning through focused argumentation, in the context of regular academic courses. To analyse whether and how collaborative learning occurs, we concentrate on students' 'epistemic' interactions during discussion (Baker, De Vries & Lund, 1999). Such interactions contain talk about content, concepts and relationships, which can involve argumentative contributions and/or constructive activities. Constructive activities in this context involve students who add, explain, evaluate, transform or summarise information to the text-based group discussion (Veerman, Andriessen & Kanselaar, 2000). In CMC systems it is expected that synchronous discussions provoke more 'direct' forms of argumentation than asynchronous discussions (e.g. countering information versus checking information to reach shared understanding). Synchronous discussions can be perceived as ongoing dialogues in that the messages are short and communication is fast. Asynchronous discussions can be regarded more like printed text, in which the flow of communication is slower, messages are longer and students sense to be less directly involved than in ongoing dialogue (Mason, 1992). Then again, in asynchronous CMC systems, students have more time to manage their own thinking and to respond to group discussions than in synchronous CMC systems. Focusing and the interpretation of communication (Moore, 1993) therefore, may be less a problem in asynchronous discussions than in synchronous discussions.

In this article we report a study on asynchronous discussions in which we assess the interplay between focusing, argumentation and constructive activities. We additionally regard effects of different task assignments and the role of moderation versus self-regulation. In section 6.2 we first state our educational context. In section 6.2.1 some former studies are described. Two former studies were conducted in synchronous CMC systems, of which theoretically relevant results are reported (section 6.2.1.1). Subsequently, an observational study conducted in an asynchronous CMC system is described, of which applicable insights are listed (section 6.2.1.2). In section 6.2.2 the present study is introduced and followed by the research questions. In section 6.3 methods and procedures are described and results are presented in section 6.4. We then turn to section 6.5, in which we discuss the results of the present study.

6.2 Electronic discussion in academic education

At Utrecht University the curriculum of Educational Sciences and Technology is being gradually transformed from a *transmission* scenario for education towards a *negotiation* scenario (Andriessen & Sandberg, 1999). Activities such as studying from textbooks for exams and listening to lectures are substituted by student-centred activities in which students negotiate about knowledge and engage in discursive practice (Veerman, Andriessen & Kanselaar, submitted; Kanselaar, De Jong, Andriessen & Goodyear, 2000). The studies described in this article are all part of this educational context.

6.2.1 Former studies

6.2.1.1 Synchronous electronic discussions

Our first two studies to analyse and compare argumentative and constructive electronic discussions were called the NetMeeting study (Veerman, Andriessen & Kanselaar, 2000) and the Belvédère study (Veerman & Andriessen, submitted). NetMeeting and Belvédère are names of CMC systems. NetMeeting is a synchronous CMC system that provides students with a basic tool for text-based chat discussion (Microsoft Corporation). In addition to such a tool, Belvédère provides students with a tool for non-linear argumentative diagram construction (Learning Research and Development Center, 1996). Both studies involved undergraduate students collaboratively working in pairs and triples on authentic discussion tasks, as part of a course in respectively Educational Technology and Computer-based learning. With and without pedagogical support (provided by human coaches or the interface), students had to discuss their knowledge, beliefs and values in order to co-construct their understanding of concepts and problems.

Task design. The NetMeeting task was specifically aimed at developing insight and understanding in the 'Conversational Framework', a theoretical model for analysing tutor-student interaction (Laurillard, 1993). In this study 20 student pairs were instructed to engage in a 45-60 minute discussion task. Student pairs were assigned to one out of three conditions: a 'structure' peer coaching condition (5 pairs), a 'reflective' peer coaching condition (6 pairs) and a control group (no coaching; 9 pairs). The 'structure' peer coach focused on argument building, particularly on generating and comparing alternative and contrasting statements, arguments and elaborations. The 'reflective' peer coach focused on checking the meaning, strength and relevance of given information and on questioning connections between claims and arguments.[3]

The Belvédère task aimed at co-constructing meaningful didactics for a computer-based training program. In this study 13 student pairs and triples were instructed to engage in a 60-90 minute discussion task. They used both the chat box and the diagram construction tool. Since an argument is not linear by nature (e.g. Adam, 1992), the tool could support students to organise their argument and to keep track of the main issues under discussion, including unjustified statements, unclear information, gaps or conflicts. Discussion could be triggered by visualised statements or arguments, which had not been discussed nor justified before (Veerman & Treasure-Jones, 1999).

Data analysis. All discussions (20 * NetMeeting; 13 * Belvédère) were analysed for each message on the factors of (1) focusing, (2) argumentation and (3) constructive activities. In collaborative learning the factors of focusing and argumentation have shown to be relevant (e.g. Baker, 1996; Baker, 1999; Erkens, 1997). We regarded the constructive activities as signals of collaborative learning in progress, as they appear to be connected with knowledge-building discourse (Scardamalia & Bereiter, 1994). We subsequently analysed the relation between these factors as well as the effects of the types of pedagogical support. In addition to frequency and correlational measurements, for each study a K-Means cluster analysis was executed. We aimed at exploring the data in further detail in order to identify relatively homogeneous sets of student discussions considering the relationships between focus, argumentation and the constructive activities produced (Everitt, 1974).

Results. In both studies students engaged in a fast flow of communication, in which they produced multiple messages per minute. Students argumentatively checked, challenged and countered each other's information. From all messages that focused on content (in contrast to e.g. planning aspects, technical issues), in the NetMeeting study 35% was coded as a constructive activity; the Belvédère study contained 48% of such messages. Argumentation when related to a focus on the meaning of concepts showed to be positively correlated to the production of constructive activities. In the Belvédère study students checked and countered each other's information more frequently and focused more strongly on the meaning of concepts than students engaged in the NetMeeting study.

[3] More details with regards to the coaching conditions can be found in Veerman, Andriessen and Kanselaar (2000).

The cluster analysis showed that three types of discussions could be distinguished in each study, based upon the factors of focusing, argumentation and constructive activities. In the NetMeeting study clustered discussions were labelled as types of (1) *conceptualisers*, (2) *conceptual achievers* and (3) *achievers*. Conceptualiser pairs focused argumentation on the meaning of concepts, shifted focus between the meaning and application of concepts, and produced a relatively high number of constructive activities. Achiever pairs focused argumentation on the application of concepts, shifted focus between task strategy and non-task related issues, and produced a low number of constructive activities. Conceptual achievers could be put in between. In the Belvédère study, we labelled the chat discussions as (1) *meaning-oriented,* (2) *pragmatic* and (3) *product-oriented*. Meaning-oriented discussions were elaborated, contained a relatively strong focus on the meaning of concepts and a fair number of constructive activities. Pragmatic discussions were less elaborated, more focused on the application of concepts but contained a comparable number of constructive activities. Product-oriented discussions were aimed at technical and planning issues in order to finish the task. They hardly included constructive activities.

Although the Netmeeting and Belvédère study differed on many aspects and a strict comparison of results could not be made, in both studies a cluster analysis revealed three types of discussions based upon the factors of focusing, argumentation and constructive activities. Considering students' task and learning goals, we specifically looked for concept-oriented and constructive discussion types. The Belvédère study contained 8 out of 13 discussions that were meaning-oriented and included a fair number of constructive activities. The NetMeeting study contained 8 out of 20 of such discussions.

With respect to pedagogical support, we found that in the NetMeeting study neither coaching type was very effective, but a 'reflective' coaching strategy appeared to be a useful start. 'Reflective' peer coaching triggered students to check more information on strength and relevance. However, in the Belvédère study student groups engaged more often in meaning-oriented and constructive discussions than 'reflectively' coached student groups in comparable, conceptually oriented NetMeeting discussions. This finding may relate to Belvédère's diagram construction tool that seemed to help students to keep focus, to keep track of the discussion and to mediate constructive chat discussions (see also Veerman, Andriessen & Kanselaar, August 1999).

6.2.1.2 Asynchronous electronic discussions

Our first study to observe students' participation in asynchronous electronic discussions was conducted by use of the Allaire Forums system (Allaire Corporation). Allaire Forums is an asynchronous CMC system, in which messages can be organised by 'threading' and 'branching' them around themes. Thus, in addition to time stamps, questions and answers, arguments and elaborations, statements and counters all can be linked together hierarchically. In Figure 6.1 Allaire Forums is shown: one discussion 'thread' is presented with several messages 'branched'.

During a 2-month course on Educational Technology (December, 1997) we used Allaire Forums to engage undergraduate students in discussing theory and concepts relevant to literature and educational practice. We organised 12 discussions across the whole course, in which students could participate. No requirements were set. Tutors could engage in these discussions to rephrase or answer questions and to raise important issues. Moderation techniques were based upon the work of Feenberg (1989; 1993) and Mason (1992). This observational study provided us with many important insights:

- Without requiring participation, only a few students engaged in these discussions with contributions varying in quality and participation decreasing over the weeks.
- Active students could not handle participation in 12 discussions; in fact, they mostly participated in only 2 discussions at the same time.
- Discussions that attracted about 12 students worked best. Smaller groups did not contribute enough messages to keep the discussion going. Larger groups contributed too many messages to keep track of.
- Discussions that started with an argumentative claim provoked more interactions than discussions in which the first message raised a question or stated a problem
- Practical claims triggered more interactions than theoretical claims.
- The role of the tutor was problematic. Students hardly responded to the tutor's actions, questions and comments. They appeared to be afraid to be judged on their contributions. They viewed the tutor as an authority who was always right, not as a helpful guide, coach or moderator.

(Van der Pol, 1998; Andriessen & Veerman, 1999)

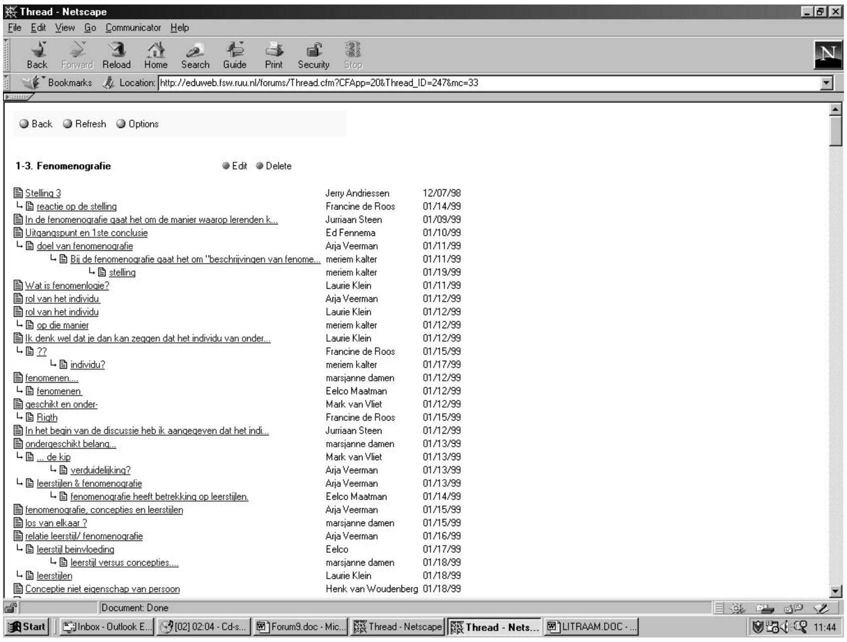


Figure 6.1. Screendump of a discussion ’thread’ in Allaire Forums.

6.2.2 Research questions

The present study on collaborative learning through argumentation in asynchronous environments was conducted in a subsequent 3-month course on Educational Technology (January, 1999). Allaire Forums was used again as an electronic platform for asynchronous discussion. Heeding our former observations, some major changes were made in the discussion format, namely in the structure, amount and participation level required. This time, every two weeks four to six discussions were organised, some about theoretical and some about practical issues in the field of education and technology. About 30 undergraduate students were assigned to two of these discussions in each 2-week period and obliged to participate in both: one about theory and one about the application of theory and technology in educational practice. Students had to make at least two contributions a week to both of the discussions they were assigned to. Tutors and experts did not directly participate in the discussions but could be reached by e-mail. All students were provided with a computer at home and had access to the Internet. After two weeks the discussions were closed and followed by the tutor’s comments on a separate web page (’Virtual College’). New two-week discussions were organised.

In the current study all asynchronous discussions gathered are assessed on the interplay between focusing, argumentation and collaborative learning, defined as a process in which students produce constructive activities. We additionally consider the effects of different types of task assignments and the effects of 'reflective' moderation. Our research questions are:

(1) How can asynchronous discussions, produced by student groups during two-week discussion assignments, be characterised in terms of focusing and argumentation and how does that relate to constructive activities? In synchronous CMC systems we had found that students engaged in short and fast discussions in which they checked, challenged and countered each other's information. In the NetMeeting system 8 out of 20 student groups engaged in conceptually oriented discussion, including a fair number of constructive activities. In the Belvédère system 8 out of 13 discussions were comparably constructive. In contrast to synchronous discussions, in asynchronous discussions students are not pushed for immediate responses, which facilitates rereading, reflection and keeping track of the discussion over time. However, they may experience asynchronous discussions more as printed text than as an ongoing dialogue, leading to less 'direct' forms of argumentation. In the current study, we expect asynchronous discussions to be slower, more focused on content but less argumentative than synchronous discussions. Considering extended time-delays, we expect more discussions to be conceptually oriented, including a higher number of constructive activities.

(2) What are the effects of type of assignment, to discuss theoretical claims versus application claims, on students' asynchronous discussions, which are characterised by focusing, argumentation and constructive activities? In the study on Allaire Forums-'97, practical claims triggered more interactions than theoretical claims. In the current study, students' participation in the discussions is obligatory and, therefore, no differences are expected in the number of interactions. However, theoretical discussions are expected to be more conceptually oriented than discussions centred on application. We expect application assignments to be more focused on immediate problem solving and finding conclusions.

(3) *What are the effects of moderation on asynchronous student discussions, expressed in terms of focusing, argumentation and constructive activities?* In the NetMeeting study we found that 'reflective' coaching triggered students to check more information. In the Belvédère study the diagram construction tool could support students to keep focus, to keep track of the discussion and to mediate constructive chat discussions. In

the study on Allaire Forums-'97 it was shown that human tutors inhibited students' discussions, which appeared to be related to their status. In the current study moderators are explicitly instructed not to take part in the content of the discussions but to coach students 'reflectively'. In addition, they are asked to provide summaries when students loose their focus in the discussion and to guard students' motivation. We expect that moderated discussions contain more constructive activities through the mediation of checks and are more focused on the meaning of concepts than self-regulated discussions.

(4) *What is the effect of 'faded' moderation on students' asynchronous discussions, characterised by focusing, argumentation and constructive activities?* Considering students' responsibility for their own learning (Andriessen & Sandberg, 1999), the moderators are instructed to scaffold students' asynchronous discussions over the weeks. They provide them with a maximum of pedagogical support in the first-phase discussions and then gradually fade away in later discussions. Students are expected to be scaffolded and to progressively move to self-regulated discussions (Teles, 1993; Wegerif, 1998), in which they apply 'reflective' actions to their own discussions.

6.3 Method

6.3.1 Sample and procedure

In 1999 about 30 undergraduate students were involved in a course on Educational Technology. They had all progressed to a comparable educational level in the department of Educational Sciences. Their main learning goals were to gain insight and understanding in educational theory and to enhance the application of theory to technology and educational practice.

In Allaire Forums, we created two discussion forums: Theory and Application. Every two weeks, two or three new discussions were opened in each forum and all former discussions were closed. Each discussion started with a strong claim related to literature and theory respectively to the application of theory to technology and educational practice. Some examples are shown in Table 6.1. Every two weeks students were randomly assigned to two discussions (1 Theory; 1 Application). They had to contribute at least two messages per discussion, per week. Deadlines were at the end of week 1 (day 7) and at the end of week 2 (day 14). Students worked in groups of 8 to 12 participants.

Table 6.1. Examples of claims about Theory and Application.

	Theory	Application
1	"To study learning processes phenomenography offers a more promising research approach than Instructional Design, Intelligent Tutoring Systems and Instructional Psychology"	"Human tutors adapt better to students' learning styles than intelligent tutoring systems"
2	"In Laurillard's Conversational Framework the categories of extrinsic and extrinsic feedback cannot be distinguished"	"Electronic media are not suitable for educational practice since they lead to superficial learning behaviour."

Before entering the discussions, all students received a list of writing guidelines and discussion rules to promote 'proper' and critical argumentation (see Table 6.2). Most were based upon earlier studies (Veerman, Andriessen & Kanselaar, submitted; Veerman, Andriessen & Kanselaar, 2000; Andriessen & Veerman, 1999), Grice's co-operative principles for communication (as discussed in Levinson, 1983), pragmatic ground rules for exploratory talk (Wegerif, Mercer & Dawes, 1998) and pragmatic discussion rules and fallacies (Van Eemeren, Grootendorst & Snoeck Henkemans, 1995).

Table 6.2. Writing guidelines and discussion rules.

Guidelines
- Keep a contribution short. A contribution that takes up more than 3/4 of the computer window is hard to read and to understand for other participants.
- Focus on the claim and task-related issues. Please submit other types of contributions to one of the virtual espresso bars.
- Be clear. Electronic communication is not the same as face-to-face communication. In text-based communication there is a lack of physical signals, such as eye contact and intonation that can support understanding.
- Don't be convinced too soon. Do you doubt or disagree? Express yourself by asking questions and countering argumentation.
- Be critical but co-operative. Do not use abusive language, forms of intimidation or threats.
- If you consult an expert, be sure to state your problem or question properly. Experts do not take part in the discussion, and they are very busy.

Two course assistants (a graduate student and a Ph.D. student), 'reflectively' moderated more than half of these two-week discussions, the others were self-regulated. In self-regulated discussions the claim was given but no further support was offered. 'Reflective' moderators were instructed to check information on meaning, strength and relevance and to question connections between claims and arguments. In addition, they were asked to summarise information particularly when focus had been lost, and to nurture students' motivation especially when discussion volumes went down. They were randomly appointed to support both Theory and Application discussions. The main guidelines and some examples of 'reflective' moderation are given in Table 6.3.

Table 6.3. Guidelines for 'reflective' moderation.

Actions	When?	Examples of interventions
Check questions	- Students disagree without explanations or arguments - Students agree without explanations or arguments	*"Can you explain what you mean?"* *"What source have you used?"* *"Why do you think that?"* *"Do you think this argument is strong or relevant?"*
Summarising information	Every 10-15 messages to prevent students from losing focus	*"To summarise, we agree on (...)."* *"Most of us appear to disagree on (...)."* *"The main points for further discussion are (...)."*
Motivation	Start new discussions	*"Welcome, my name is (...). I'll be your moderator for the next two weeks."* *"I hope you will all have a great discussion."*
	The discussion volume is down	*- Inviting guests* *- Organising a guided tour*
	Positive feedback; random	*"Well done, [name/ group]!"*
	When students flame	*- Send a personal e-mail* *"Remember the guidelines."*
	Closing discussions	*"We have to draw some conclusions now."*

The moderators were additionally instructed to scaffold students by fading support. In the first-phase discussions, they were allowed to contribute 25% of the total number of messages. They were instructed to decrease their share of contributions to 20%, 15%, 10% and less than 5% in later weeks (see Table 6.4). In week 9-10, moderation had faded out almost completely and therefore all discussions were categorised as self-regulated. In total, 16 out of 28 discussions were moderated.

Table 6.4. Faded moderation in asynchronous discussions about Theory and Application.

Asynchronous discussions (N=28)		Theory (N=14)		Application (N=14)	
	Faded moderation	*Moderated (N=8)*	*Self-regulated (N=6)*	*Moderated (N=8)*	*Self-regulated (N=6)*
Week 1-2	25 %	2	1	2	1
Week 3-4	20 %	2	1	2	1
Week 5-6	15 %	2	1	2	1
Week 7-8	10 %	2	1	2	1
Week 9-10	< 5 %	0	2	0	2
Week 11-12		*--- Evaluation ---*			

6.3.2 Data analyses

6.3.2.1 Analysing system

All electronic discussions were logged electronically on the computer by date, time, discussion thread, contribution and content. First of all, messages were categorised on focus types. As in the NetMeeting and Belvédère study, students were assumed to coordinate their discussions, to co-construct the meaning of concepts and to apply conceptual knowledge to technology and educational practice. The focus type categories reflected this: (F1) thematic talk: focused on the meaning of concepts, (F2) thematic talk: focused on the application of concepts, (F3) planning talk, and (F4) off-task talk. Thematic talk (F1 & F2) was subsequently analysed on dialogue moves, including *argumentative* dialogue moves, and on the production of constructive activities. These categories are shown in Table 6.5, and will be described in the next paragraphs.

Table 6.5. Categories of focus (and focus shifts), dialogue moves, (incl. argumentation), and constructive activities.

Focus	Dialogue moves, including *argumentative* dialogue moves (F3 & F4)	Constructive Activities (F3 & F4)
F1: Thematic talk: focus on the meaning of concepts F2: Thematic talk: focus on the application of concepts	D1: statement - neutral D2: statement - positive D3: statement - negative D4: others Da1: check question Da2: challenge Da3: counter-argument	CA1: addition CA2: explanation CA3: evaluation CA4: summary CA5: transformation
F3: Planning talk: focus on planning issues	--	--
F4: Off-task talk: focus on off-task issues	--	--
F5: Focus shifts between thematic talk vs. planning & off-task talk	---	---
F6: Focus shifts within thematic talk between the meaning versus the application of concepts	---	---

Thematic talk contained contributions in which information was expressed in relation to the task goal, and was divided into two categories: focus on the meaning of concepts (e.g. “What is the definition of phenomenography…?”), and focus on the application of concepts (e.g. “In support to the claim, phenomenography can be used in educational practice to…”). Planning talk contained contributions about how to start, continue or close the discussion, about proposals to consult an expert, how to search for answers etc. Off-task talk contained talk about the weather, personal comments about the course etc. (e.g. “I hate this course, it is too time consuming”). Focus shifts occurred when attention moved between the different types of talks: thematic talk, planning talk etc. Focus shifts were all categorised in relationship to thematic talk. Since not many messages contained planning and off-task talk, these two focus categories were combined (see F5). In addition, focus shifts between talk about the meaning versus the application of concepts were categorised (F6).

Messages focused on thematic talk (F1 & F2) were subsequently categorised as to type of dialogue moves: statements, checks, challenges, counters and others (D1 - Da3). Contrary to the NetMeeting and Belvédère studies, each discussion was started off with a clear and strong claim. F1 and F2 contributions were categorised as (D1) neutral, (D2) positive or (D3) negative statements oriented towards the claim *or* as one of the following *argumentative* dialogue moves (Da): checks (Da1), challenges (Da2), and counter-arguments (Da3). Checks included questions expressing doubt, e.g. verification questions aimed at reaching understanding. Challenges were defined as 'direct' types of questions expressing doubt and disagreement, e.g. provocative questions aimed at triggering justifications. Counter-arguments expressed explicit disagreement. An additional category called 'others' (D4) contained a number of acceptances, conclusions etc. that could not be coded as one of the other categories.

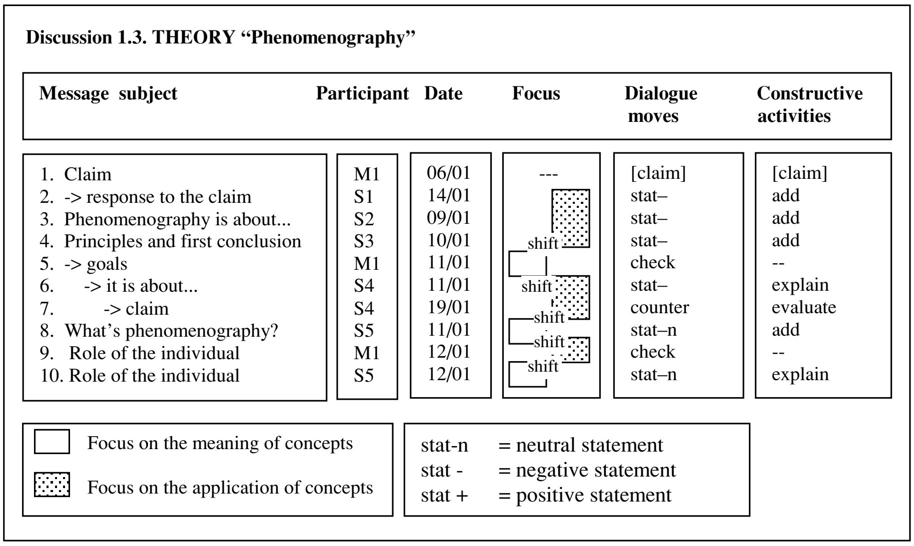
At the epistemological level thematic talk (F1 & F2) was finally analysed on the production of constructive activities (CA). We distinguished five types of constructive activities in which discussion information was (CA1) added, (CA2) explained, (CA3) evaluated, (CA4) summarised or (CA5) transformed. Adding information meant that a contribution contained new information that could be linked to the ongoing discussion. Explaining information meant that thematic information, stated earlier in the same discussion, was for example differentiated, specified, categorised, or made clear by examples. Evaluations were contributions that contained justified considerations of the strength or relevance of existing information. Information transformations contained evaluations and integrations of existing information in such a way that a new insight or a new direction was reached. Summarising information meant that earlier stated information was reorganised in such a way that selected points were put into relation with each other so as to pinpoint the main content of the discussion.

6.3.2.2 Example

In Figure 6.2 an example of an asynchronous discussion fragment is shown, which is analysed on focusing, focus shifts), dialogue moves (incl. argumentative categories) and constructive activities (p. 140). The discussion starts with Claim 3, which considers phenomenography and the role of the individual (see text in Figure 6.2). The discussion is moderated (M1) and the fragment involves 5 students (S1-S5). All messages (1-10) are organised by their 'message subject' and 'date'. In Allaire Forums these messages can be viewed full screen by clicking on the 'message subject'. The messages are shown as text in Figure 6.2.

Message nr. 1 includes a claim sent by the tutor ("In phenomenography the role of the individual is insignificant"). S2 and S3 respond to the claim (message nr. 3 and 4; notice the date!), and both add thematic information against the claim. The moderator intervenes and asks the students to define the concept of phenomenography (message nr. 5). She tries to establish common ground but does not add her own statement or definition to the discussion. S4 reacts and gives an explanation (message nr. 6; underlined text) of earlier stated information (bold text) in direct relationship to the claim (focus on the application of concepts; italic text). S5 then defines the concept by specifically referring to literature. The moderator subsequently asks another check question: what do the students think about the role of the individual considering a phenomenographical approach (message nr. 9). S5 continues the discussion by explaining some earlier stated information (bold text) and referring literature (italic text).

The fragment shows that messages are not organised by date but by message replies. For example, S4 counters her own negative statement eight days later (message nr. 7); S1 replies to the first message at 14/01 (message nr. 2).



Message nr.	Text
1	"In phenomenography the role of the individual is insignificant"
2	Phenomenology: research about students' learning styles. Individuals are necessary. They are observed and questioned to define various learning styles. The individual is very important, not trivial! When various learning styles are developed, the individual becomes less important, attention shifts to groups of students with the same learning styles.
3	Phenomenography is about the way students learn and what they do with knowledge. Thus, the individual is not unimportant.
4	Principle (p. 34, 269; Laurillard): Phenomenography is about descriptions (graphy) of cases as they are (phenomena). Important is that different people describe (or conceptualise) in various ways the same (phenomenological) concept. Thus, I would say that the phenomenographical approach starts from the individual and does not suppress it.
5	Before we continue the discussion about the role of the individual, it may be useful to define phenomenography: is it a learning theory, a research method, a collection of ideas, what is it all about, what's it for?
6	**Phenomenography is about "descriptions of phenomena", especially about how students conceptualise important phenomena.** <u>It is a research method, according to Laurillard. It can be used to find out which concepts of reality students already gained</u>. *I don't see how the students can be insignificant. I don't think that is true.*
7	I'll take it back. I now think the individual is insignificant: it is all about concepts of the student population as a whole; no attention is paid to individual student concepts. To subscribe the claim: the individual is insignificant...
8	Phenomenography is a research method. The method serves to analyse the descriptions of phenomena provided by students. This is what I think, because Laurillard states that some studies are phenomenographical because they describe the phenomena that students produce. On p. 43 Laurillard states: 'the methodology of phenomenography will tell us.'
9	The next question is about the role of the individual versus the meaning of groups in relationship to phenomenography. What is Laurillard's opinion?
10	I found something about the role of the individual on p. 36, third section. "**The goal of phenomenography is not about the student's conception but to study different conceptions of the population as a whole"**. *Laurillard: "The analysis is not by individual, therefore, but is carried out in terms of the meaning of the conceptions invoked in the course of a student's explanation".*

Figure 6.2. Example of a discussion fragment analysed on focusing, dialogue moves, including *argumentation* and constructive activities.

6.4 Results

We gathered 28 asynchronous discussions, which involved on average 9 students each. All discussions started on a Wednesday and finished two weeks later on Tuesday night. Students had to contribute at least two times a week to the discussions they were assigned to and deadlines for contribution were at the end of week 1 (day 7) and week 2 (day 14). Generally, the 28 discussions showed a comparable pattern of participation (see Figure 6.3). Contributions peaked to an average of 6 on deadline days; at other times only 1-2 messages a day were sent.

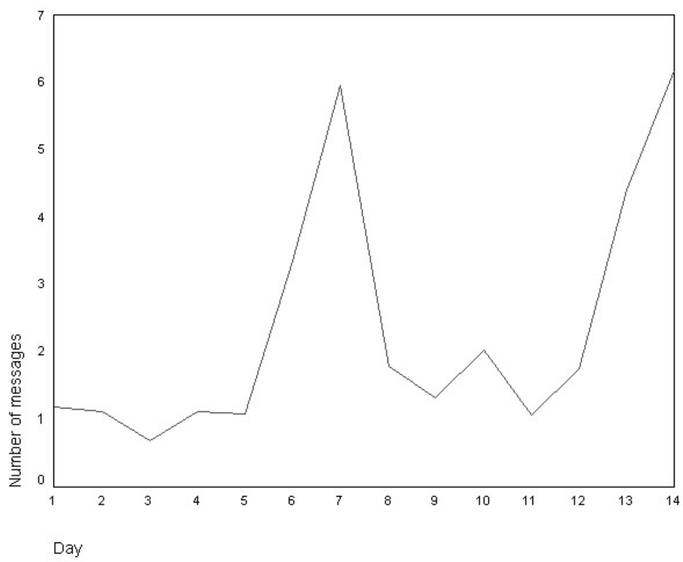


Figure 6.3. Pattern of students' contributions in two-week discussions (across discussions, on average).

6.4.1 Focusing, argumentation and the production of constructive activities

All 28 asynchronous discussions were characterised by focusing (including focus shifts), dialogue moves (including argumentation), and constructive activities. After extensive practice two student assistants, who analysed 9 out of 28 discussion protocols together (approx. 180 messages), achieved acceptable inter-reliability rates. A Cohen's kappa of 0.91 for *focusing*, 0.89 for *dialogue moves* (including argument moves) and 0.74 for *constructive activities* was achieved (Cohen, 1968).

As shown in Table 6.6, the discussions comprised on average 34 messages. Messages were mainly thematically focused ($\bar{x}$ = 30). On average, 4 messages were focused on off-task talk and planning talk ($\bar{x}$ = 3, resp. 1). Thematic messages were focused both on the meaning of concepts ($\bar{x}$ = 14) and on the application of concepts ($\bar{x}$ = 16). Focus shifts were about twice as frequent between the meaning and application of concepts ($\bar{x}$ = 9) than between thematic talk and off-task and planning talk ($\bar{x}$ = 5). Of the thematically focused messages, 2/3 was coded as a neutral statement ($\bar{x}$ = 13), 1/3 was categorised as a statement for or against the claim ($\bar{x}$ = 2 resp. 5). Argumentative moves were overwhelmingly categorised as information checks ($\bar{x}$ = 7); hardly any were aimed at challenging or countering information (in both cases, $\bar{x}$ = 1). Other types of messages (conclusions, acceptances, etc.) were rarely produced ($\bar{x}$ = 1). On average, 22 out of 30 thematically focused messages could be coded as being constructive. About half of these messages could be coded as explanations ($\bar{x}$ = 11), followed by additions ($\bar{x}$ = 7) and evaluations ($\bar{x}$ = 3). Contrary to our expectations, hardly any summaries or transformations were made (in both cases: $\bar{x}$ < 1).

Table 6.6. Means and standard deviations of various measures of the discussions.

Asynchronous discussions (n=28)	Mean	S.D.
Number of contributions	34	7
∑Thematical focused contributions	30	5
Focused messages		
- Planning talk	1	0.4
- Off -task talk	3	2
- Thematic focus: (a) meaning of concepts	14	6
- Thematic focus: (b) applying concepts	16	5
Focus shifts		
- Shifts between thematic talk and off-task and planning talk	5	2
- Shifts between the meaning and the application of concepts	9	3
Dialogue moves (Σ Thematic focused messages)		
- statement neutral	13	5
- statement -	5	3
- statement +	2	2
- others	1	1
Argumentative moves		
- checks	7	3
- challenges	1	1
- counters	1	1
Constructive Activities (Σ Thematic focused messages)		
- additions	7	4
- explanations	11	6
- evaluations	3	4
- summaries	0.3	0.5
- transformations	0.3	1
- not constructive	8	4

The interplay between focusing, argumentation and the production of constructive activities was measured by executing a Pearson's correlation analysis. Considering the small numbers in several subcategories, we measured the relationships between the following categories:

- Meaning messages: thematically focused messages about the meaning of concepts (F1)
- Application messages: thematically focused messages about the application of concepts (F2)
- Focus shifts between thematic and off-task and planning talk (F5)
- Focus shifts between use and application (F6)
- Argumentative dialogue moves: sum of argumentative moves (Da1 + Da2 + Da3)
- Constructive activities: sum of constructive activities (CA1 - CA5)

We found three positive relationships between the production of constructive activities on the one hand, and on the other hand:

(1) argumentative dialogue moves: $r = 0.34$; $p = 0.09$;

(2) messages that focused on the meaning of concepts: $r = 0.55$; $p < 0.05$;

(3) focus shifts between meaning and application of concepts: $r = 0.67$; $p < 0.01$.

Thus, the more argumentative moves were stated, the more constructive activities were produced; the more one focused on and shifted focus towards the meaning of concepts, the more constructive activities were produced.

To gain more insight into the complex interplay between the variables used for correlation measures, we decided to exploratively reorganise the discussions into clusters. We executed a K-Means Cluster Analysis that iteratively classified the discussions into three final clusters (see Table 6.7). We additionally computed analysis of variance F statistics to reveal information about the contribution of each variable to the separation of the clusters.

Table 6.7. Asynchronous student discussions clustered on focusing, focus shifts, argumentation and constructive activities.

Clusters of asynchronous discussions (n=28) Variables	1.Meaning-oriented (n=6)	2.Application-oriented (n=8)	3.Compact (n=14)	ANOVA (F)	p-value
Thematic focus: meaning	23	12	10	22.00	0.00
Thematic focus: application	13	20	14	4.83	0.02
Focus shifts: meaning <--> application	11	10	8	5.21	0.01
Focus shifts: thematic <--> off-task	4	5	5	0.33	0.72
Σ (Argumentative moves)	12	8	8	6.70	0.01
Σ (Constructive activities)	28	26	17	18.95	0.00

In Table 6.7, it is shown that the first cluster contains discussions that are argumentative, highly constructive, mainly focused on the meaning of concepts and contained most focus shifts between the meaning and application of concepts. The second and third cluster include discussions that are less argumentative and more strongly focused on the application of concepts. Considering focus shifts between the meaning and application of concepts and the production of constructive activities, discussions in the second cluster are comparable to discussions in the first cluster. The third cluster contains discussions that contain the lowest number of thematically focused messages and the lowest number of constructive activities. We label the first cluster as a group of *meaning-oriented* discussions (n = 6): constructive discussions emphasising argumentation focused on the meaning of concepts. The second cluster is labelled as a group of *application-oriented* discussions (n = 8): constructive discussions including contributions focused on the application of concepts, and focus shifts to the meaning of concepts. The third cluster is labelled as a group of *compact* discussions: less elaborated discussions focused more on application than on the meaning of concepts, and containing a lower number of constructive activities (n = 14).

6.4.2 Task assignments

Theoretical discussion threads (n=14) and Application threads (n=14) were compared on focusing, argumentation and constructive activities by executing an Independent-samples T-test. Theoretical discussions were expected to be more conceptually oriented than Application discussions, which were expected to be more focused on immediate problem solving and finding conclusions.

Table 6.8. Theoretical and Application assignments compared on focusing, argumentation and constructive activities.

	Theory (n=14)		Application (n=14)		T (df = 26)	p-value
	mean	*s.d.*	*mean*	*s.d.*		
Thematic focus: meaning	15	6	12	6	0.98	0.34
Thematic focus: application	14	5	17	6	1.71	0.10
Focus shifts: meaning <--> application	9	2	10	3	1.45	0.16
Focus shifts: thematic talk <--> off-task and planning talk	6	2	4	2	2.43	0.02
Σ (Argumentative moves)	9	3	9	3	0.56	0.58
Σ (Constructive activities)	21	5	23	8	0.92	0.37

As shown in Table 6.8, Application assignments included more messages focused on the application of concepts. However, this difference was not significant ($p = 0.10$). Both types of task assignments triggered a comparable amount of argumentation and constructive activities. Theoretical assignments, however, included a significantly higher number of focus shifts between thematic talk and off-task talk compared to application assignments ($p = 0.02$).

6.4.3 Moderation and self-regulation

Moderated discussion threads ($n = 16$) and self-regulated discussion threads ($n = 12$) were also compared on focusing, argumentation and constructive activities by executing an Independent-samples T-test. Moderated discussions were expected to include more constructive activities through the mediation of checks and to be more conceptually oriented than self-regulated discussions.

Before executing a T-test, we checked the moderators' 'reflective' actions during discussion. The moderators were instructed to check students' information on understanding, strength and relevance, to not engage in constructive discussion and, if necessary, to produce summaries and to motivate students. In Table 6.9 the moderators' contributions are shown across the 16 moderated discussions. With respect to the small numbers, we summed up the different types of statements.

Table 6.9. The moderators' contributions (in 16 discussions).

Moderators' contributions	Frequency (Σ= 119)
Focusing	
- off-task talk:	32
- planning talk:	28
- thematic talk: meaning of concepts	29
- thematic talk: use of concepts	30
Dialogue moves (Σ thematic messages)	
- statement (Σ (neutral, +, -))	7
- check	46
- challenge	1
- counter	0
- other	5
Constructive activities (Σ thematic messages)	
Not constructive	41
- additions	5
- explanations	9
- evaluations	1
- summaries	3
- knowledge transformations	0

Table 6.9 shows that across the discussions the moderators focused on off-task talk and planning talk as many times as on thematic talk (32 + 28 messages versus 29 + 30 messages). Considering thematic talk, they particularly produced information checks (46 messages). Most thematic messages could not be coded as constructive, which means that the moderators hardly contributed to the content of the discussions as they were instructed. They only produced 3 summaries.

In Table 6.10 a comparison is made between moderated and self-regulated discussions by an Independent-samples T-test. Although self-regulated discussions were slightly less focused on the meaning of concepts, no significant differences could be found. Thus, the moderators acted according to their roles but did not have an overall effect on the student discussions considering focusing, argumentation and the production of constructive activities.

Table 6.10. Moderated and self-regulated asynchronous discussions: focusing, argumentation and constructive activities.

	Moderated (n=16)		Self-regulated (n=12)		T (df = 26)	p-value
	mean	*s.d.*	*mean*	*s.d.*		
Thematic focus: meaning	15	6	12	6	1.05	0.30
Thematic focus: application	15	5	16	6	0.51	0.62
Focus shifts: meaning <--> application	9	3	9	3	0.51	0.62
Focus shifts: thematic talk <--> off-task & plan	4	3	5	2	0.32	0.75
Σ (Argumentative moves)	9	3	9	2	0.66	0.51
Σ (Constructive activities)	22	7	21	6	0.30	0.77

6.4.4 *The role of the moderator: scaffolding discussions?*

The moderators were instructed to scaffold students' asynchronous discussions. They had to provide the students with a maximum of pedagogical support in first week discussions and then gradually fade away in later discussions. Students were expected to be scaffolded and to progressively move to self-regulated discussions in which they applied 'reflective' actions to their own discussions.

We focused on the number of checks to analyse the moderators' fading actions and the students' modelled behaviour over the weeks (see Table 6.11). During the first set of discussions (week 1 and 2) the moderators and students checked information comparably often (21 versus 21 check messages). In the second round (week 3 and 4), students checked an increased amount of information whereas the moderators checked less information (31 versus 10 messages). As shown in Table 6.11, from week 5 to week 9 the moderators slowly faded while the number of check questions asked by the students stabilised. Thus, as far as checking behaviour is concerned, the moderator's modelling actions appeared to affect students' behaviour immediately in the first couple of weeks.

Table 6.11. Frequency of students' and moderators' information checks.

	∑ (checks)	Students' checks	Moderators' checks
Week 1-2	42	21	21
Week 3-4	41	31	10
Week 5-6	42	32	9
Week 7-8	32	28	4
Week 9-10	31	29	2

We exploratively investigated some other effects the moderator could have had on the students' discussions. We looked at the moderators' many off-task messages (see Table 6.9: x = 32). We wondered if these messages could have played a role in re-energising students' discussions after an 'impasse', a certain period of silence we often observed. We defined an impasse as a period of two days at least in which there was silence and neither students nor moderators contributed thematic messages. We found that 19 discussions contained at least one impasse, which mostly occurred between day 1-4 and between day 9-11. These impasses could be partly explained by the deadlines for contributions since some were easily overcome when the deadline approached. However, sometimes a moderator re-energised a discussion by a social contribution, messages that were coded as non-task related. Successful social contributions were messages in which the moderator:

- specified where or how to find support (e.g. in the literature or by e-mailing experts)
- organised practical activities (e.g. a guided tour on the Internet)
- emphasised the need for contributions
- called for personal participation

Unsuccessful interventions were general announcements about literature or participation. Students sometimes re-energised a discussion themselves by stating specific (social) problems or by asking others to explicitly share theirs.

6.5 Conclusions and discussion

The present work reports a study on collaborative learning through argumentation in an asynchronous computer-mediated communication (CMC) system. We recorded how academic students, involved in a course on Educational Technology, discussed meaning and application of educational theories and concepts in relation to educational practice and technology. We studied 28 two-week discussions (9 - 12 students), in which we were specifically interested in the relationships between students' focus maintenance on thematic information and argumentation on the one hand, and their production of constructive activities on the other hand, a measure for studying collaborative learning-in-process. In addition, we researched the effects of two types of discussion assignments (Theory versus Application assignments), and of scaffolding students by 'reflective' moderation. This research follows earlier studies on student discussions in synchronous CMC systems, respectively the NetMeeting and the Belvédère system. Although the studies differ in assignments and systems used, we studied the relationships between the variables of focusing, argumentation and the production of constructive activities across all systems, which allows us to make some comparisons.

The results showed that, first of all, students' asynchronous discussions were highly task-oriented. On average, in each discussion 30 out of 34 messages (88%) were thematically focused. Thematic talk was focused on both the meaning and application of concepts and students regularly shifted focus between these two categories. Thematic messages were subsequently coded on argumentative dialogue moves and constructive activities. In argumentative moves information could be critically assessed by checks, challenges or counter-arguments. Constructive activities were messages in which information was added, explained, evaluated, summarised or transformed. These activities were regarded as signals of collaborative learning-in-process.

Only 1/3 of the thematically focused messages included argumentation, mostly the 'indirect' forms. Students checked each other's information, but they hardly challenged each other or stated counter-arguments. However, they produced a high number of constructive activities. On average, 22 out of all 34 messages could be coded as constructive (65%), which is 73% of all thematic contributions (22 out of 30 messages). Most constructive activities could be labelled respectively as: explanations, additions and evaluations. Summaries or transformations rarely occurred. This may be due to the text-based records of the discussed information, which may make summaries superfluous from the students' point of view. Perhaps it also has to do with the writing constraints we imposed on the students. Students were not allowed to write messages longer than 3/4 of their computer window. Nevertheless, they might have needed more space to write summaries or to transform information. Given the pattern of writing-at-the-last minute (Tuesday-night peaks), students may also not have had enough time left to write extensive summaries.

We compared discussions that centred on theory versus the application of knowledge on the effects of focusing, argumentation and the production of constructive activities. Although the assignments varied in their emphasis on theory and application, they were all meant as starting points for thorough discussion and not for solving pressing problems in educational practice. Contrary to our expectations, students focused, argued and constructed knowledge in a comparable fashion in both situations. Students may have experienced the different types of assignments as similar since instruction, procedures and task strategies were comparable, only the content slightly differed. In a post-course evaluation, some students mentioned that in order to discuss about application, theories and concepts must be discussed first and this may take up all discussion time (Gardenbroek, 1999).

We compared 'reflectively' moderated student discussions with self-regulated discussions on the variables of focusing, argumentation and the production of constructive activities. In contrast to our expectations, no overall differences were found. Only in the first two weeks of the course, moderated discussions included more information checks than self-regulated discussions. The 'reflective' moderator's role (which mainly considered information checking) appeared to be easily taken over by the students immediately after the first couple of weeks. The moderators sometimes sent social types of messages that supported students to re-energise discussions after an 'impasse', a period of silence. Moderators sent such messages more often than students did and they seemed to be more successful. It may be that after an introduction of 'reflective' modelling, social moderation becomes more important in order to incite students to break silence and to overcome impasses in asynchronous discussions.

With respect to the interplay between focusing, argumentation and constructive activities, we first of all found a weak relationship between argumentation and the constructive activities produced. Argumentation mainly included information checks. Focusing on the meaning of concepts and shifting focus between the meaning and application of concepts showed to be significantly related to the production of constructive activities. The discussions could be subsequently clustered into three groups, which we labelled as: (a) *meaning-oriented*, (b) *application-oriented*, and (c) *compact* discussions. Meaning-oriented discussions included focused argumentation (mainly checks) on the meaning of concepts and the production of constructive activities. Application-oriented discussions included mainly thematic talk about the application of concepts, focus shifts towards the meaning of concepts and constructive contributions. Compact discussions contained fewer messages, thematic talk was focused on both the application and the meaning of concepts, and contained a lower number of constructive activities.

Discussions studied in synchronous and asynchronous CMC systems (NetMeeting, Belvédère and Allaire Forums) were characterised differently on the variables of focusing, argumentation and the production of constructive activities. Although these differences were not measured statistically, relatively speaking the asynchronous discussions were more often thematically focused than the synchronous discussions (there were no pure product-oriented discussions or groups of achievers), students were less engaged in 'direct' forms of argumentation (challenges and counter-argumentation), and they produced more constructive activities (see also Veerman, Andriessen & Kanselaar, 1999). This may be due to time-delays that can be used for rereading information, to the organisation of information at the interface and the transparency of the user-interface, all of which may prevent students from a loss of focus and from technical disturbances.

Across the studies, focusing on the meaning of concepts and shifting focus between meaning and application appears to be more important in relationship to the production of constructive activities than heavy and 'direct' forms of argumentation. In addition, students hardly produced summaries or transformations in any of the studies. Despite text-based discussion records, writing constraints and required cognitive effort, the lack of information transformations may also be due to an incomplete, intuitive and personalised understanding of information under discussion (Treasure-Jones, submitted thesis; Kuhn, 1991). Students need sufficient understanding of a topic and a mutual framework for interpreting each other's information before they can state firm positions and stick to a position (Coirier, Andriessen & Chanquoy, 1999). To reach new insights, there must be a certain level of (shared) understanding. In the brief discussions, reaching (deeper) understanding may have been the highest goal attainable. Reaching new insights may be the next step, for instance, when students are sufficiently prepared to take firm positions.

To conclude, this research indicates that the asynchronous CMC system Allaire Forums contains some specific characteristics that may enhance students' constructive discussions. However, effective use of such a CMC system also depends on contextual features, such as task design, student groups' characteristics and social aspects. Therefore, studying CMC systems for educational purposes needs to be grounded in current learning theory. Since technical and human factors interact within the broader social context, such studies are complex by definition. However, effort must be made to engage in more than formative studies and students' evaluations of attractiveness and fun. We consider our research to analyse and compare electronic discussions on aspects of focusing, argumentation and constructive activities in different CMC systems, as a step in this direction.

Chapter 7

SUMMARY AND DISCUSSION

7.1 The thesis in context

In recent years educators have become increasingly interested in using Internet and web-based applications for educational purposes. Such applications do not only offer advantages with regards to independency of time and place, but also of flexibility of information exchange. Information can be stored, presented and accessed in multiple formats (text, graphics, pictures, tables and figures, animations, simulations, interactive video, virtual reality etc.). In addition, communication between students and tutors can be facilitated by the use of computer-mediated communication (CMC) systems. CMC systems are network-based computer systems offering opportunities for group communication. Examples are Internet relay chat, newsgroups, e-mail conferencing systems and virtual classrooms. CMC systems can support synchronous communication (same time, different place) as well as asynchronous communication (different time, different place). Currently, most CMC systems offer users text-based modes for communication only, due to the limitations in bandwidth[1]. Advanced technology will enhance access to applications that combine synchronous and asynchronous communication, digitalised text, video, sounds, graphics etc. on one platform (Collis, 1996).

This research is aimed at academic students in social sciences who have to deal with complex, often ambiguous, ill-defined and not easily accessible knowledge, as well as with open-ended problems. To obtain insight and understanding in complex concepts or to solve open-ended problems, collaborative learning situations can be organised in which students are able to articulate and negotiate information, not only in relationship to fixed facts and figures but also to personal beliefs and values.

[1] Definition of bandwidth: The range of frequencies required for transmitting a signal. For example, voice over the telephone network requires a bandwidth of 3 kilohertz while uncompressed video requires a bandwidth of 6 megahertz (Collis, 1996; p. 598).

In such situations, argumentation can be viewed as one of the main mechanisms for collaborative learning. (e.g. Piaget, 1977; Dillenbourg & Schneider, 1995; Baker, 1996; Savery & Duffy, 1996; Erkens, 1997; Petraglia, 1997). Argumentation gives prominence to conflict and negotiation processes in which students can critically discuss information, elaborate on arguments and explore multiple perspectives. Knowledge and opinions can be (re) constructed and co-constructed through argumentation and expand students' understanding of specific concepts or problems.

Computer-supported collaborative learning (CSCL) situations offer new opportunities for students to actively participate in argumentative and constructive forms of interaction. Text-based and time-delayed communication may facilitate students to uncover contradictions, gaps and conflicts. Menu-based interfaces or graphical tools for organising arguments may be used to structure effective types of interactions. However, little is known about the effective use of electronic systems in order to support collaborative learning in academic education. Even less is known about the role of argumentation.

In this thesis, all studies reported were conducted at the department of Educational Sciences at Utrecht University in the Netherlands. Undergraduate students were studied who engaged in several collaborative learning assignments in courses on Educational Technology or Computer-based learning. The research questions centre on the role of students' text-based and argumentative discussions in learning collaboratively. A range of contextual factors was considered: task, instruction, (peer) student, tutor, different forms of information representations and different modes of electronic interaction. The investigation is aimed at discovering principles with regards to collaborative learning, argumentation and educational technology that can be framed and used as a vehicle for further studies in the field of CSCL and educational practice.

In this concluding chapter, the main research findings will be summarised. The results will be discussed in the light of theoretical and methodological considerations, and in relation to parallel studies. The section will be closed with some suggestions for educational implications.

7.2 Summary of the main research findings

To assess the role of argumentation, one must create an environment that facilitates argumentative interaction. Therefore, the research starts with a search for principles that *provoke* argumentation in the context of academic and collaborative learning situations.

Chapter 2: how to provoke students' argumentation; contextual factors. The first concern was how collaborative learning situations should be organised to *provoke* students' argumentation. Contextual aspects affecting argumentation were considered: the role of student, peer student, tutor, task, instruction and communication medium. Three studies were conducted in sequence: two in face-to-face (F2F) situations, with and without a tutor, and a third study using the electronic CMC system Belvédère (Learning Research and Development Center, 1996). The Belvédère system was used as a tool for synchronous text-based communication (chat box) and as an argumentative diagram construction tool. In the three studies, students' assignments were respectively to evaluate constructed learning goals of a computer-based learning (CBL) program, to develop insight into a theoretical framework and to design pedagogics for a CBL program.

In each study, undergraduate students were instructed to work in pairs or triples and to discuss one or two complex issues or open-ended problems. The first study included 11 student groups engaged in F2F tutoring sessions (approx. 1 hour each), in the second study 12 student pairs engaged in two F2F discussion tasks (10 minutes each) and the third study included 14 Belvédère sessions (7 student pairs * 2 tasks; approx. 1 hour each). Although the studies differed on many aspects, all discussions were analysed on the presence of argumentative fragments. Such fragments included at least one explicit expression of doubt or disagreement (e.g. check question) and one argument for support. In lengthy fragments, subsequently all expressions were separately categorised as a type of question or an arguments for, against or neutrally oriented towards a certain claim or problem statement. In order to discover several principles to provoke argumentation in collaborative learning situations, the argumentative fragments were compared across studies.

First of all, the students turned out not to be prepared very well and given this situation other facilitating factors were looked for that provoked collaborative argumentation. In producing self-defined (competitive) claims and being asked for a joint product, student groups could be encouraged to engage in argumentation. Second, multiple perspective taking and elaboration could be stimulated by providing students with basic guidelines on argumentative behaviour and tools to organise arguments graphically, a feature provided by the Belvédère system. Third, question asking showed to be effective in provoking argumentation, in particular open-answer questions and verification questions. The presence of a tutor appeared to suppress students' ability to ask such questions, as they were easily swayed towards the tutor's opinions.

Chapter 3: how to provoke and support students' argumentation; electronic features. In this chapter, the main research questions were how to *provoke* and *support* argumentation in electronic collaborative problem-solving situations. The chapter started with an exploration of literature related to important cognitive processes. In addition to critical information checking, argument elaboration and the taking of multiple perspectives, focus maintenance was discussed as an important factor in effective argumentation and collaborative problem solving. Considering these factors, five studies on different CMC systems were reviewed, which were all designed for educational tasks and in which argumentation was emphasised as a method for collaborative problem solving or an end goal for learning. In all studies only students interacted; no tutors were involved. Published results were available and included data related to argumentation. The selected CMC systems demonstrated a range of approaches to structuring interaction at the user-interface in order to support communication and more specifically, argumentation (e.g. turn-taking control, menu-based dialogue buttons, graphical argument structures). In discussing the success of the systems at provoking and supporting argumentation, characteristics of the task, instruction and structured interaction were considered.

The review revealed that structuring interaction at the interface does not necessarily *provoke* argumentation. The initiation of argument rather seems to be related to task characteristics, such as the use of competitive task design. However, providing a combination of structured and unstructured interaction modes may *support* argumentative processes. In communication windows (chat boxes), combining free text entry with well designed argument moves or sentence openers can stimulate students to critically check information. In task windows constructing argumentative diagrams can improve the exploration of multiple perspective taking and argument elaboration. However, some task characteristics can also enhance such processes. Therefore, task features and structured interaction at the user-interface must be considered in close relationship to each other in order to support argumentation in CSCL situations. In addition, support for focus maintenance may be considered. Tasks that can provoke argument have at least some of the following features:

- multiple acceptable solutions
- competitive instructions
- role-playing or predefined conflicting stances
- required information is split between group members
- students with conflicting original beliefs are grouped together
- students construct their own stance/solution in an initial individual work stage
- a joint product is required

To summarise, the studies reported in chapter 2 and 3 reveal that argumentation can be *provoked* by task characteristics rather than by features of the electronic system. In order to *support* argumentative processes of multiple perspective taking, argument checking and argument elaboration a combination of structured and unrestricted interaction at the user-interface can be provided. Offering support for focus maintenance is proposed as an additional opportunity.

The three empirical studies in Chapter 4, 5 and 6 include argumentative task designs. Text-based electronic discussions are mediated by the use of different CMC systems, with and without pedagogical support provided by humans or the user-interface. Although the studies vary on several aspects, they are comparably analysed on focusing, argumentation and the production of constructive activities, a measure that was developed to define collaborative learning-in-process. The measure of constructive activities is based on the ideas of co-constructing knowledge and knowledge building discourse (Scardamalia & Bereiter, 1994).

Chapter 4: how to support CSCL through argumentation; synchronous communication. The main question considered was how to support collaborative learning through argumentation in synchronous CMC systems. Student pairs were studied (20 pairs), while carrying out a 45 - 60 minute electronic discussion task in NetMeeting, a network-based software system that facilitates synchronous communication and the sharing of computer applications between several users. The purpose of the discussion task was to develop insight and understanding in a theoretical model. It was assessed how student pairs *focused* on and *argued* about this model and how a 'structure' versus a

’reflective’ peer coach influenced their behaviour. ’Structure’ peer coaches were instructed to trigger multiple perspective taking and counter-argumentation. ’Reflective’ peer coaches were instructed to encourage checking information on strength and relevance and to offer support in linking claims to evidence. Findings of focusing, argumentation and coaching were related to student pairs’ production of *constructive activities*, a content measure that was developed to assess collaborative learning-in-process. Constructive activities were defined as task-related messages, in which information was added, explained, evaluated, summarised or transformed.

The results indicated that argumentation is an effective factor in computer-supported collaborative learning but only when focus is taken into account. Argumentation was effective in discussions that were focused on or shifted focus towards the meaning of concepts. However, most discussions were not conceptually oriented but were instead aimed at finishing the task (12 out of 20 discussions). Only three discussions could be labelled as conceptually focused; five discussions were mixed. The coaching conditions did not fulfil the expectations. Only ’reflective’ peer coaches somewhat increased the number of check questions. Information checks appeared to be more powerful at increasing the number of constructive activities than other, ’direct’ forms of argumentation, such as challenges or counter-arguments.

Chapter 5: how to support CSCL through argumentation; synchronous communication and diagram construction. The issue studied was of providing specific *computer support* for collaborative learning through argumentative discussion in synchronous CMC systems. Small student groups were studied, which used the Belvédère system for synchronous chat discussion and argumentative diagram construction (n = 13). They were instructed to co-construct meaningful pedagogics for a CBL program in 60 - 90 minute discussion assignments (see also Chapter 2). The relationship between aspects of the chat discussion and argumentative diagram construction was of specific interest. The diagram construction tool was expected to *support* students in keeping track of the main issues under discussion and in triggering argumentation by visualising (unclear) statements and arguments, gaps and conflicts. Chats were analysed on focus maintenance, argumentation and the production of constructive activities; diagrams were analysed on argument organisation and balance. Information that appeared both in the chats and diagrams was separately coded as ’overlapping information’. This turned out to be an important construct.

The results showed a complex interplay between chat discussion, diagram construction, student groups' task approaches and preparation activities. Chat discussions could be clustered into three groups, which were labelled as (a) meaning-oriented, (b) pragmatic and (c) product-oriented. Meaning-oriented discussions were most elaborated, focused mainly on the meaning of concepts and included particularly checks and constructive activities. Pragmatic discussions focused on both the meaning and application of concepts, included less argumentation and fewer constructive activities, and aimed more at finishing the task. Product-oriented discussions were mainly aimed at finishing the task. The Belvédère diagrams could also be clustered into three groups, which were characterised as (a) adaptive, (b) deliberative and (c) generative diagrams. Adaptive diagrams were small and mainly contained overlapping information from the chat discussion. Generative diagrams were large and hardly contained overlapping information with the chat. Deliberative diagrams fell in between: they were moderately large and contained information that only partly overlapped with the chat. It was found that the more overlapping information students produced, the more constructive activities were produced. Overlapping information could be mostly observed in adaptive diagrams; constructive activities were mostly produced in meaning-oriented chat discussions. However, student groups varied in linking information between chats and diagrams and this appeared to be related to both student groups' task approaches and preparation activities.

In comparing the results of the Belvédère study to the NetMeeting study (Chapter 4), some similarities were found as well as some differences. First of all, in both studies effective discussions included in particular information checks and constructive activities (mainly additions and evaluations). In addition, such discussions were mainly focused on the meaning of concepts. Furthermore, in both studies many focus shifts were made in order to co-ordinate and synchronise communication. However, one of the main differences concerned the effects of such focus shifts on the chat discussions. Effective Belvédère discussions appeared to be less harmed by such shifts than the NetMeeting discussions, probably because the constructed diagrams encouraged students to keep track of the main issues under discussion. Other differences were that, relatively speaking, more Belvédère chats were focused on the meaning of concepts, more information was countered during discussion and, a higher percentage of messages were coded as being constructive than in the NetMeeting discussions.

Chapter 6: how to support CSCL through argumentation; asynchronous communication. The main question addressed was how to support collaborative learning through asynchronous electronic argumentation. Effects were studied of different *task assignments* and *moderation interventions* on student groups' focus, argumentation and the production of constructive activities. During a course on Educational Technology 28 two-week discussions were studied of 9-12 students, who engaged in discussion assignments using Allaire Forums, an asynchronous CMC system. Student groups were instructed to discuss claims about the meaning or application of various educational theories and concepts they had to study by literature. Some discussions were 'reflectively' moderated. Moderation interventions particularly aimed at checking information on strength and relevance and purposely faded over the weeks of the course.

The results showed, first of all, that students' discussions were highly thematically oriented and focused on both the meaning and application of concepts. Discussions were 'indirectly' argumentative since they mainly included check questions. Nevertheless, a large number of constructive activities was produced. Focusing on and shifting focus towards the meaning of concepts proved to be positively related to the production of constructive activities. Furthermore, no effects of task assignments could be found and moderation effects were small. Then again, students appeared to easily take over the moderator's role in the first couple of weeks of the course.

The discussions could be clustered into three groups, which were labelled as (1) meaning-oriented, (2) application-oriented, and (3) compact discussions. Meaning-oriented discussions were mainly focused on the interpretation of theories and concepts and included a large number of information checks and constructive activities. Application-oriented discussions were mainly focused on the use of theories and concepts into educational practice and here, focus shifted back and forth to the meaning of concepts. They also included many constructive contributions. Compact discussions contained fewer messages, which were focused on both the meaning and application of concepts, and fewer constructive activities were produced. However, percentage-wise the number of constructive activities was still considerable.

In comparing the results to the NetMeeting and Belvédère study (Chapter 4 and 5), in Allaire Forums the discussions could be characterised differently (see also Veerman, Andriessen & Kanselaar, 1999). Here, students' discussions were mainly thematically focused (there were no absolute product-oriented discussions). They hardly included

’direct’ forms of argumentation (challenges or counter-arguments), and more constructive activities were produced. In addition, the types of constructive activities differed. In NetMeeting and Belvédère, discussions mainly contained additions and evaluations whereas in Allaire Forums the discussions mostly included explanations. However, across studies students groups hardly produced any summaries or information transformations. In addition to task constraints and required cognitive effort, this may be due to students groups’ incomplete, intuitive and personalised understanding of the information under discussion.

7.3 Theoretical considerations

Framed by constructivist learning theory, this thesis specifically centres on studying the role of argumentation in CSCL situations. First of all, principles were searched for that *provoked* argumentation in the context of academic and collaborative learning situations (Chapter 2). In addition, features were assessed of electronic systems that could *provoke* or *support* argumentation in collaborative problem-solving situations (Chapter 3). The studies revealed that argumentation could be *provoked* by task characteristics (e.g. competitive task design) rather than by features of the electronic systems. A combination of structured and unrestricted interaction at the user-interface could *support* argumentative processes of multiple perspective taking, argument checking and argument elaboration. In addition, providing support for focus maintenance appeared to be important for fruitful argumentation. In order to study support for collaborative learning through argumentation in network-based environments, it was concluded that interconnections between task characteristics, structured interaction at the interface, focusing and argumentation had to be considered thoroughly.

Three experimental studies were subsequently organised that examined student groups’ academic discussions mediated by the synchronous CMC systems NetMeeting and Belvédère and the asynchronous system Allaire Forums (Chapter 4, 5 and 6). All discussions were analysed and compared on the factors of focusing, argumentation and the production of constructive activities, a measure that was used to define collaborative learning-in-process. In addition, various forms of pedagogical support were considered, provided by humans or the user-interface. In the rest of this section the findings of these three studies will be discussed.

The results showed, first, that a study of collaborative learning from electronic discussions requires analyses of focus in relationship to argumentation. Constructive discussions were particularly focused on the meaning of concepts and included focus shifts back and forth to the application of concepts, while information was critically checked. Second, in contrast to 'direct' forms of argumentation (challenges, counter-argumentation),'indirect' forms of argumentation in particular showed to be effective (checks). The more information was checked, the more constructive activities were produced. Absent effects of the 'direct' forms of argumentation may be explained by the following paradox: - to engage in critical debate, students should have well established views on subjects and be able to mutually recognise opposed knowledge and attitudes - (Baker, De Vries & Lund, 1999). However, a characteristic of the knowledge of students engaged in debates for collaborative learning purposes is that these views are not always well elaborated, since they are subject to the learning process. Third, the discussions mainly contained additions, explanations and evaluations. Summaries or information transformations hardly occurred. This may be due to required cognitive effort but also to an incomplete, intuitive and personalised understanding of information under discussion (Treasure-Jones, submitted; Kuhn, 1991). To transform information, there must be a certain level of (shared) understanding. In the studies considering task characteristics, students' preparation activities, prior knowledge and time available for discussion, obtaining (deeper) understanding may have been the highest goal achievable. Reaching new insights may just be a next step, for instance, when students are sufficiently prepared and have established a mutual framework for interpreting each other's information in order to engage in critical, hefty discussions (Coirier, Andriessen & Chanquoy, 1999).

Discussions mediated by the synchronous CMC systems NetMeeting and Belvédère and the asynchronous CMC system Allaire Forums, appeared to have different characteristics concerning focusing, argumentation and the production of constructive activities. Relatively speaking, the synchronous discussions in NetMeeting and Belvédère included more 'direct' forms of argumentation (challenges, counter-argumentation), more focus shifts to non-task related issues and they were less constructive than the asynchronous discussions in Allaire Forums. The asynchronous discussions were only 'indirectly' argumentative (including information checks), they maintained a more conceptually oriented focus and contained more constructive activities. To maintain a conceptually oriented focus and to co-ordinate interactions appears to be particularly related to the asynchronous and synchronous modes of communication. In synchronous discussions students engage in a fast flow of communication. Real-time pressures them (psychologically) to read and respond to each other's contributions within seconds or at most minutes. Focus shifts to non-task related aspects or technical issues easily cause students to lose track of an argument or to lose the overview of the main issues under discussion. In asynchronous discussions students may take hours, days, weeks, and sometimes even longer to read, write and think about contributions that triggered their interest, instead of seconds or minutes. More time may afford re-reading and reflection, keeping track of the line of discussion and treating non-task related interactions or technical disturbances as they are: temporary interruptions.

In all three studies human or interface support primarily aimed at promoting argumentative processes. However, no effects were found of human 'structure' coaches who supported multiple perspective taking and counter-argumentation. 'Reflective' support increased the number of check questions asked, which later turned out to be powerful in relationship to the production of constructive activities. Graphical support on the Belvédère interface triggered students to produce more counter-arguments, a 'direct' form of argumentation. However, counter-argumentation was not shown to be related to effective student discussions. Then again, the Belvédère discussions were relatively more often conceptually oriented and constructive than the NetMeeting discussions. Perhaps the separate window for argumentative diagram construction particularly facilitated focus maintenance, and subsequently stimulated the production of constructive activities. It may be possible, however, that a tool for regular concept mapping[2] might have been just as effective as the diagram construction tool (Van Boxtel, 2000). It is not known (yet) to what extent the beneficiary effect is due to particular constructs of the Belvédère system.

To refer back to one of the earlier points mentioned, relatively speaking the asynchronous discussions in Allaire Forums were more often conceptually oriented and constructive than the synchronous Belvédère and NetMeeting discussions. The NetMeeting discussions were most often focused on finishing the task. However, in clustering the discussions on the factors of focusing, argumentation and constructive activities, some discussions in Allaire Forums were also found to be less effective; some Belvédère discussions were completely product-oriented and a few NetMeeting discussions were

[2] Concept mapping homepage: http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm

even found to be highly conceptually oriented and constructive. This indicates that in addition to features of the electronic systems and task characteristics, effective discussions also relate to individual group differences, such as task approaches, preparation activities or collaboration strategies, and to factors of the broader educational context. Interesting studies considering such issues can be found in Brand (1999), Treasure-Jones (submitted) and Andriessen & Veerman (1999).

In summary, the role of argumentation in collaborative learning situations should be reconsidered. Triggering students to critically check each other's information in order to maintain shared levels of understanding seems to be useful and can be effectively provoked through task design and instruction. However, stimulating 'direct' forms of argumentation appears to be effective only then when students are well prepared and have a substantial knowledge base. In CSCL situations, support is needed to co-ordinate communication and to establish and maintain a conceptually oriented focus. More studies are required to assess human support, especially considering the role of the tutor, which is still unclear. In addition, experimental studies are required to research effects of interface design and modes of communication in order to support students' collaborative learning in computerised environments.

7.4 Methodology considerations

This research is focused on CSCL through argumentation in academic education. To assess argumentation as a mechanism that can support collaborative learning in complex and ill-structured knowledge domains, some methodological challenges immediately occur. First of all, how can argumentation be analysed in weakly structured dialogue protocols? Second, how can collaborative learning be assessed in open-ended knowledge domains and third, what methods can be used to relate argumentation to collaborative learning effects? In this section, some of the methodological problems encountered are evaluated in specific relation to the system for data analyses. The section will be closed with a few remarks on the statistical analyses and possible generalisations of the findings.

Argumentation. The present research started with a simple question: how to provoke argumentation in (computer-supported) collaborative learning sessions, with or without a tutor at hand (Chapter 2). Collaborative learning sessions were organised and the discussions triggered were recorded and subsequently analysed on the presence of argumentative fragments. An argumentative fragment is a pieced text in which at least some doubt or disagreement occurs and in which one or more arguments are expressed: for, against or neutrally oriented towards a certain claim or problem statement (Van Eemeren, Grootendorst & Snoeck Henkemans, 1995). Thus, frequencies of positive and negative arguments could be counted and used in further measurements of multiple perspective taking, balance and argument elaboration. In this method knowing the content of arguments is important. However, in categorising arguments it was found that distinguishing arguments from problem statements or claims could not always be accomplished and this caused subsequent problems to categorise argument orientations. Most troublesome were collaborative learning situations in which claims or problem statements were not defined beforehand. As a result, argumentative fragments could not be structured by content. In such situations a constant effort had to be made on analysing discussions in a sufficient and reliable way. Hence, a less content-dependent method was searched for.

The second, less content-dependent system developed for argument analyses was derived from the similar principle that: 'all argumentative fragments include at least some doubt or disagreement' (Van Eemeren et al., 1995). This starting point was combined with material from several approaches to analysing Educational Dialogue (such as used in Dialogue Games, Exchange Structures and Communicative Acts, Argument and Rhetorical Structure; see Pilkington, McKendree, Pain & Brna, 1999; Treasure-Jones, submitted; Erkens, 1997). In this second system argument categories were developed that indicated how argumentation was triggered, not what content was under discussion. Explicit doubt and disagreement was analysed at the interactive level of communication. Expressions of doubt were categorised as check questions and critical challenges, disagreement as counter-arguments. An analysis of discussions based upon such a categorisation of 'indirect' to 'direct' *argumentative dialogue moves* (checks, challenges and counter-arguments), was used for measuring the proportion of argument moves made per discussion and to assess argumentative strength. The number of counter-arguments could still be used as an indicator to assess multiple perspective taking and the balance of argumentation.

In the three studies presented in Chapter 4, 5 and 6 all electronic chat discussions were analysed on argumentative dialogue moves. The analysing system proved to be straightforward to handle and inter-reliability scores were sufficiently high across the studies (Cohen's Kappa = resp. .82, .83 and .89). Additional analysis measures were developed in the Belvédère study in order to assess argumentative diagrams (Chapter 5). Such diagrams included explicit claims and links to pro and contra arguments. Thus, counting arguments and measuring balance between positively and negatively oriented arguments was not problematic. In the last study (Chapter 6), in addition to analysing argumentative dialogue moves, the orientations of statements were also categorised. This was possible because these asynchronous discussions started by strongly predefined claims that triggered clear statements, which were oriented positively, negatively, or neutrally towards the claim.

Focusing. The review study in Chapter 3 concerned features of electronic systems that could provoke and/or support argumentation in order to enhance collaborative problem solving. In addition to argumentation, focusing was discussed as an important factor that could also need to be supported, particularly in CSCL situations. In the subsequent studies presented in Chapter 4, 5 and 6 therefore, the system for analysing argumentation was extended with focus analysis, which aimed at assessing students' attention to the main task- and learning goals. Since task and learning goals differed across studies, focus categories varied slightly, also in relationship to the electronic systems used.

In the Belvédère study (Chapter 5) some difficulties occurred in analysing focus in a reliable way, possibly due to the electronic system used. In this study information overlapped between chat discussions and diagrams, which made it sometimes hard to define what students were focusing on. Thus, inter-reliability scores dipped to a Cohen's Kappa of .74., whereas a score of .91. was reported in both the NetMeeting study (Chapter 4) and in Allaire Forums (Chapter 6).

Collaborative learning. To develop a system for analysing the extent of collaborative learning in complex and open-ended academic knowledge domains is quite a challenge. Students need to develop understanding and insights into complex theories and concepts, which depend not only on facts and figures but also on prior knowledge and experiences, beliefs and values, and expectations on what has to be learned. It is demanding to assess such knowledge beforehand and to relate this to collaborative learning processes. The only reason why some factual prior knowledge tests were used was to be able to distinguish prepared students from non-prepared students, not to assess individual learning effects (see Chapter 4). Because of the unpredictable nature of the unfolding discussions themselves, reliable post-tests are even more complicated to conceive.

Instead of using pre- and post-tests, collaborative learning processes were assessed. The discussions were viewed as collective information networks in which content could grow and change dynamically by the production of *constructive activities:* messages in which content-related information was added, explained, evaluated, summarised or transformed. The production of constructive activities is regarded as to signal collaborative learning-in-process and is related to the concept of knowledge-building discourse (Scardamalia & Bereiter, 1994). Subsequently, a system was developed to analyse discussions on the presence of constructive activities. Extensive practice appeared to be required for a reliable analysis. The highest inter-reliability rate was achieved by two student assistants, who collaborated for two weeks to get a grip on the analysing system (Cohen's Kappa = .86; Chapter 6). A Cohen's Kappa of .74 and .78 was measured in the other two studies (Chapter 4 and 5), in which less time was spent on practice (about a day). For qualitative data analysis that heavily depends on the interpretation of categories, these rates are still 'substantially' high and acceptable (Heuvelmans & Sanders, 1993).

Statistical analyses. To assess the relationships between argumentation, focusing and the production of constructive activities, every message in each discussion was analysed on each of these three variables. Since the variables were defined by using different dimensions in the data (resp. dialogue moves, task and learning goals and content), they could be independently measured. In order to assess linear relationships between the variables, correlation measurements were conducted. In addition, cluster analyses were used in an explorative manner to gain more insights into the interplay between focusing, argumentation and constructive activities. Clustered groups of discussions were subsequently labelled. Yet the names given were not always chosen very well, particularly in the NetMeeting study (Chapter 4). In this study, names as the Conceptualisers and the Achievers were provided to grouped discussions, but appeared to refer to students' characteristics rather than to those of the discussions. To avoid further confusion, later discussions were labelled according to their own characteristics, such as meaning-oriented, pragmatic or product-oriented discussions (see Chapter 5 and 6)[3].

Generalising the findings. All studies were conducted in real and authentic collaborative learning situations in academic education. Therefore, ecological validity was outstanding. However, there were also some drawbacks. First of all, the number of students

[3] The NetMeeting study was already accepted for publication. Therefore, the former labels were maintained in Chapter 4.

that participated in the studies was the same as that subscribed to the yearly courses on Educational Technology and Computer-based learning (between 1996 and 1999), and varied between 20 and 60 students per course. Subsequently, the number of small group discussions that could be assessed, ranged between 13 and 28 discussions per study. In addition, students' regular academic attitudes and preparation activities could not be controlled well, although they affected the discussions without any doubt. Furthermore, different systems and assignments were used across the studies, and this did not allow a strict comparison of results. Then again, assessing similarities in the relationships between focusing, argumentation and constructive activities across the three studies revealed some common findings. However, to increase the number of options for generalisation to other situations, the results need to be tested as future hypotheses in further experimentally designed studies.

7.5 Parallels to other studies

Several authors studied argumentation in relationship to other (interactive) mechanisms in CSCL situations. In research by Erkens (1997), focusing, checking and argumentation were also revealed as essential factors in collaborative learning processes. In addition, parallel studies aimed at argumentation, epistemic interactions and grounding processes contributed to gaining more understanding of the mechanisms that can support collaborative learning through (electronic) dialogue. In this section, some results of corresponding studies are evaluated and related to the research findings.

In Erkens' research project 'Dialogue Structure Analysis of interactive problem solving' (Erkens, 1997) focusing, checking and argumentation were revealed as essential factors in collaborative learning processes. In this project the main question was how processes of problem solving on the task-related level relate to those on the communication level when young students (10-12 years old) engage in a collaborative problem-solving task. On the basis of students' dialogues a prototype of an 'intelligent' computer-based collaborative partner was developed and used for the study of interaction and collaborative problem solving in further detail. It was found that differences in effective problem-solving dialogues could be explained by co-ordination mechanisms between the levels of task-content and communication. One of these mechanisms concerned the degree in which students checked uncertain information. In addition, focus maintenance and argumentation were found to be essential factors. Focusing was defined as students' shared attention on themes and topics under discussion. Argumentation included explicit reasoning processes to justify decisions and conclusions aimed at persuasion. Although other work has researched similar factors in isolation (e.g. Grosz, 1981; Clark & Schaeffer, 1987), Erkens' model combined interactive mechanisms and problem-solving processes within a broader framework.

Although the importance of focus maintenance and information checking coincides with the findings in this research, there are some differences as well. First of all, in Erkens' study argumentation was found to be crucial, which may be explained by differences in task characteristics. All information needed to solve the task was divided amongst the students. Argumentative processes, therefore, did not need to include conceptually oriented discussions but essential reasoning processes about when and how to use what piece of information. Second, in this research it was shown that focus shifts to non-task related information negatively affect collaborative learning processes, which is comparable to Erkens' findings. However, focus shifts between the meaning and application of concepts were found to be positively related to collaborative learning. This result could be explained by Laurillard's work on academic learning (Laurillard, 1993). Laurillard theorises that academic learning cannot be directly experienced. Students have to work on both descriptions of the world (theories, concepts etc.) and act within this world (apply knowledge and concepts to tasks). Shifting focus between the meaning and application of concepts, therefore, could be especially fruitful for students' academic learning.

In Baker's line of studies, the role of argumentation in collaborative learning situations is thoroughly assessed in different electronic systems and in a range of theoretically different dimensions (e.g. Baker, 1999). However, no clear relationships are found between argumentation and collaborative learning processes. Baker has recently shifted attention towards studying epistemic interactions, which reflects an aspiration to broaden the view on argumentation in order to include relationships to other (interactive) mechanisms and contextual features. This research supports such a differentiated approach, which emphasises which mechanisms cause what kind of learning in what circumstances.

Baker started to research the role of knowledge negotiation in several teacher-student and student-student dialogues and explored essential negotiation strategies: refining knowledge, argumentation and standing pat (Baker, 1994). In refining knowledge, participants modify and build on each other's knowledge by proposing and accepting information. This can be done symmetrically (both participants propose and accept information), or asymmetrically (one participant stands pat; the other one elaborates). In argumentation, participants do not accept a particular piece of information and try to convince each other of their own viewpoints. Baker studied argumentation strategies in greater depth, in relation to students' conceptual change in collaborative problem-solving dialogues (Baker, 1996). He found that in all cases where arguments had a dialectical outcome (a 'winner' and 'loser'), arguments were refuted rather than defended. However, no clear relationships were found between argumentation, conceptual change and the quality of the problem solution produced.

Baker, De Vries & Lund (1999) recently conducted an intriguing study aimed at promoting epistemic interactions in a CSCL environment. Instructional aspects as well as interface characteristics were considered in order to provoke epistemic interactions: a combination of argumentations and explanations. Students were systematically paired according to measured differences in interpreting a problem situation in physics. They subsequently tried to solve the problem by expressing their (conflicting) ideas and opinions in CONNECT, a synchronous network-based system for Confrontation, Negotiation and Construction of Text. CONNECT allows free input of text in addition to menu-based communication to be used for interaction management. The results showed that students (still) encountered many problems in interaction management, which is in line with the findings in this research that relate to the use of synchronous CMC systems. In addition, conceptual change could be achieved by dissolving conceptual differences as well as by resolving conflicts in a dialectical sense. Moreover, realising what was not understood could be as much a start for learning as encountering conflict and disagreement. Thus, the research indicates that CSCL situations need to be studied on various conceptual levels, multiple dimensions of argumentation and different types of learning. The present research specifically promotes to include analyses of critical information, focus maintenance and the production of constructive activities.

Parallel studies on grounding contribute to gaining more insight into the mechanisms that can support collaborative learning through (electronic) dialogue. Studies on grounding processes reflect an interest in the factor of focusing. Grounding can be defined as an interactive process, in which mutual understanding can be constructed and maintained (Baker, Hansen, Joiner & Traum, 1999). Grounding can occur at the linguistic level (words, sentences) as well as at the cognitive level (concepts, problems, problem-solving strategies; Dillenbourg & Traum, 1999). Like focusing, grounding can also occur at the level of understanding thematic information in relation to certain task and learning goals.

Regarding the influence of computer environments and interfaces, research on grounding processes can be particularly found in the work of Dillenbourg and colleagues. One of their most recent studies assessed the role of a shared whiteboard in a collaborative problem-solving task in a MOO environment[4] (Dillenbourg & Traum, 1999). The whiteboard was part of the MOO environment. Students could use the MOO for text-based communication and spatial navigation. The whiteboard could be used to display text, graphics, diagrams etc. in a shared and persistent window. It was presumed that the use of the whiteboard would facilitate grounding processes and thereby the construction of a shared problem solution. The results showed that the use of the whiteboard was not related to the problem-solving outcomes. It was concluded that the whiteboard had mainly served as a tool to maintain a shared representation of the state of the problem along the problem-solving process, not as a tool for recording grounded utterances or representing final problem solutions. The whiteboard appeared to serve as a display for group memory and could be viewed as a tool that functions differently in relation to various contexts.

The current research warrants such a view of computer tools. Interface constructs are not always used for the purpose for which they may have been designed. For instance, the Belvédère study showed that conceptual focus maintenance could be enhanced by use of the shared diagram construction tool in addition to the tool for text-based chat discussion. However, effective use appeared to be related to students' task approaches, their preparation activities and types of information represented in the diagram construction tool.

To conclude, several scientists studied argumentation and other (interactive) mechanisms in CSCL situations. In earlier research, focusing, checking and argumentation were already recognised as essential factors in collaborative learning. However, studying the interplay between these three factors in close relationship to contextual features and different electronic environments, uncovered some complex but valuable new insights. Parallel studies about epistemic interactions and grounding processes contributed to gaining more insight into the mechanisms that can support (computer-supported) collaborative learning.

[4] A Multiple Object Oriented system (MOO) is a synchronous, text-based virtual environment serving multiple users simultaneously (see 3.4.2).

In spite of this, the results indicate that processes and interrelationships with contextual features are not yet clear or precisely defined.

7.6 Educational implications

Academic education can be viewed as an ongoing process of argumentation (Petraglia, 1997). It is the process of discovering and generating acceptable arguments and lines of reasoning underlying scientific assumptions and bodies of knowledge. In collaborative learning students can negotiate different perspectives by externalising and articulating them, and learn from each other's insights and different understandings. Thus, through negotiation processes, including argumentation, they can (re-) and co-construct knowledge in relationship to specific learning goals.

The present research suggests that the role of argumentation needs to be reconsidered. Across studies 'direct' forms of argumentation (challenges, counter-argumentation) did not relate to the production of constructive activities, a measure to define learning-in-process. This may be explained by the paradox that students should have a well-established understanding of knowledge in order to take firm positions. However, their knowledge is under discussion and subject to the learning process itself. Therefore, facilitating students to challenge and counter each other's information may not be the most fruitful approach to offer support. However, information checking did show to be important, which was regarded as an 'indirect' form of argumentation. The more information was checked, the more constructive activities were produced. Students can be provoked to critically check each other's information through instruction and task design, which includes at least some of the following characteristics:

- Pragmatic ground rules for exploratory talk and critical behaviour are provided beforehand; this models students' critical behaviour to assess and question information in a social, but constructive manner.
- Students construct their own understanding of the material during an initial individual work stage; this gives firm ground to compare and check each other's differences in understanding.
- Students with conflicting original beliefs are grouped together; recognised conflict gives ground for a critical exchange of thoughts and discussion.

- Symmetrical social interaction is preferable; opinions of dominant partners are easily accepted despite doubt or disagreement.
- Multiple interpretations or problem solutions exist; this gives reason to explore different parts of the problem space, to search for different answers and to share and discuss differences in thoughts and ideas.
- A joint product is required as an end-result; this serves as a motivation for students to put serious effort in constructive collaboration activities, including critical information checking.

With regard to computerised learning environments the research indicates that students particularly need facilitation in co-ordinating electronic and text-based communication and in keeping track of the main issues while producing networked-based discussions. Technical disturbances and a loss of thematic focus easily occur, especially in synchronous CMC systems, and have a negative effect on collaborative learning processes. Additional tools to keep a (graphical) overview of the issues at hand can be helpful, such as the diagram construction tool provided by the Belvédère system (Chapter 5).

There are some other suggestions to prevent students losing focus. First of all, it might be helpful to support students to summarise the issues under discussion regularly, in particular when discussions run over a long period of time. Students barely summarise their information spontaneously. However, it is known that summarising is time-consuming and difficult. It may be useful to assign students to summarise in turns, or to use an external moderator. Second, to enhance content-related, conceptually focused and critical discussion, CMC systems could provide students with multiple negotiation spaces, in which different aspects of the communication process can be discussed separately. Such spaces could include ’rooms’ for content, planning aspects, technical problems, off-task issues etc. Hence, content-related discussions will be less disturbed by other types of talk and focus could be maintained more easily. Furthermore, flexible-structured interaction at the user-interface or distributed intelligent agents could then be developed to offer tailored support to students’ needs in the various functional spaces, e.g. to critically check information. Moreover, additional spaces could be designed and assessed in future studies, such as the use of a separate clarification space (to discuss concepts that are not yet clear) or a glossary space (to list mutually defined concepts). Hyperlinks could be used to establish functional connections between different spaces.

Much is possible, but so far not much is known about the relationships between collaborative learning, argumentation and educational technology. This research has shown that such relationships are neither simple nor predictable. Hence, much more research is needed that will examine the role of (interactive) mechanisms such as argumentation and focusing in relationship to features of CSCL situations. Studies considering academic education, collaborative learning, learning mechanisms, distance learning, CSCL, computer-mediated communication, interface design, artificial intelligence and so forth, can be of help and research results will have to be to put together. In addition, more experimental studies will have to be conducted for theory building. A good start could be to test some of the findings revealed by this study. Thus, relationships found between focusing, argumentation and constructive activities could be studied in other CSCL situations and be used for generalising the findings as well as for theorising. If anything, this thesis hopefully will be encouraging scientists to continue this line of research for further studies in the field of collaborative learning and educational technology.

REFERENCES

Adam, J. M. (1992). *Les textes: Types et prototypes - Récit, description, argumentation et dialogue* [The texts: Types and prototypes- Story, description, argumentation and dialogue]. Paris: Nathan.

Alamargot, D. (1997). *Processus de récupération et d'organisation dans l'activité de rédaction de texte: Effets de l'acquisition de connaissances référentielles* [Recall and organisation processes during text production activity: Effects of learning domain knowledge]. Unpublished doctoral dissertation, Poitiers University, France.

Andriessen, J. E. B., Erkens. G., Overeem, E., & Jaspers, J. (1996, September). *Using complex information in argumentation for collaborative text production*. Paper presented at the UCIS '96 conference. Poitiers, France.

Andriessen, J. E. B., & Sandberg, J. A. C. (1999). Where is Education and how about AI? *International Journal of Artificial Intelligence in Education, 10*(2), 130-150.

Andriessen, J. E. B., & Veerman, A. L. (1999). Samenwerkend telestuderen in het hoger onderwijs [Collaborative telelearning in higher education]. *Pedagogische Studiën, 6*(76), 157 - 178.

Baker, M. (1992). Modelling negotiation in intelligent teaching dialogue. In M. Elsom-Cook & R. Moyse (Eds.), *Knowledge negotiation* (pp.199 - 240). London: Paul Chapman Publishing.

Baker, M. (1994). A model for negotiation in teaching-learning dialogues. *Journal of Artificial Intelligence in Education, 5*(2), 199-254.

Baker, M., & Bielaczyc, K. (1995). Missed opportunities for learning in collaborative problem-solving interactions. In J. Greer (Ed.), *Proceedings of AI-ED 95 - 7th World Conference on Artificial Intelligence in Education* (pp. 210-218). Charlottesville: Association for the Advancement of Computing in Education (AACE).

Baker, M. (1996). *Argumentation and cognitive change in collaborative problem-solving dialogues* (Report No. CR-13/96). France: COAST.

Baker, M. J., & Lund, K. (1996). Flexible structuring the interaction in a CSCL environment. In P. Brna, A. Paiva & J. Self (Eds.), *Proceedings of EuroAIED* (pp. 401-407). Lisbon: Fundacao Calouste Gulbenkian.

Baker, M. J., & Lund, K. (1997). Promoting reflective interactions in a computer-supported collaborative learning environment. *Journal of Computer Assisted Learning, 13,* 175-193.

Baker, M. (1999). Argumentation and constructive interaction. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 179-202) Amsterdam: Amsterdam University Press.

Baker, M., De Vries, E., & Lund, K. (1999). Designing computer-mediated epistemic interactions. In S.P. Lajoie & M. Vivet (Eds.), *Proceedings of the 9th International Conference on Artificial Intelligence in Education* (pp. 139 - 146). Amsterdam: IOS Press.

Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp.31 - 63). Amsterdam: Pergamon.

Bereiter, C., & Scardamalia, M. (1987). *The Psychology of Written Composition.* Hillsdale, NJ: Erlbaum.

Bereiter, C., & Scardamalia, M. (1993). *Understanding expertise*. La Salle, IL: Open Court.

Bonk, C. J., Supplee, L., Malikowski, S., & Dennen, V. (1999, August). *We're entitled to dream: Working toward "The interplanetary teacher learning exchange"*. Paper presented at the 8th European conference for Research on Learning and Instruction, Göteborg, Sweden.

Bostock, A. J. (1996). A critical review of Laurillard's classification of educational media. *Instructional Science, 24*, 71-88.

Brand, M. (1999). *Leren als sociaal proces in een universitaire, CSCL omgeving.* [Learning as a social process in academic CSCL situations]. Unpublished master's thesis, Utrecht University, The Netherlands.

Buckingham Shum, S. J., MacLean, A., Bellotti, V. M. E., & Hammond, N. V. (1997). Graphical argumentation and design cognition. *Human-Computer Interaction, 12,* 267-300.

Bull, S., & Broady, E. (1997). Spontaneous peer tutoring from sharing student models. In B. du Boulay & R. Mizoguchi (Eds.), *Proceedings of Artificial Intelligence in Education* (pp. 143-150). Kobe: IOS Press.

Bunt, H. C. (1989). Information dialogues as communicative action in relation to partner modelling and information processing. In M. M. Taylor, F. Neel, & G. Bouwhuis (Eds.), *The structure of multimodal dialogue* (pp. 47-75). Amsterdam: Elsevier Sciences.

Burnett, R. E. (1993). Decision-making during the collaborative planning of co-authors. In A. Penrose & B. Sitko (Eds.), *Hearing ourselves think: Cognitive research in the college writing classroom* (pp. 125-146). NY: Oxford University Press

Chan, C. K. K. (1995). Collaborative processing of incompatible information. *Proceedings of the Seventeenth Annual Conference of the Cognitive Science Society* (pp. 346-351). Amsterdam: Lawrence Erlbaum.

Clark, H. H., & Schaeffer, E. F. (1987). Collaborating on contributions to conversation. *Language and Cognitive Processes, 2*, 19-41.

Cohen, J. (1968). Weighted kappa: nominal scale agreement with provisions for scales disagreement of partial credit. *Psychological Bulletin, 70*, 213-220.

Coirier, P., Andriessen, J. E. B., & Chanquoy, L. (1999). From planning to translating: The specificity of argumentative writing. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 1-28). Amsterdam: Amsterdam University Press.

Collis, B. (1996). *Tele-learning in a digital world: The future of distance learning*. London: International Thomson Computer Press.

Csikszentmihalyi, M. (1977). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.

Dansac, C., & Alamargot, D. (1999). Accessing referential information during text composition: When, how, and why? In M. Torrance & D. Galbraith (Eds.), *Knowing what to write: Conceptual processes in text production* (pp.79-97). Amsterdam: Amsterdam University Press.

Dillenbourg, P., & Schneider, D. (1995). Mediating the mechanisms which make collaborative learning sometimes effective. *International Journal of Educational Telecommunications, 1*(2-3), 131-146.

Dillenbourg, P., & Baker, M. J. (1996). Negotiation spaces in human-computer collaboration. In COOP Group (Ed.), *Proceedings of the Second International Conference on Design of Co-operative Systems* (pp. 186-206). Juan-les-Prince, France.

Dillenbourg, P., & Traum, D. (1997, August). *The relationship between interaction and problem solving in virtual collaborative environments*. Paper presented at the 7th European conference for Research on Learning and Instruction, Athens, Greece.

Dillenbourg, P. (1999). *Collaborative learning: Cognitive and computational approaches.* Amsterdam: Pergamon.

Dillenbourg, P., & Traum, D. (1999). Does a shared screen make a shared solution? In C. Hoadly & J. Roschelle (Eds.), *Proceedings of the third conference on Computer Supported Collaborative Learning* (pp. 127 - 135). California: Stanford University.

Doise, W,. & Mugny, G. (1984). *The social development of the intellect.* Oxford: Pergamon.

Erkens, G. (1997). Coöperatief probleemoplossen met computers in het onderwijs: Het modelleren van coöperatieve dialogen voor de ontwikkeling van intelligente onderwijssystemen [Co-operative problem solving with computers in education: Modelling of co-operative dialogues for the design of intelligent educational systems]. Utrecht, The Netherlands: Brouwer Uithof.

Erkens, G. (1998). *Multiple Episode Protocol Analysis (MEPA 3.0)* (Internal Report). Utrecht, The Netherlands: Department of Educational Sciences, Utrecht University.

Everitt, B. (1974). *Cluster analysis*. London: Heinemann Educational books.

Feenberg, A. (1989). The written world. In R. Mason & A. Kaye (Eds.), *Mindweave: communication, computers and distance education* (pp. 22-39). Oxford: Pergamon.

Feenberg, A. (1993). Building a global network: The WBSI experience. In L. M. Harasim (Ed.), *Global networks: Computers and international communication*. USA, MIT.

Freeman, J. B. (1992). Relevance, warrants, backing, inductive support. *Argumentation, 6,* 219-235.

Gardenbroek, M. (1999). *Teleleren bij Onderwijskunde* [Tele-learning in Educational Sciences]. (Internal Report). Utrecht, The Netherlands: Department of Educational Sciences, Utrecht University.

Golder, C., & Pouit, D. (1999). For a debate to take place the theme must be discussible: Developmental evolution of the negotiation and admissibility of the arguments. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 137-148). Amsterdam: Amsterdam University Press.

Graesser, A. C., Person, N. K., & Huber, J. (1993). Question asking during tutoring and in the design of educational software. In M. Rabinowitz (Ed.), *Cognitive foundations of instruction* (pp. 149-172). Hillsdale, NJ: Lawrence Erlbaum.

Greeno, J.G. (1997). Response: On claims that answer the wrong question. *Educational Researcher, 20*(1), 5-17

Grosz, B. (1981). Focusing and description in natural language dialogues. In A. Joshi, B. Webber & I. Sag (Eds.), *Elements of discourse and understanding* (pp. 84-105). Cambridge: Cambridge University Press.

Gyselinck, V. & Tardieu, H. (1999). The role of illustrations in text comprehension: What, when, for whom, and why? In H. van Oostendorp & S. Goldman (Eds.), *The construction of mental representations during reading* (pp. 195-218). Mahwah, NJ: Erlbaum.

Hakkarainen, K. (1995, August). *Collaborative inquiry in the computer-supported intentional learning environments (CSILE).* Paper presented at the 6th European conference for Research on Learning and Instruction, Nijmegen, The Netherlands.

Hansen, T., Dirckinck-Homfeld, L., Lewis, R., & Rugelj, J. (1999). Using telematics for collaborative knowledge construction. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp 169-197). Amsterdam: Pergamon.

Heuvelmans, A. P. J. M. & Sanders, P. F. (1993). Beoordelaarsoverstemming [Inter-reliability measurement]. In Eggen, T. J. H. M. & P. F. Sanders (Eds.), *Psychometrie in de praktijk* (pp. 443-469). Arnhem, The Netherlands: CITO.

Hightower, R., & Sayeed, L. (1995). The impact of computer-mediated communication systems on biased group discussion. *Computers in Human Behaviour, 11,* 33-44.

Järvelä, S., & Häkkinen, P. (1999, March). *Case-based conferencing on the web: Reciprocal understanding and perspective taking in conversation.* Paper presented at the conference on Computer Assisted Learning, London.

Jermann, P., & Schneider, D. (1997). Semi-structured interface in collaborative problem-solving. Retrieved in 1997 from the World Wide Web: *http://tecfa.unige.ch/tecfa/publicat/jermann-papers/lsnne97/lsne-97-1.html*

Jermann, P., Dillenbourg, P., & Brouze, J. C. (1999). Dialectics for collective activities: An approach to virtual campus design. In S. Lajoie & M. Vivet (Eds.), *Proceedings of the 9th International conference Artificial Intelligence in Education* (pp. 570-577). Amsterdam: IOS Press.

Johnson, D. W., & Johnson, R. T. (1993). Creative and critical thinking through academic controversy. *American Behavioural Scientist, 37*(1), 40-53.

Kanselaar, G., Jong, T. de, Andriessen, J. E. B, & Goodyear, P., (2000). New technologies. In P .R. J. Simons, J. L. van der Linden, & T. Duffy (Eds.),. *New learning* (pp. 49 - 72). Dordrecht: Kluwer Academic Publishers.

Kanselaar, G., & Erkens, G. (1996). Interactivity in co-operative problem solving with computers. In S. Vosniadou, E. DeCorte, R. Glaser & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 185 - 202). Mahwah, New Jersey: Lawrence Erlbaum.

Katz, S., O'Donnel, G., & Kay, H. (1999, July). An approach to coding educational dialogues for descriptive and prescriptive purposes. *Proceedings of Workshop 3: 'Analysing educational dialogue interaction: Towards models that support learning'* (pp. 22-32). Le Mans, France: AI-Education '99.

Kiesler, S. (1986). The hidden message in computer networks. *Harvard Business Review, 64*(1), 46-58.

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

Kozma, R. B. (1991). The impact of computer-based tools and embedded prompts on writing processes and products of novice and advanced college writers. *Cognition and Instruction, 8*(1), 1-27.

Krosnick, J. A. & Petty, R. E. (1995). *Attitude strength: Antecedents and consequences.* New Jersey: Lawrence Erlbaum.

Kuhn, D. (1991). *The Skills of Argument.* Cambridge: University Press.

Laurillard, D. (1993). *Rethinking university teaching: A framework for the effective use of educational technology.* London: Routledge.

Learning Research and Development Center (1996). Advanced cognitive tools for learning. Retrieved in 1996 from the World Wide Web: *http://advlearn.lrdc.pitt.edu/Belvédère/index.html*

Levinson, S. C. (1983). *Pragmatics.* New York: Cambridge University Press.

Littleton, K., & Hakkinen, K. P. (1999). Learning together: Understanding the processes of computer-based collaborative learning. In P. Dillenbourg (Ed), *Collaborative learning: Cognitive and computational approaches* (pp. 20-31). Amsterdam: Pergamon.

Lord, C. G., Ross, L., & Lepper, M. R. (1979). Biased assimilation and attitude polarization: The models: Some practical issues. *Psychological Bulletin, 114,* 533 - 541.

MacKenzie, J.D. (1985). No logic before Friday. *Synthese*, *63,* 329-341.

Mason, R. (1992). The textuality of computer networking. In R. Mason (Ed.), *Computer conferencing: The last word* (pp. 22-38). Victoria, BC: Beach Holme Publishers.

McCutchen, D. (1987). Children's discourse skill: Form and modality requirements of schooled writing. *Discourse Processes, 10*, 267-286.

Moore, D. (1993). *Dialogue game theory for intelligent tutoring systems.* Unpublished doctoral dissertation, Leeds Metropolitan University.

Moore, M. G. (1993). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 22-38). London: Routledge.

Novak, J. D. (1991). Clarify with concept maps: A tool for students and teachers alike. *The Science Teacher, 58*(7), 45-49.

Ohlsson, S. (1993). Learning to do and learning to understand: A lesson and a challenge for cognitive modelling. In P. Reimann & H. Spada (Eds.), *Learning in humans and machines* (pp. 37-62). Oxford: Pergamon.

Pea, R. D. (1993). Learning scientific concepts through material and social activities: Conversational analysis meets conceptual change. *Educational psychologist, 28*(3), 265-277.

Petraglia, J. (1997). *The rhetoric and technology of authenticity in education.* Mahwah, NJ: Lawrence Erlbaum.

Petty, R. E. & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 123-205). San Diego, CA: Academic Press.

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures*. New York: Viking Penguin.

Pilkington, R. M., & Mallen, C. (1996). Dialogue games to support reasoning and reflection in diagnostic tasks. In P. Brna, A. Paiva & J. Self (Eds.), *Proceedings of EuroAIED* (pp. 213-220). Lisbon: Fundacao Calouste Gulbenkian.

Pilkington, R. (1999). *Analysing educational discourse: the DISCOUNT scheme* (Report No. 2 99/2). Leeds: Computer-based learning unit, Leeds University.

Pilkington, R., McKendree, J., Pain, H., Brna, P. (1999, July). *Analysing educational dialogue interaction: Towards models that support learning.'* A One day Workshop at AI-Ed '99', Le Mans, France.

Pilkington, R., Treasure-Jones, T., & Kneser, C. (1999). An investigation of participants' role in CMC seminars using exchange structure analysis. *Proceedings of Workshop 3: Analysing educational dialogue interaction: Towards models that support learning* (pp. 44-52). Le Mans, France: AI & Education '99.

Reimann, P. (1999). Commentary: The role of external representations in distributed problem solving. *Learning and Instruction, 9*(4), 419 - 424.

Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *The journal of the learning sciences, 2*(3), 235-276.

Roschelle, J., & Teasley, S. D. (1995). Construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer-supported collaborative learning*. New York (pp. 69-97): Springer-Verlag.

Rutter, D. R. (1987). *Communicating by telephone*. Oxford: Pergamon.

Salomon, G. (1997, August). *Novel constructivist learning environments and novel technologies: Some issues to be concerned.* Invited key-note address at the EARLI conference, Athens, Greece.

Savery J., & Duffy, T. M. (1996). Problem based learning: An instructional model and its constructivist framework. In B. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 135-148). Englewood Cliffs, NJ: Educational Technology Publications.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the learning sciences, 3*(3), 265-283.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. New York: Wiley.

Smith, J. B. (1994). *Collective intelligence in computer-based collaboration*. Hillsdale, NJ: Lawrence Erlbaum.

Spears, R., & Lea, M. (1992). Social influence and the influence of the 'social' in computer-mediated communication. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 30-65). Hemel-Hempstead: Harvester-Wheatsheaf.

Steeples, C., Unsworth, C., Bryson, M., Goodyear, P., Riding, P., Fowell, S., Levy, P., & Duffy, C. (1996). Technological support for teaching and learning: Computer-mediated communications in higher education. *Computers & Education, 26*(1-3), 71-80.

Stein, N. L., & Miller, C. A. (1991). I win-you lose: The development of argumentative thinking. In J. F. Voss, D. N. Perkins & J. W. Segal (Eds.), *Informal Reasoning and Education*. Hillsdale, New Jersey: Lawrence Erlbaum.

Stein, N. L., Calicchia, D. J,. & Bernas, R. S. (1996). Conflict talk. Understanding and resolving arguments. In T. Givon (Ed.), *Typological studies in language: Conversational analysis* (pp. 233-267). Amsterdam: John Benjamins.

Suthers, D., & Weiner, A. (1995). Groupware for developing critical discussion skills. In J. L. Schnase & E. L. Cunnius (Eds.), *Proceedings of CSCL '95, the first international conference on computer support for collaborative learning*. (pp.341-348). NJ: Lawrence Erlbaum Associates.

Suthers, D. (1998, April). *Representations for scaffolding collaborative inquiry on ill-structured problems*. Paper presented at the 1998 conference of the American Educational Research Association, San Diego.

Teles, L. (1993). Cognitive apprenticeship on global networks. In L. M. Harasim (Ed.), *Global networks: Computers and international communication* (pp. 271-281). USA: MIT Press.

Toulmin, S. (1958). *The Uses of Argument*. London: Cambridge University Press.

Toulmin, S., Rieke, R., & Janik, A. (1984). *An introduction to reasoning*. New York: Macmillan Publishing.

Treasure-Jones, T. (submitted thesis). *Supporting students' critical essay planning: towards a computer-based approach*. Computer-based learning unit, The University of Leeds.

Van Boxtel, C. A. M. (2000). Collaborative concept learning. Student interaction, collaborative learning tasks and physic concepts. Enschede, The Netherlands: Print Partners Ipskamp.

Van der Pol, J. (1998). *Argumentatie in elektronisch gevoerde discussies en het effect van verschillende manieren om een discussie op te zetten* [Argumentation in electronic discussions and how to design them] (Internal report). Utrecht, the Netherlands: Department of Educational Sciences, Utrecht University.

Van Eemeren, F. H, Grootendorst, R., & Snoeck Henkemans, A.F. (1995) *Argumentatie* [Argumentation]. Groningen, The Netherlands: Woltersgroep.

Van Merriënboer, J. (1999). *Cognition and Multimedia Design for Complex Learning*. Inaugurale rede, Open Universiteit Heerlen, The Netherlands.

Van Wijk, C. (1995) *Levels of competence in writing*. Paper presented at the 5th European workshop on natural language generation, Leiden, The Netherlands.

Veerman, A. L. (1996, October). *Argumentation during solving ill-structured problems*. Paper presented at the First International Workshop on Argumentative Text Processing, Barcelona.

Veerman, A. L. (1996). *De relatie tussen vragen stellen en argumentatie in onderwijsleergesprekken* [The relationship between question asking and argumentation in tutoring sessions] (Internal Report). Utrecht, The Netherlands: Department of Educational Sciences, Utrecht University.

Veerman, A. L., & Andriessen, J. E. B. (1997, September). *Academic learning and writing through the use of educational technology*. Paper presented at the conference on Learning & Teaching Argumentation, Middlesex, London.

Veerman, A. L., & Treasure-Jones, T. (1999). Software for problem solving through collaborative argumentation. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 203-230). Amsterdam: Amsterdam University Press.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (1999, August). *Computer-mediated discussions through graphically structured interaction*. Paper presented at the 8th European conference for Research on Learning and Instruction, Göteborg, Sweden.

Veerman, A. L., Andriessen, J. E. B., & G. Kanselaar (1999). Collaborative learning through computer-mediated argumentation. In C. Hoadly & J. Roschelle (Eds.), *Proceedings of the third conference on Computer Supported Collaborative Learning* (pp. 640 - 650). California: Stanford University

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (2000). Learning through synchronous electronic discussion. *Computers & Education, 34*(2-3), 1-22.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (submitted). Collaborative argumentation in academic education. *Instructional Science*.

Veerman, A. L., & Andriessen, J. E. B. (submitted). Co-constructing meaning through diagram-mediated electronic discussion. *Journal of Artificial Intelligence and Education*.

VonGlasersfeld, E. (1989). Cognition, construction of knowledge, and teaching. *Synthese, 80*, 121-140.

Voss, J. F., & Means, M. L. (1991). Learning to reason via instruction in argumentation. *Learning and Instruction, 1,* 337-350.

Wan, D., & Johnson, P. M. (1994). Experiences with CLARE: A computer-supported collaborative learning environment. *Proceedings of the 1994 ACM Conference on Computer Supported Work* (pp. 1-29). North Carolina: Chapel Hill.

Wegerif, R., Mercer, N., & Dawes, L. (1998). Software design to support discussion in the primary classroom. *Journal of Computer Assisted Learning, 14*(3), 199-211.

SAMENVATTING

Context van het proefschrift

Het gebruik van Internet en netwerk-gebaseerde computersystemen in het onderwijs staat momenteel sterk in de belangstelling. Dat komt niet alleen door de voordelen die dit soort systemen biedt ten aanzien van tijd en plaats, maar ook door de flexibele wijze waarop met informatie kan worden omgegaan. Informatie kan op verschillende manieren worden opgeslagen, gerepresenteerd en toegankelijk gemaakt (tekst, tekeningen, foto's, tabellen en figuren, animaties, simulaties, video, 'virtual reality' etc.). Daarnaast kan de communicatie tussen studenten en docenten worden gefaciliteerd door gebruik te maken van computer-gemedieerde communicatie (CMC)-systemen. CMC-systemen zijn netwerk-gebaseerde computerprogramma's en bieden allerlei mogelijkheden voor elektronische communicatie. Voorbeelden zijn: chat-systemen, nieuwsgroepen, e-mail en virtuele schoolklassen. CMC-systemen kunnen zowel synchrone communicatie ondersteunen (zelfde tijd, verschillende plaats) als asynchrone communicatie (verschillende tijd, verschillende plaats). Momenteel is het gebruik van CMC-systemen nog voornamelijk gericht op het faciliteren van tekstuele communicatie, gezien de huidige beperkingen in bandbreedte.[1] In de toekomst zullen geavanceerde technologieën het steeds beter mogelijk maken om te werken met systemen die op één platform een combinatie aanbieden van synchrone en asynchrone communicatie, gedigitaliseerde tekst, video, plaatjes en geluid etc. (Collis, 1996).

Dit onderzoek is gericht op studenten in het academisch onderwijs die een opleiding volgen in de sociale wetenschappen. Deze studenten krijgen veelvuldig te maken met abstracte en complexe leerstof die ambigu is, tegenstrijdig, slecht gedefinieerd en moeilijk te begrijpen. Daarnaast worden zij vaak voor 'open' problemen gesteld die op allerlei manieren kunnen worden aangepakt en waar vele oplossingen voor mogelijk zijn. Om begrip te ontwikkelen in dit soort complexe kennisdomeinen en inzicht te bevorderen in de

[1] Definitie van bandbreedte: de benodigde breedte van frequenties om signalen door te geven. Bijvoorbeeld: geluid via de telefoon vraagt om een bandbreedte van 3 kilohertz terwijl videosignalen een bandbreedte van 6 megahertz nodig hebben (Collis, 1996; p. 598)

aanpak van open probleemsituaties, kunnen samenwerkingsvormen worden ontwikkeld waarin studenten van elkaars inzichten en oplossingsmethoden kunnen leren.

In samenwerkende leersituaties kunnen studenten informatie met elkaar bespreken en bediscussiëren, niet alleen op feitelijke en/of onderzoeksmatige aspecten maar ook in relatie tot persoonlijke voorkeuren, normen en waarden. Argumentatie kan hierbij worden gezien als een van de belangrijkste mechanismen die tot leren in samenwerking kunnen leiden (bv. Piaget, 1977; Dillenbourg & Schneider, 1995; Baker, 1996; Savery & Duffy, 1996; Erkens, 1997; Petraglia, 1997). Argumentatie betreft het voorop stellen van conflicten en geeft aanleiding tot onderhandelingsprocessen waarin informatie kritisch kan worden gecheckt op betekenis en waarde, argumenten kunnen worden uitgewerkt (elaboratie) en vanuit verschillende perspectieven worden bekeken. Via argumentatie kunnen studenten hun kennis en opvattingen bijstellen, vervangen en/of gezamenlijk opbouwen (co-constructie van kennis), waardoor een beter begrip en inzicht kan ontstaan in specifieke kennisdomeinen en/of probleemsituaties.

Samenwerkend leren via Internet en netwerk-gebaseerde computersystemen biedt studenten nieuwe mogelijkheden om actief deel te nemen aan argumentatieve en constructieve vormen van interactie. Tekstuele en in tijd vertraagde communicatie kan studenten helpen om tegengestelde meningen, kennishiaten en/of kennisconflicten te ontdekken. Menu-gestuurde interactie via het beeldscherm of het gebruik van systemen om argumenten grafisch te organiseren, kunnen effectieve vormen van interactie oproepen en/of ondersteunen. Tot nu toe is echter weinig bekend over het effectief gebruik van dergelijke computersystemen ter ondersteuning van samenwerkend leren in het academisch onderwijs. De rol van argumentatie in zulke situaties is nog minder onderzocht.

Alle studies die in dit proefschrift worden beschreven, zijn uitgevoerd bij de opleiding Onderwijskunde van de Faculteit Sociale Wetenschappen aan de Universiteit Utrecht in Nederland. Studenten die deelnamen aan verschillende samenwerkingsactiviteiten in de modulen Onderwijs & Informatietechnologie (OIT) en Computer Ondersteund Onderwijs (COO)[2] werden voor deze studies bestudeerd. De onderzoeksvragen zijn gericht op de rol van tekstuele en argumentatieve communicatie in samenwerkende leersituaties. Er is een aantal contextuele factoren bekeken: de taak, de instructie, de (mede-) student, de docent, verschillende manieren om informatie te

[2] Tijdens de uitvoering van dit onderzoek (1996 - 1999) werden de modulen OIT & COO aangeboden in het tweede doctoraaljaar van de opleiding Onderwijskunde.

representeren en diverse vormen van elektronische communicatie. Het onderzoek is gericht op het ontdekken van principes met betrekking tot samenwerkend leren, argumentatie en onderwijstechnologie die kunnen worden gebruikt als raamwerk voor verder onderzoek naar computer ondersteund samenwerkend leren en voor de onderwijspraktijk.

De belangrijkste bevindingen

Om de rol van argumentatie te onderzoeken, is het van belang een omgeving te creëren waarin argumentatieve interactie kan voorkomen. Het onderzoek begon daarom met het zoeken naar principes die argumentatie oproepen in de context van het academisch onderwijs en in samenwerkende leersituaties.

Hoofdstuk 2: hoe studenten kunnen worden aangezet tot argumentatie; contextuele factoren. Het eerste onderzoek was gericht op het organiseren van samenwerkingssituaties waarin studenten worden aangezet tot argumentatie. Daarbij werd een aantal contextuele factoren bekeken dat hierop van invloed zou kunnen zijn: de rol van student, medestudent, docent, taak, instructie en communicatiemiddel. Drie studies werden achtereenvolgens uitgevoerd: twee in 'face-to-face' situaties[3], met en zonder docent, en een derde met behulp van het netwerk-gebaseerde computersysteem Belvédère (Learning Research and Development Center, 1996). Het Belvédère-systeem werd gebruikt voor synchrone communicatie (chatten) en voor het maken van een argumentatief diagram. In de drie studies kregen de studenten de opdracht om respectievelijk leerdoelen te evalueren met betrekking tot een computer-ondersteund onderwijssysteem (COO), inzicht te ontwikkelen in een theoretisch model en om didactische richtlijnen te ontwerpen voor een COO-systeem.

In elke studie werkten studenten samen in groepjes van twee of drie. Zij voerden discussie over een of twee complexe onderwerpen of over 'open' probleemsituaties. De eerste studie betrof elf groepjes studenten in 'face-to-face' situaties waarbij ook een docent aanwezig was (ca. één uur per discussie); in de tweede studie voerden twaalf groepjes studenten twee korte 'face-to-face' discussietaken uit zonder docent (ca. tien minuten per discussietaak); in de derde studie werden veertien discussietaken uitgevoerd via het Belvédère-systeem: zeven groepjes studenten maakten twee taken (ca. één uur per taak).

[3] In 'face-to-face' (F2F) situaties zijn personen fysiek aanwezig. De communicatie verloopt op natuurlijke wijze, zonder tussenkomst van computers en/of andere (elektronische) hulpmiddelen.

Alhoewel de studies in vele aspecten verschilden, werden alle discussies geanalyseerd op het voorkomen van argumentatieve discussiefragmenten. In zulke fragmenten werd

minimaal één expliciete uitspraak gedaan waarmee twijfel of kritiek werd aangegeven (bv. door het stellen van een 'waarom'-vraag of door het geven van een tegenargument) en er werd minimaal één argument ter onderbouwing gegeven. In lange argumentatieve discussiefragmenten werden alle uitspraken apart gecategoriseerd als vraagtype of als argument voor, tegen of neutraal ten opzichte van een stelling. Door het analyseren van deze argumentatieve fragmenten konden de verschillende studies met elkaar worden vergeleken en een aantal principes worden ontdekt waarmee argumentatie kan worden opgeroepen in de context van het academisch onderwijs en in samenwerkende leersituaties.

Allereerst moet worden opgemerkt dat de studenten in de verschillende studies zich minder goed hadden voorbereid op de discussietaken dan mogelijk was geweest. Gegeven deze situatie werd gezocht naar andere factoren die argumentatie konden uitlokken. Situaties waarin de studenten zelf (competitieve) stellingen moesten formuleren en die waarbij zij een gezamenlijk product moesten afleveren, bleken hiervoor geschikt te zijn. Het bekijken van verschillende perspectieven en het uitwerken van argumenten (elaboratie) kon worden gestimuleerd door studenten te voorzien van basisregels betreffende argumentatief gedrag en middelen om argumenten grafisch te representeren, zoals in Belvédère. Ook het stellen van vragen bleek effectief te zijn, zeker wat betreft het stellen van open vragen en verificatievragen. In de aanwezigheid van een docent stelden de studenten dit soort vragen niet: zij leken sterk geneigd te zijn om zonder discussie aan te nemen wat de docent beweerde.

Hoofdstuk 3: hoe argumentatie kan worden opgeroepen en hoe argumentatie kan worden ondersteund; elektronische kenmerken. In dit hoofdstuk komen de onderzoeks-vragen aan de orde hoe argumentatie kan worden *opgeroepen* en hoe argumentatieve processen vervolgens kunnen worden *ondersteund*. Deze vragen hebben specifiek betrekking op elektronische leersituaties waarin studenten gezamenlijk probleemtaken oplossen. Het hoofdstuk begint met een zoektocht door de literatuur in relatie tot belangrijke cognitieve processen. Naast het kritisch checken van de betekenis van informatie, het uitwerken van argumenten en het uitgaan van verschillende perspectieven, wordt het behoud van een gezamenlijke focus (het vasthouden van aandacht op bepaalde aspecten in de dialoog) besproken als een belangrijke factor voor effectieve argumentatie en samenwerkend probleemoplossen. Aangaande deze factoren werden vijf studies geselecteerd waarin verschillende CMC-systemen waren ontworpen en werden gebruikt voor onderwijstaken. Hierbij werd argumentatie benadrukt als een methode voor het oplossen van problemen of als een einddoel voor leren. Alle studies publiceerden resultaten en data met betrekking tot argumentatieve interactie en waren allemaal gericht op 'student-student' interactie; docenten speelden geen rol. De geselecteerde CMC-systemen kenmerkten zich door op verschillende manieren interactie te structureren via het beeldscherm. Zo werd geprobeerd bepaalde vormen van communicatie en meer specifiek van argumentatie uit te lokken en te ondersteunen. Dit gebeurde bijvoorbeeld door het controleren van beurtwisselingen, door studenten tekst in te laten voeren via een gestructureerd menu of via buttons en door argumenten grafisch te laten organiseren. Bij het bediscussiëren van de vijf CMC-systemen in relatie tot het oproepen en ondersteunen van argumentatie werd aandacht geschonken aan kenmerken van de taak en instructie en de wijze waarop de interactie werd gestructureerd.

De studie laat zien dat het structureren van interactie via het beeldscherm niet noodzakelijkerwijs argumentatie *oproept*. Het uitlokken van argumentatie lijkt vooral te zijn gerelateerd aan taak- en instructiekenmerken, zoals het gebruik van een competitieve taakopzet. Het aanbieden van een combinatie van gestructureerde en vrije vormen van interactie kan argumentatieve processen wel *ondersteunen*. In communicatieschermen (chat boxes) kan een vrije invoer van tekst in combinatie met het aanbieden van argumentatieve 'zinopeners', in de vorm van buttons of een menu, studenten stimuleren om informatie kritisch te checken. In taakschermen kan het grafisch organiseren van argumenten studenten helpen om verschillende perspectieven te bediscussiëren en om argumenten verder uit te werken. Aangezien ook taakkenmerken dit soort processen kunnen ondersteunen, dienen taakkenmerken en vormen van gestructureerde interactie in samenhang te worden bekeken teneinde argumentatieprocessen optimaal te stimuleren in computer ondersteunde situaties voor samenwerkend leren. Daarnaast kan ondersteuning voor het vasthouden van een gezamenlijke aandachtsfocus worden overwogen. Taken die argumentatieve interactie oproepen kenmerken zich in ieder geval door een aantal van de volgende aspecten:

- verschillende oplossingen zijn mogelijk
- er wordt competitieve instructie gegeven
- er is sprake van een (competitief) rollenspel

- conflicterende standpunten zijn vooraf opgesteld
- relevante informatie wordt verdeeld onder de deelnemers
- studenten met conflicterende meningen worden gegroepeerd
- studenten stellen zelf standpunten op in een voorbereidende werkfase
- een gezamenlijk product wordt vereist

Samenvattend kan worden gesteld dat op grond van de studies in hoofdstuk 2 en 3, argumentatie eerder wordt opgeroepen door taakkenmerken dan door kenmerken van het computersysteem. Om argumentatieve processen zoals het checken van informatie, het uitwerken van argumenten en het innemen van verschillende perspectieven te ondersteunen, kan een combinatie worden aangeboden van gestructureerde en vrije vormen van interactie via het beeldscherm. Het aanbieden van steun voor het vasthouden van een gezamenlijke aandachtsfocus wordt gezien als een mogelijke aanvulling.

De drie empirische studies in hoofdstuk 4, 5 en 6 gaan uit van een argumentatieve taakopzet waarbij elektronische, tekst-gebaseerde discussies worden gevoerd via verschillende CMC-systemen, met en zonder didactische ondersteuning van mensen of computersystemen. Hoewel de studies in een aantal kenmerken verschillen, kunnen de discussies met elkaar worden vergeleken, omdat zij op overeenkomstige wijze zijn geanalyseerd op focusing, argumentatie en op het voorkomen van constructieve activiteiten, een maat die is ontwikkeld om het proces van samenwerkend leren te onderzoeken. Het meten van constructieve activiteiten is gebaseerd op ideeën over kennisconstructie en 'knowledge building discourse' (Scardamalia & Bereiter, 1994).

Hoofdstuk 4: hoe computer-ondersteund samenwerkend leren via argumentatie kan worden bevorderd; synchrone communicatie. De hoofdvraag is hoe samenwerkend leren kan worden bevorderd via argumentatie in synchrone CMC-systemen. In dit onderzoek zijn twintig studentparen onderzocht die een elektronische discussietaak uitvoerden van 45-60 minuten. Zij maakten hiervoor gebruik van het computerprogramma NetMeeting, een netwerk-gebaseerd softwaresysteem voor synchrone communicatie (o.a. chatten). Het doel van de discussietaak was om inzicht in en begrip van een theoretisch model te ontwikkelen. Er werd onderzocht hoe de studentparen dit model bespraken: hoe zij hun aandacht vasthielden (focus), argumentatief discussie voerden en hoe een 'structuur'-coach versus een 'reflectie'-coach hun gedrag beïnvloedde. 'Structuur'-coaches werden geïnstrueerd om studenten aan te moedigen verschillende perspectieven te onderzoeken en tegen-argumenten te bedenken. 'Reflectie'-coaches werden geïnstrueerd om studenten aan te zetten tot het kritisch bespreken van de betekenis van informatie en om standpunten te koppelen aan bewijslast. De resultaten met betrekking tot focusing en argumentatie werden vervolgens gerelateerd aan het aantal en type constructieve activiteiten dat in de discussies voorkwam. Er werd onderscheid gemaakt tussen de volgende typen constructieve activiteiten: toevoegen van informatie, uiteenzetten van informatie (uitleg), het evalueren van informatie, het transformeren van informatie (bereiken van nieuw inzicht) en het samenvatten van informatie.

De resultaten gaven aan dat argumentatie een effectieve factor is in computer ondersteund samenwerkend leren, maar moet worden onderzocht in relatie tot de aandachtsfocus van studenten. Argumentatie was effectief in discussies waarin de focus was gericht op of werd verplaatst naar het bespreken van de betekenis van concepten. De meeste discussies werden daarentegen niet op conceptueel niveau gevoerd, maar waren gericht op het zo snel mogelijk afhandelen van de taak (twaalf van de twintig discussies). Slechts drie discussies konden worden gecategoriseerd als conceptueel georiënteerd, vijf discussies waren gemengd. De coaches voldeden niet aan onze verwachtingen alhoewel de 'reflectie'-coach de studenten aanspoorde om elkaars informatie vaker te checken op betekenis. Het checken van informatie leek meer doeltreffend te zijn voor het produceren van constructieve activiteiten dan 'directe' vormen van argumentatie: het elkaar uitdagen om verantwoording af te dwingen of het tegenspreken.

Hoofdstuk 5: hoe computer-ondersteund samenwerkend leren via argumentatie kan worden bevorderd; synchrone communicatie en diagramconstructie. Deze studie was gericht op het aanbieden van specifieke computerondersteuning voor argumentatie tijdens samenwerkend leren in synchrone CMC-systemen. Het onderzoek betrof dertien groepjes studenten, tweetallen en drietallen, die gebruik maakten van het Belvédère-systeem om met elkaar te communiceren (chatten) en om samen een argumentatief diagram op te bouwen. De groepjes werden geïnstrueerd om een aantal betekenisvolle didactische activiteiten te ontwerpen voor een computer-ondersteund onderwijssysteem in een 60-90 minuten durende discussietaak. De interesse ging met name uit naar de relatie tussen kenmerken van de chat-discussie en die van het argumentatieve diagram. De verwachting was dat het opbouwen van een argumentatief diagram studenten zou ondersteunen in het kunnen volgen van de belangrijkste onderwerpen uit de discussie (aandachtsfocus) en dat argumentatie zou worden gestimuleerd door de visuele weergave van (onduidelijke) informatie, kennishiaten en conflicten. De chatdiscussies werden geanalyseerd op focusing, argumentatie en de productie van constructieve activiteiten. Argumentatieve diagrammen werden geanalyseerd op organisatiekenmerken en op balans. Informatie die voorkwam in zowel de chatdiscussie als in het argumentatieve diagram werd apart gecategoriseerd als 'overlappende' informatie. Dit bleek later een belangrijke codering te zijn.

De resultaten lieten een complex samenspel zien tussen chatdiscussie, diagram-constructie, taakaanpak en voorbereidende activiteiten. De discussies konden in drie clusters worden verdeeld die werden betiteld als (a) betekenis-georiënteerd, (b) pragmatisch en (c) product-georiënteerd. Betekenis-georiënteerde discussies waren het meest uitgewerkt: de aandachtsfocus was sterk gericht op de betekenis van concepten, informatie werd veelvuldig gecheckt en er werd een groot aantal constructieve activiteiten geproduceerd. Pragmatische discussies waren zowel gericht op de betekenis als op de toepassing van concepten. Zij bevatten minder argumentatie en minder constructieve activiteiten. Product-georiënteerde discussies waren vooral gericht op het zo snel mogelijk afhandelen van de taak. De Belvédère-diagrammen konden ook worden ingedeeld in drie clusters die werden betiteld als (a) adaptief, (b) deliberatief en (c) generatief. Adaptieve diagrammen waren beperkt in omvang en de meeste informatie in het diagram overlapte de informatie in de chatdiscussie. Generatieve diagrammen waren omvangrijk en de informatie in het diagram overlapte nauwelijks de informatie in de chatdiscussie. Deliberatieve diagrammen konden hier tussenin worden geplaatst. Zij waren gemiddeld van grootte en de informatie in het diagram overlapte gedeeltelijk de informatie in de chatdiscussie. Uit het onderzoek bleek dat hoe meer informatie in het diagram de informatie in de chatdiscussie overlapte, hoe meer constructieve activiteiten werden geproduceerd. De meeste overlap van informatie kwam voor in de adaptieve diagrammen; de meeste constructieve activiteiten kwamen voor in de betekenis-georiënteerde chatdiscussies. Niettemin kon geen directe relatie worden gevonden tussen de drie typen chatdiscussies en de drie typen diagrammen. Afgezien van het kleine aantal groepjes in het onderzoek leek dit ook samen te hangen met de verschillende manieren waarop studenten hun taak aanpakten en de mate waarin zij zich hadden voorbereid op de taak.

Bij vergelijking van de resultaten van het Belvédère-onderzoek met de NetMeeting-studie (Hoofdstuk 4), werden enkele overeenkomsten en verschillen duidelijk. Allereerst kwamen in beide studies effectieve chatdiscussies voor waarin veel informatie werd gecheckt en waarin veel constructieve activiteiten werden geproduceerd (met name informatietoevoegingen en evaluaties). Dit type discussie was vooral gericht op het bespreken van de betekenis van concepten. Ten tweede werd in beide studies veelvuldig van focus gewisseld teneinde de interactie te coördineren en de aandachtsfocus gelijk af te stemmen. Een belangrijk verschil tussen beide studies was de invloed van dit soort focuswisselingen op de kwaliteit van de discussie. De Belvédère-discussies leken minder te worden verstoord door focuswisselingen dan de NetMeeting-discussies, wellicht omdat het construeren van argumentatieve diagrammen de studenten ondersteunde in het vasthouden van de aandacht op bepaalde onderdelen van de discussie. Andere verschillen waren dat de Belvédère-discussies in vergelijking met de NetMeeting-discussies relatief sterker waren gericht op het bespreken van de betekenis van concepten, dat meer informatie werd tegengesproken en dat meer constructieve activiteiten werden geproduceerd.

Hoofdstuk 6: hoe computer-ondersteund samenwerkend leren via argumentatie kan worden bevorderd; asynchrone communicatie. De belangrijkste vraag in dit onderzoek was hoe samenwerkend leren kan worden bevorderd via argumentatie in asynchrone CMC-systemen. De effecten van verschillende *discussie-opdrachten* en *moderatie interventies* (ingrepen die werden verricht door een discussiebegeleider) werden onderzocht op asynchrone groepsdiscussies. Hierbij werd specifiek gelet op effecten betreffende de aandachtsfocus, argumentatie en de productie van constructieve activiteiten. Gedurende de module Onderwijs & Informatietechnologie werden 28 elektronische discussies bestudeerd die ieder twee weken duurde en waaraan negen tot twaalf studenten deelnamen per discussie. De discussies werden gevoerd in Allaire Forums, een asynchroon CMC-systeem voor het voeren van elektronische, tekst-gebaseerde discussies in groepen (vergelijkbaar met een nieuwsgroep). Studenten kregen de opdracht om tweewekelijks stellingen met elkaar te bediscussiëren aangaande de betekenis en toepassing van verschillende onderwijstheorieën en concepten die zij moesten bestuderen met behulp van literatuur. Sommige discussies werden 'reflectief' gemodereerd. Moderatie-interventies waren met name gericht op het checken van informatie op feitelijkheid/waarheid en relevantie. Het aantal interventies werd doelbewust verminderd naarmate de module vorderde.

De resultaten toonden aan dat de discussies zeer inhoudelijk waren en dat zij waren gericht op zowel de betekenis als de toepassing van informatie (aandachtsfocus). De discussies waren 'indirect' argumentatief: informatie werd wel gecheckt, maar studenten daagden elkaar nauwelijks uit tot het geven van verantwoordingen en zij spraken elkaar niet of nauwelijks tegen. Niettemin was het percentage constructieve activiteiten hoog. Het vasthouden van of het wisselen naar een betekenis-georiënteerde aandachtsfocus bleek van significant belang te zijn voor een toename in de productie van constructieve activiteiten. Er werden verder geen effecten gevonden voortkomend uit het verschil in discussie-opdrachten en de effecten van moderatie-interventies op de discussie waren beperkt. Een effect was wel dat studenten de rol van moderator binnen een paar weken gemakkelijk overnamen.

De discussies konden worden verdeeld in drie clusters die werden betiteld als (a) betekenis-georiënteerd, (b) toepassings-georiënteerd en (c) compact. Betekenis-georiënteerde discussies waren vooral gericht op de interpretatie van theorieën en concepten. In dit type discussie werd de betekenis van informatie veelvuldig gecheckt en werden er veel constructieve activiteiten geproduceerd. Toepassing-georiënteerde discussies waren voornamelijk gericht op het gebruik van theorieën en concepten in relatie tot de praktijk van het onderwijs. In dit soort discussie werd veelvuldig van focus gewisseld om informatie te kunnen bespreken op zowel conceptueel niveau als ook op toepassingsniveau. Er werden veel constructieve activiteiten geproduceerd. Compacte discussies waren minder uitgebreid dan de beide andere soorten, en gericht op zowel conceptueel niveau als op toepassingsniveau. In dit type discussie kwamen minder constructieve activiteiten voor, alhoewel het aantal in percentages nog steeds aanzienlijk was.

Bij vergelijking van deze studie met de NetMeeting- en Belvédère-studie (Hoofdstuk 4 en 5), werd duidelijk dat de discussies in Allaire Forums anders konden worden gekarakteriseerd (zie ook Veerman, Andriessen en Kanselaar, 1999). In Allaire Forums waren de discussies zeer inhoudelijk (er zijn geen product-georiënteerde discussies), zij bevatten niet of nauwelijks 'directe' vormen van argumentatie (uitdagingen en/of tegenwerpingen), en het percentage constructieve activiteiten was hoog. Daarbij werd in NetMeeting en Belvédère informatie vooral toegevoegd en geëvalueerd, terwijl in Allaire Forums informatie voornamelijk werd uitgelegd. In geen van de studies werd informatie regelmatig samengevat en niet of nauwelijks getransformeerd.

Conclusie

Tenslotte werden in het laatste hoofdstuk de resultaten bediscussieerd aan de hand van verschillende theoretische en methodologische overwegingen. Geconcludeerd werd dat de rol van argumentatie in samenwerkend leren moet worden herzien. Het stimuleren van studenten om informatie te checken op betekenis is zinvol en kan worden uitgelokt door de taakopzet en diverse vormen van instructie. 'Directe' vormen van argumentatie (uitdagingen en/of tegenwerpingen) lijken in dit soort leersituaties pas dan effectief te zijn wanneer studenten zich goed voorbereiden op de taak en al een behoorlijke basiskennis bezitten wat betreft het onderwerp van discussie. Dit zouden tevens de voorwaarden kunnen zijn voor studenten om te kunnen komen tot kennistransformaties. Bij samenwerkend leren in computer-ondersteunde situaties is daarnaast ondersteuning nodig om interactie te coördineren en een inhoudelijke aandachtsfocus te stimuleren en vast te houden. Meer studies zijn nodig om de rol van de docent /coach /moderator, die nog steeds onduidelijk is, in deze te onderzoeken. Hierbij moet niet alleen worden gelet op het stimuleren van cognitieve processen, maar ook op het ondersteunen van sociale processen, zeker wanneer het gaat om langdurige asynchrone discussies. Daarnaast is meer experimenteel onderzoek nodig naar effecten van beeldschermontwerp (interface design), het structureren van interactie en verschillende vormen van communicatie in relatie tot samenwerkend leren. Het zou een goede start kunnen zijn om de in deze studie gevonden relaties tussen focus, argumentatie en de productie van constructieve activiteiten als hypothesen te toetsen in vervolgonderzoek. De resultaten zouden dan kunnen worden gebruikt voor het generaliseren van de bevindingen en voor het opbouwen van een theoretisch model.

CURRICULUM VITAE

Arja Veerman werd geboren op 9 februari 1969 in Woerden. Na enkele jaren te hebben genoten van (buiten-) schools plezier aan het Minkema College, behaalde zij in 1987 haar HAVO-diploma aan het Kalsbeek College te Woerden. In september van datzelfde jaar begon zij aan een PABO-opleiding tot leerkracht basisonderwijs aan de Marnix Academie in Utrecht. Na haar laatste onderwijsassistentschap te hebben verricht aan de Nederlandse school voor basisonderwijs in Nairobi (Kenya), behaalde zij in 1992 haar diploma. In de periode 1992 - 1996 werkte zij als groepsleerkracht en remedial teacher in het Utrechtse basisonderwijs en was met name verbonden aan de Catharinaschool. Tussen 1993 en 1996 volgde zij tevens de doctoraalopleiding Onderwijskunde aan de Universiteit Utrecht en specialiseerde zich op het gebied van Leren met Nieuwe Media. In 1996 studeerde zij af en werd vervolgens aangesteld als assistent-in-opleiding (aio) bij Onderwijskunde Utrecht, Faculteit Sociale Wetenschappen. Binnen deze aanstelling werkte zij aan het onderzoek waarvan in dit proefschrift verslag wordt gedaan. Zij volgde de aio-opleiding bij het Interuniversitair Centrum voor Onderwijsonderzoek (ICO) en vulde deze aan met facultaire aio-cursussen en modulen bij de Faculteit der Letteren. Binnen de opleiding Onderwijskunde verzorgde zij voor een belangrijk deel de modulen Onderwijs & Informatietechnologie en Computer Ondersteund Onderwijs. Zij was lid van de facultaire Wetenschapscommissie, voorzitter van het facultaire aio-overleg (OOCA), bestuurslid zowel van de Vereniging voor Onderwijs Research (VOR) als van het VOR Promovendi-Overleg (VPO) en redactiemedewerker van de ICO-Nieuwsbrief. Vanaf 1 juni 2000 zal zij als wetenschappelijk medewerker in dienst treden bij TNO-Technische Menskunde te Soesterberg.

PUBLICATIONS AND REPORTS

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (2000)[1]. Learning through synchronous electronic discussion. *Computers & Education*, *34*(2-3), 1-22.

Veerman, A. L., & Treasure-Jones, T. (1999)[2]. Software for problem solving through collaborative argumentation. In P. Coirier & J. E. B. Andriessen (Eds.), *Foundations of argumentative text processing* (pp. 203 - 230). Amsterdam: Amsterdam University Press.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (1999). Collaborative learning through computer-mediated argumentation. In C. Hoadly & J. Roschelle (Eds.), *Proceedings of the third conference on Computer Supported Collaborative Learning* (pp. 640 - 650). Palo Alto, California: Stanford University.

Andriessen, J. E. B., & Veerman, A. L. (1999). Samenwerkend telestuderen in het hoger onderwijs [Collaborative telelearning in higher education]. *Pedagogische Studiën, 6,* (76). 157 - 178.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (submitted)[3]. Collaborative argumentation in academic education. *Instructional Science*.

Veerman, A.L., Andriessen, J.E.B., & Kanselaar, G. (submitted)[4]. Collaborative learning through argumentation in electronic environments. *Educational Technology, Research & Development*.

Veerman, A. L., & Andriessen, J. E. B. (submitted)[5]. Co-constructing meaning through diagram-mediated electronic discussion. *Journal of Artificial Intelligence and Education*.

Andriessen, J. E. B., Claasen, Y., & Veerman, A. (1998). *Voortgangsrapport project Teleleren en Studeerbaarheid* [Progress report telelearning and studyablility] (Internal Report). Utrecht, The Netherlands: Department of Educational Sciences.

Veerman, A. L. (1998), Samen schrijven via Internet [Collaborative writing through the Internet]. *Didactief & School, 11/12,* 1998.

Veerman, A.L. (1996). *De relatie tussen vragen stellen en argumentatie in onderwijsleergesprekken* [The relationship between question asking and argumentation in tutoring sessions]. (Internal report). Utrecht, The Netherlands: Department of Educational Sciences.

---

[1] This article is included as Chapter 4 in this thesis.
[2] This article is included as Chapter 3 in this thesis.
[3] This article is included as Chapter 2 in this thesis.
[4] This article is included as Chapter 6 in this thesis.
[5] This article is included as Chapter 5 in this thesis

PRESENTATIONS

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (1999, December). *Collaborative learning through computer-mediated argumentation.* Paper presented at the third conference on Computer Supported Collaborative Learning. Palo Alto, California.

De Vries, E., & Veerman, A. L. (1999, August). *Computer-mediated argumentation for collaborative learning.* Symposium organised at the 8th European conference on Learning and Instruction, Göteborg, Sweden.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (1999, August). *Computer-mediated discussions through graphically structured interaction.* Paper presented at the 8th European conference for Research on Learning and Instruction, Göteborg, Sweden.

Kanselaar, G., Erkens, G., Andriessen, J. E. B., & Veerman, A. L. (1999, August). *The effects of different environments for computer-mediated communication on discussion and argumentation*. Paper presented at the 8th European conference for Research on Learning and Instruction, Göteborg, Sweden.

Andriessen , J. E. B., Veerman, A. L., & Kanselaar, G. (1999, July). *Learning through computer-mediated collaborative argumentation*. Paper presented at the workshop on analysing educational dialogue interaction: Towards models that support learning (AI & ED '99), Le Mans, France.

Veerman, A. L., Andriessen , J. E. B., & Kanselaar, G. (1999, March). *Constructive discussions in electronic environments.* Paper presented at the conference on Computer Assisted Learning (CAL'99), London, UK. *Award for Outstanding Contribution.*

Kanselaar, G., Veerman, A. L., Andriessen, J. E. B., Treasure-Jones, T., (1998, October). *Software for argumentation and writing.* Paper presented at the sixth International Conference on Computers in Education, Beijing, China.

Veerman, A. L., & Treasure-Jones, T. (1998, July). *Software to support argumentation and writing*. Paper presented at the second Workshop on Argumentation, Poitiers, France.

Veerman, A. L., Andriessen, J .E. B., Kanselaar, G., & Treasure-Jones, T. (1998, May). *Software voor het ondersteuning van argumentatie tijdens samenwerkend probleemoplossen*. [Software to support argumentation and collaborative problem solving]. Paper presented at the ORD conference, Enschede, The Netherlands.

Veerman, A. L., & Andriessen, J. E. B. (1997, September). *Argumentative text production in electronic environments.* Paper presented at the conference on Writing the Future, Brighton, UK.

Veerman, A. L., & Andriessen, J. E. B. (1997, September). *Academic learning and writing through the use of educational technology.* Paper presented at the conference on Learning and Teaching Argumentation, Middlesex, London.

Veerman, A. L. (1997, August). *Computer-supported learning through argumentation in higher education.* Paper presented at the 7th European conference on Learning and Instruction, Athens, Greece.

Veerman, A. L., & Andriessen, J. E. B. (1997, August). *Academic learning and writing through question asking in electronic environments.* Paper presented at the 7th European conference on Learning and Instruction, Athens, Greece.

Veerman, A. L,. & Andriessen, J. E. B. (1997, July). *Question asking to support critical argumentation.* Paper presented at the 7th conference of the Society of Text and Discourse, Utrecht, The Netherlands.

Veerman, A. L. & Andriessen, J. E. B. (1996, December). Argumentatie tijdens het oplossen van zwak gestructureerde problemen [Argumentation during ill-structured problem solving]. Paper presented at the VIOT congress, Utrecht, The Netherlands.

Veerman, A. L. (1996, October). *Argumentation during solving ill-structured problems.* Paper presented at the first Workshop on Argumentative Text Production, Barcelona, Spain.