Arguing to learn

Supporting interactive argumentation through Computer-Supported Collaborative Learning

Lisette Munneke

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Argumenteren om te leren

Een onderzoek naar hoe computer ondersteund samenwerkend leren gezamenlijk argumenteren kan ondersteunen.
(met een samenvatting in het Nederlands)

Proefschrift

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Promotoren: Prof. dr. G. Kanselaar
Prof. dr. P. A. Kirschner
Co-promotor: Dr. J. E. B. Andriessen

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* This chapter contains a English summary

Chapter 1

General introduction

Bob: *What is your opinion?*
Martin: *In my opinion, genetic modification is dangerous. It can disturb the biological system.*
Bob: *Yeah, you are right, but have you some more reasons why it is dangerous?*
Martin: *This is the only disadvantage and despite this it can be useful to adjust planting.*
Bob: *Nevertheless, there are evil people who can misuse it?*
Martin: *Every new development entails those risks. After the development of the first car, bank robbers could escape much faster by car compared to escaping by feet.*
Bob: *Yeah, you are right, lets recapitulate. Just like you, in my opinion genetically modification must be permitted.*

Two adolescent boys attending secondary school produced the above discussion about genetically modified organisms (GMOs) by chatting via a computer supported chat program. Comparing the discussion of these two boys with the picture of a competent reasoner that Voss and Means (1991) paint, namely presenting well supported and reasoned arguments as well as engaging with alternative points of view including challenging, critiquing, or defending them when appropriate or necessary, shows that the argumentation of these two boys is far from the ideal picture. They quickly and simply agree with each other and are unable to elaborate and support their arguments with genuine evidence. Be that as it may, it is the start of a process of interaction and collaboration, which is widely believed to promote the development of individual reasoning (e.g., Andriessen, 2006; Baker, 1999; Kuhn, Shaw, & Felton, 1997; Schwarz, Neuman, & Biezuner, 2000). This critical reasoning is necessary, because students must be able to reflect in a critical manner about presented information to advance their knowledge and to participate in a democratic society (e.g., Bereiter, 2002; Laurillard, 2003; Petraglia, 1998). As Kuhn (2005) puts it:

> We want students to overcome the temptation to cling to their existing explanation of the way things are as 'good enough' ways of knowing

> the world and to understand and therefore value critical thinking as a path to purposefully enriching their existing understanding. (p. 77)

To profit from the benefits of collaborative reasoning and argumentation, students need to become really engaged in collaborative argumentation. This is the principle premise underlying this dissertation. The scope of this dissertation is *arguing to learn*, with the support of computer-supported collaborative learning (CSCL) tools in pre-university education. The main question concerns how CSCL tools can support argumentative interactions in such a way that students thoroughly explore a topic – crisscrossing a conceptual landscape in many different directions (Feltovich, Spiro, Coulson, & Feltovich, 1996). In the remainder of this dissertation this is referred to as *the exploration of the space of debate*. In this introductory chapter we will first discuss research on argumentation in learning situations, focusing on criteria for constructive learning interactions. We will then discuss the role of different CSCL tools for overcoming problems with argumentation during collaborative learning in school situations. Finally, we will discuss some methodological issues that arise when studying argumentative interactions and will give an overview of the studies in this dissertation.

Arguing to learn

One way to think of argumentation is as a form of debate; winning or losing the struggle to define truth and have it prevail. It is thought that the determination to pursue truth by setting up a debate between two sides leads to the belief that every issue has only two sides. If the two sides are confronted with each other, all relevant information will emerge, and the best case will win. However, an issue often is not composed of two opposing sides, but is like a multi-faceted crystal of which the many sides need to be explored and where truth is in the complex middle (Tannen, 1998). Research has shown that clearly defined opinions and indisputable (rigid) attitudes towards a position, which are common in dialectic argumentation, can form an epistemological obstacle for students in the accumulation of knowledge (Baker, 1999; Johnson & Johnson, 1985; Stein, Bernas, & Calicchia, 1997). This consequence of thinking of argument as debate is often defined as 'my side bias' (e.g., Baron, 1991; Hightower & Sayeed, 1995; Klaczynski, Gordon, & Fauth, 1997; Perkins, 1989), which is the tendency to only consider arguments that confirm one's opinion and to avoid or quickly reject arguments which challenge this opinion.

Consequently, it is important to see argumentation as dialogic and to recognise that one's argument develops through engaging with and negotiating others' views. To learn from arguing, students need to distantiate themselves from their own claims and be open minded for one another's claims and arguments. To explicitly differentiate these kinds of processes from argumentation as debate, we have chosen to call these processes *arguing to learn* (Andriessen, 2006), which is in our opinion a specific form of argumentation that gives students opportunities to learn.

Arguing to learn as collaborative learning activity

But what does this arguing to learn look like and why does engaging students in such arguing give them opportunities to learn? In the first place, we see arguing to learn as a collaborative activity. In this dissertation we start from the idea that social interaction is a primary means for promoting individual reasoning with argumentation as one of the core activities (Baker, 2002; Chinn & Anderson, 1998; Kuhn, 1992; Pontecorvo & Girardet, 1993; Schwarz et al., 2000). Research has demonstrated the superiority of collaborative over individual argumentation (e.g., Kuhn et al., 1997; Reznitskaya et al., 2001; Roschelle & Teasley, 1995; Schwarz et al., 2000; Zohar & Nemet, 2002), which Chinn and Anderson call *interactive argumentation* during collaborative reasoning. Interactive argumentation refers to discussion which takes the form of conversations in which participants collectively search for reasons and evidence for different positions rather than trying to convince one another of the value and truth of their own position. This can be compared with the notion of socially shared knowledge which is mutually constructed (Roschelle, 1992); students need to engage critically, but constructively, with each other's opinions instead of simply accepting and agreeing with each other or disputing who is wrong or right (Mercer, 1996; Elbers & Streefland, 2000).

In the second place, arguing to learn is not about learning to argue. Though those skills are prerequisites for arguing to learn we want to make a clear distinction in this dissertation between arguing to learn and learning to argue. Learning to argue is about how to debate and how to construct a valid argument (i.e., the claims, data, warrants, and backings that form the substance of an argument) in order to convince the opponent, while arguing to learn is related to what people know about the diversity of points of view and arguments within a specific topic after arguing about it. As Van Amelsvoort (2006) describes it:

> Many issues have been debated for centuries, such as issues dealing with war and peace. Involved are different conceptions, facts, emotions, and different stakeholders with different points of view, all present in what we call the 'space of debate'. The goal for students is to collaboratively explore this space of debate, and answer questions such as: what kinds of 'facts' are there, what can we agree on, what different opinions are there, what arguments for and against? (p.22)

This collaborative exploration within an indefinable space of debate can be accomplished with both a certain breadth and a certain depth. Exploring the breadth of the space of debate has to do with exploring the different viewpoints and subtopics within a topic. For example, in a topic like genetically modified organisms (GMOs), students need to explore the different stakeholders (i.e., environmental activists, governments, farmers, consumers, and companies), become conscious of different subtopics (i.e., health, environmental issues, ethics, and economics). Exploring the depth of the space of debate is about how distinct subtopics or arguments are elaborated upon by students. For example, when companies producing GMOs argue that GMOs need less pesticides, deepening the space of debate would entail extensively exploring this issue and arguing about whether the companies are right, what other stakeholders are saying about this issue, and what kind of research supports the claim of the companies, etcetera. In other words it is going into depth about a specific aspect of the debate.

What does it accomplish?

But what does this exploration of breadth and depth of the space of debate, bring about for learning? Dillenbourg (1999) argues that the key to understanding collaborative learning lies in the relations between the collaborative learning situations, interactions between students, processes, and effects of collaborative learning. A simple model for collaborative learning is that a certain collaborative learning situation generates specific interactions, that these interactions trigger cognitive mechanisms which in turn generate cognitive effects. This dissertation covers the issue of the way a specific collaborative learning situation (CSCL) can trigger argumentative interactions (i.e., exploring the breadth and depth of the space of debate). The focuses on the argumentative interactions, starting from the idea that knowledge is situated in a social context and learning, is dialogical (Vygotsky, 1978). As Akkerman (2006) phrased it "the individual and the social environment are not seen as two separate 'places', but already as by definition interrelated" (p.176).

Nonetheless, with this specific focus on argumentative interactions, it is important to mention the underlying theoretical assumptions about which kinds of cognitive learning processes could be stimulated by interactive argumentation processes. Interactive argumentation involves producing and comparing arguments using a variety of types of reasoning which give opportunities for learning. A first opportunity to learn during argumentation involves interactive argumentation stimulating students to explicate, articulate, and verbalise their opinions and the arguments supporting these opinions (Andriessen, Baker, & Suthers, 2003) – processes consistent with the self-explanation effect (Chi, Bassok, Lewis, Reimann, & Glaser, 1989). A second opportunity to learn lies in the use of counterarguments. Having disagreements and resolving contradictions can be beneficial for learning because students are stimulated to restructure their knowledge and change their conceptions (De Vries, Lund, & Baker, 2002; Leitaõ, 2000). Finally, students can be stimulated by interactive argumentation to build on each others information and ideas and co-elaborate new knowledge (Andriessen et al., 2003; Mercer, 1996; Van Boxtel, Van der Linden, & Kanselaar, 2000).

What is worth arguing about?

But what is worth arguing about? Do all kinds of topics give the same opportunities for cognitive processes during interactive argumentation? An important aspect of the notion of exploring a space of debate is that this space is indefinable and gives opportunities for an extensive search of both its breadth and its depth. The nature of this search is determined by the context and topic of the learning tasks that students are offered (Van der Linden, Erkens, Schmidt, & Renshaw, 2000). Interactive argumentation is entirely different in contexts where tasks are conceptually ill-defined as opposed to contexts where tasks have fixed procedures and answers.

Cohen (1994) stresses that open tasks with answers that are not fully predetermined, and thus requiring a variety of information sources and that have multiple acceptable solutions are more suitable for collaborative learning and that people engaged in these kinds of tasks do not need to be stimulated by rewards because of the intrinsically motivating nature of such tasks. Several authors indicate that ill-defined, open learning tasks need essential processes like open discussion and argumentation (Van Bruggen, Boshuizen, & Kirschner, 2003; Van der Linden et al., 2000). Thus, tasks involving interactive argumentation need ill-defined or even wicked problems (Rittel & Webber, 1984) which give optimal opportunity to explore the space of debate in an extensive and indefinable way.

Difficulties for students in interactive argumentation

Situating interactive argumentation as a means to engage students in cognitive processes raises the question as to whether students are really capable of arguing in a thorough way about complex problems. As stated, students experience difficulties while arguing. Several studies into student argumentation skills show that these skills are often inadequate (Felton & Kuhn, 2001; Kuhn, 1991; Marttunen, 1992; 1994) and that exercising of argumentation skills is necessary to develop these sufficiently (Anderson, Howe, Soden, Halliday, & Low, 2001; Kuhn & Udell, 2003).

Kuhn (1991) studied different argumentation skills and provided data indicating the difficulties people encounter during arguing. She executed a series of two interviews involving 160 subjects of different ages in which she asked the subjects to generate theories regarding the possible causes of two social problems (children's school failure and causes of criminal recidivism). After subjects offered their supportive theories, they were asked to give reasons for why they held those theories. In a next segment of the interviews, subjects were asked to imagine how an opponent would react to their supportive theories. This question was intended to elicit counterarguments with respect to the subject's own supportive theory or elicit alternative theories. After this, subjects were asked for rebuttals to show that the opponent's was wrong. The results showed that many subjects have problems with (a) supporting their own supporting theories (i.e., opinions) with evidence, (b) generating genuine evidence, (c) thinking about alternative theories, and (d) rebutting the counterarguments and alternative theories. These problems were widespread in the adult population, which indicates that age is not the most important factor in terms of explaining differences in argumentation skills. Summarised, students can have difficulties generating valid evidence for their opinions and viewing their own personal opinions as objects for critical reflection. These results are in line with the findings of other researchers (Baron, 1991; Bennet & Dunne, 1991; Chan, 2001; Hightower & Sayeed, 1995; Klaczynski, et al., 1997; Perkins, 1989) and later research of Kuhn on the development of argumentative skills in interactive settings (Felton & Kuhn, 2001; Kuhn & Udell, 2003).

How, then should we proceed if we assume that students do not possess the argumentation skills necessary to explore the breadth and depth of the space of debate in such a way that it stimulates the described cognitive processes? What needs to be determined is how students can be supported in such a way that they engage in interactive argumentation in a fruitful and appropriate way. The main question of this dissertation is: How can computer-supported collaborative learning (CSCL) tools support specific argumentation skills during interactive argumentation?

Interactive argumentation in CSCL-environments

Assumed general benefits of CSCL-environments

In 1996, Koschman indicated CSCL as an emerging paradigm within instructional technology. Subsequent to the rise of paradigms implicitly constructed upon behaviourist and information processing theories of learning, such as Computer-Assisted Learning and Intelligent Tutoring Systems, more socially oriented learning theories (i.e., constructivism, situated cognition) gave rise to the paradigm of CSCL research. In this kind of research, the central question is how computer technology might serve to support collaborative learning (Bannon, 1995; Erkens, 2004; Koschman, 1996; Lipponen, Hakkarainen, & Paavola; 2004), which is a broad question because both CSCL environments and collaborative learning situations are very diverse.

Generally spoken, CSCL provides students with an environment in which carrying out their task and their communication can be supported by computer mediated communication (CMC) and specific online computer tools. Benefits are derived from the time- and place independence of many CSCL environments which allows students to have more time to formulate their communications and to consider and to construct their ideas carefully (Marttunen & Laurinen, 2001; Weinberger & Fisher, 2006). A second benefit is derived from the written form of CMC. Because students cannot use non-verbal communication, they have to carefully explicate their thoughts which may lead to more reflection and awareness (Kanselaar, De Jong, Andriessen, & Goodyear, 2000; Veldhuis-Diermanse, 2002). Along with the written form of CMC, a third benefit comes from the fact that most CMC gives rise to the existence of a history of conversation which gives opportunities for reflection upon learning and collaboration processes (Veerman, Andriessen, & Kanselaar, 2000).

However, these assumed benefits are not undisputed. Several mentioned characteristics of CSCL environments that can support collaborative learning are also thought to frustrate interactions between students because of the lack of non-verbal communication and time- and place independence. The anonymity and written form of CMC can also lead to misunderstanding, non-constructive or even harmful interpretations, and erroneous behaviour such as flaming and negative conflicts (Kiesler & Cummings, 2002). A second problem lies in the general character of assumed benefits, which makes it very difficult to generate hypotheses about the influence of specific CSCL environments on specific collaborative learning interactions such as interactive argumentation. CSCL environments differ according to the use of different kinds of CMC, use of different representational tools, and the different functionalities offered by the combination of the two. For example, CSCL environments using synchronous CMC -not time independent-, ask for quick reactions from students. Thus, not al mentioned benefits are applicable to all CSCL environments.

Supporting interactive argumentation with CSCL

How can CSCL support interactive argumentation? Several approaches can be distinguished in research on supporting interactive argumentation with CSCL such as scaffolding the communication or the use of different kinds of CMC.

In the first place, in CSCL argumentation skills can be scaffolded by so-called 'cognitive tools' which constrain the nature of student interactions (Cho & Jonassen, 2002; Jonassen & Reeves, 1996; Pilkington, 2004). One way is the constraining of communication by using sentence-openers in synchronous CMC (i.e., CONNECT and AcademicTalk); (Baker & Lund, 1997; De Vries et al., 2002; McAlister, Ravenscroft, & Scanlon, 2004), pre-determining the subject headings of messages in asynchronous communication (i.e., CSILE); (Scardamelia & Bereiter, 1994), or scripting the collaboration (O'Donnel & Dansereau, 1992). Another way of constraining the communication between students is visualising argumentation with representational tools (i.e., graphical diagrams and matrices) (Kirschner, Buckingham Shum, & Carr, 2003). Such visualisation is a representation of the relations between claims, arguments and corresponding counterarguments and can support learners to refine, elaborate, or balance their argumentation (Bell, 2004; Kirschner et al.). Several researchers tried to support interactive argumentation with representational tools such as Belvédère (Paolucci, Suthers, & Weiner, 1995), SenseMaker (Bell, 2004), Drew (Baker, Quignard, Lund, & Séjourné, 2003; Van Amelsvoort, Andriessen, & Kanselaar, in press), TC3 (Erkens, Prangsma, & Jaspers, 2006; Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005), QuestMap™† (Buckingham Shum, MacLean, Bellotti, & Hammond, 1997), pro-con tables (Schwarz, Neuman, Gil, & Ilya, 2003), and matrices (Suthers & Hundhausen, 2003). The precise ways in which representations actually support interactive argumentation; depends on the format they use to display information and the representational notations (Suthers & Hundhausen, 2003; Van Bruggen et al., 2003). Research has shown benefits from representational tools, but not all claims made about representations are supported with empirical evidence or the results have been mixed (Kirschner et al., 2003; Van Amelsvoort, 2006).

In the second place, CSCL can support interactive argumentation by using different kinds of CMC according to their synchronicity. Generally, it is thought that students working together via asynchronous CMC (i.e., discussion board), as compared to synchronous CMC (i.e., chat systems), have more time to formulate their arguments and reflect upon the argumentation, which may facilitate the exploration in the space of debate (Marttunen & Laurinen, 2001; Weinberger & Fisher, 2006). Yet, many CSCL environments with the aforementioned representational tools use synchronous CMC, which could cause a problem for students. Research comparing synchronous and asynchronous CMC for interactive argumentation is relatively scarce. Veerman, Andriessen, and Kanselaar (1999) compared different studies in which college students carried out online collaborative discussions in three different CSCL environments, including NetMeeting®‡ (a synchronous chatting tool), Belvédère (synchronous tool structured by the use of an argumentative diagram), and Allaire Forums™§ (an asynchronous bulletin board system). These discussions were part of a course students had to take during their study Educational Sciences. The content of the discussions was characterised in terms of focus (i.e., do students have a shared focus on the same parts of the task), argumentation (i.e., checks, challenges, and counters) and constructive activities (i.e., interactions leading to construction of new knowledge such as adding, explaining, evaluating, summarising, and transforming). Veerman et al. (1999) found that

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† QuestMap™ is a trademark of GDSS, Inc.
‡ NetMeeting® is a registered trademark of Microsoft Corporation.
§ Allaire Forums™ is a trademark of Allaire Corp.

synchronous discussions supported by an argumentative diagram (Belvédère) were the most argumentative discussions –students checked, challenged and countered each other's information most frequently. Yet, the asynchronous discussions were characterised by the production of more constructive activity and a conceptually oriented focus of the communication. On the basis of the data of this study, Veerman (2000) suggested that synchronous CMC is less effective for conceptually oriented and constructive argumentation due to the fast flow of communication and real-time pressures.

However, these results and suggestions can be questioned. First, Veerman's suggestions are based on the comparison of studies which used very different tasks, different CSCL environments, and different sizes of student groups. Thus, instead of the synchronicity of CMC there were many other variables that could explain the differences found between synchronous and asynchronous CSCL environments. Second, the way Veerman defined argumentation and constructive activity is different from the way we define interactive argumentation. The argumentative dialogue moves Veerman proposed suit the more dialectical kind of arguing where the main goal can be defined as attacking the opponent to win the debate instead of arguing to learn. In our opinion arguing to learn automatically contains the proposed constructive activities -when students explore the space of debate according to breadth and depth they automatically should add, explain, evaluate, summarise, and transform information.

General research question

In the section about difficulties in interactive argumentation we identified the obstacles for arguing to learn, such as the difficulties students encounter with generating valid evidence for opinions and on reflecting critically on their own personal opinions. These obstacles underlined the need for supporting interactive argumentation, as expressed in the general research question of this dissertation: *What are the effects of different characteristics of CSCL environments on interactive argumentation; more specifically on the breadth and depth of the space of debate, and how can we explain these effects?*

In the section about supporting interactive argumentation with CSCL we described several characteristics of CSCL environments that would help students during interactive argumentation. We choose to focus on two specific characteristics of CSCL environments: (1) visualisations of the interactive argumentation with argumentative diagrams and (2) the synchronicity of CMC because we try to examine and to elaborate on the findings of Veerman (2000). We indicated that results from CSCL research for interactive argumentation are diffuse due to the differences between environments, tasks, collaborative group sizes, and topics. To try to overcome these problems, we attempted to create a more stable research context with the same task, collaborative group size, and topic. Before giving an overview of this dissertation, we first will consider some methodological issues when studying interactive arguments in a CSCL environment.

Methodological issues

When assessing interactive argumentation as opportunities for collaborative learning in CSCL, some methodological issues immediately occur. The first issue relates to the task design necessary to give rise to interactive argumentation. The second issue concerns the way of measuring interactive argumentation in discourse.

Task design

As stated before, tasks involving interactive argumentation need to deal with ill-defined problems, because such problems provide an opportunity to explore the breadth and depth of the space of debate. Arguing to learn can only emerge when wicked problems are encountered. Along with this requirement, Veerman and Treasure-Jones (1999) recommended asking students to produce an individual or joint product as the goal of a discussion and presenting clear instructions that encourage students to be critical, use multiple perspectives, and be elaborative.

For the studies in this dissertation we developed an argumentative task meeting the aforementioned requirements. We tried to design an ill-defined task which students would encounter as authentic. Authentic, in this context, boils down to the fact that students' learning was part of the curriculum. To find out which kind of tasks and topics for discussion were relevant; we interviewed Dutch Language and General Science high school teachers. From the interviews, the topic of Genetically Modified

Organisms (GMOs) was chosen as the topic for the discussion tasks. This topic fits the studies in this dissertation because of our need to use a wicked problem without correct answers and/or solutions. The topic also fits well both General Sciences and Dutch Language classes, because the curriculum of general sciences deals with scientific problems in biology, physics, and chemistry and because learning to argue is part of the Dutch language curriculum.

Measuring interactive argumentation

Because interactive argumentation always takes place on the basis of dialogues, the analysis of dialogues forms an important method for understanding the way students argue. Gaining insight into the processes of interactive argumentation requires detailed analyses of content and structure of the communication (Kneser & Ploetzner, 2001; Osborne, Erduran, & Simon, 2004). However, developing a coding scheme for analyzing argumentative discourse is a formidable task. Kuhn and Udel (2003) indicate that due to this complex task, less research has been devoted to argumentative discourse than to arguments that are the cognitive constructions of individuals. Often, formalised models for the analysis of argument like Toulmin's (1958), have been applied to provide rational criteria for judging the quality of argumentation (e.g., Cho & Jonassen, 2002; McAllister et al., 2004; Osborne et al., 2004). Although these models proved to be very useful for judging individual argument, they proved to be problematic when applied to argumentative dialogues (Leitaõ, 2000; Stein et al., 1997). Keefer, Zeitz, and Resnick (2000) write in this context:

> When the object of inquiry becomes the norms or rational quality of dialogue as opposed to the validity of individual arguments, the irreducibly social character of dialogue becomes apparent. Studying dialogue from a more social perspective means understanding it as a cooperative or socially distributed activity in which each participant's commitments can be likened to moves in a game. (p. 55)

Leitaõ argues that Toulmin's model does not take into account the social and dialogical character of interactive argumentation. The model concentrates on describing the side of a proponent giving data, claims, warrants, backings, qualifiers, and rebuttals and it assigns only a minor role to the opponent. To make it possible to grasp the dialogical nature of interactive argumentation we focus in this dissertation on the application of argumentative skills as listed by Kuhn (1991), namely the ability to: give an opinion, give supportive theory supported by evidence, construct counterargumentation, and evaluate alternative perspectives on an issue with the use of rebuttals.

Taking this into account, how can we analyse these skills within the protocols produced by students discussing in a CSCL environment? Since the work of Henri (1992) on computer conferencing and content analysis, there is growing attention for the analysis of communication transcripts. One of the approaches to content analysis is a qualitative approach to analysing interaction, using methods such as case summaries (e.g., Baker & Lund, 1997) and inferring trends in interactions with help of grounded theory (e.g., Chan, 2001; Gunawardena, Lowe, & Anderson, 1997). However, because qualitative approaches usually suffer from subjective interpretation and nonreplicability, another approach that has been developed is the quantitative approach. In this approach, frequencies of certain moves are counted and subjected to precise statistical tests (e.g., Erkens et al., 2006; Van Drie et al., 2005; Veerman, 2000; Veldhuis-Diermanse, 2002). These kinds of studies often investigated the microstructure of interactive argumentation (i.e., Chinn & Anderson, 1998), which is the occurrence of particular moves related to successful learning, by which the frequency of particular individual moves during discussions indicates learning. Consequently, this kind of content analyses does not provide an overall picture of the macrostructure of argumentation, which is the way students built their arguments and react on each other during argumentation. Throughout this dissertation, we develop a content analysis system of interactive argumentation in which we combine a functional analysis of task acts and argumentative acts with a more sequential approach mirroring the way students explore the breadth and depth of the space of debate.

Overview of the dissertation

In order to study the effects of different characteristics of CSCL environments on the breadth and depth of the space of debate, two characteristics are taken into account in this dissertation: visualizing argumentation with help of an argumentative diagram and the synchronicity of CMC.

In Chapter 2, we explore the role of diagrams in synchronous argumentative interaction. The main question compares the characteristics of discussions and diagrams between a condition during which a diagram is constructed individually before a debate about GMO and a condition where the discussion and diagram construction proceed in parallel. The research tries to shed light on the way students use argumentative diagrams and what kind of effect this has on the breadth and depth of argumentation.

In Chapter 3, we elaborate on the role of diagrams in argumentative interactions and compare the breadth and depth of argumentative interactions of a condition with a text outline and a condition with an argumentative diagram, both used in parallel during discussion as a preparation of the writing of a collaborative text. The analysis of breath and depth is further developed, and compared to the research reported in the previous chapter.

In Chapter 4, the effects of different types of CMC are investigated. In this study we compare depth and breadth of discussion with synchronous and asynchronous CMC, as a preparation of collaborative text production. The expectation was that there would be greater depth and breadth in synchronous chat, because of the assumption that establishing shared meaning requires high synchronicity.

Chapter 5 investigates the role of epistemological beliefs and raising awareness of controversies. The preceding studies showed a great variation in approaches of students to the assignments for which CSCL characteristics explained only a small part of the variance. Because of this, we sought other explanations of the variance between students. According to Kuhn (1991) epistemological beliefs could be an explaining factor of differences in arguing. Students were asked to synchronously discuss (chat) two cases with support of an argumentative diagram To reduce task complexity, the writing assignment was omitted. Between the two cases, students received a questionnaire to raise their awareness of controversies. At the end of the second case there was a posttest in which students were asked to generate as many argumentative sequences as possible.

Finally, in Chapter 6 we will discuss the results of the different studies and reflect upon theory and methodological issues of this dissertation. This chapter will end with some practical implications and suggestions for future research.

Chapter 2

The role of diagrams in collaborative argumentation-based learning**

Abstract

In this article two studies on the use of diagrams in computer-supported collaborative learning are compared. Focus is on the way argumentative diagrams can be used during collaborative learning tasks, more specifically how diagrams support argumentative interaction between students when they discuss ill-defined topics. The main goal is to discover how diagram construction before discussion, and diagram construction during discussion, influence the way students explore the space of debate during discussion. Twenty pairs of 16/17-year-old students were randomly selected from 126 pairs. Ten pairs worked with a diagram before discussion and ten during discussion. The research showed that students use diagrams in very different ways, ranging from a means for talking to just a notebook. Our expectation that using a diagram during discussion leads to more depth in discussion than using one before discussion, was not confirmed. Possible explanations for this finding are structure of the task, and the way students interpreted the goal of the task.

** Munneke, L., Van Amelsvoort, M., Andriessen, J. (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39,* 113-131.

Mike: *I am against GMOs, because they can disturb the natural ecosystem.*
Bob: *Yes, you are right.*
Mike: *But, it is very handy to adapt those plants.*
Bob *But what about evil people? They can misuse those GMOs.*
Mike: *You mean for biological weapons?*
Bob: *No not really, I mean for example that they change plants in such a way that people get sick from eating them.*
Mike: *That is what I meant with biological weapons.*
Bob: *Ok, that is clear.*

This fragment is part of an electronic interaction between two secondary school students in a computer-supported collaborative learning environment. They chat about the topic of genetically modified organisms (GMOs). One may ask questions about the quality of the fragment: is this a 'good' discussion? Do these students learn something here? What support is needed to make this a valuable learning experience in everyday classroom practice? In this article we zoom in on a specific kind of collaborative interaction: argumentative interaction. We describe argumentative interactions, and how to support these with a specific tool: a computer-based argumentative diagram. Two ways of constructing diagrams, before and during the discussion, are compared with respect to how well students explore the space of debate in the domain of GMOs.

Theoretical background

Collaborative learning and ICT in the Dutch classroom

The focus in research on collaborative learning has shifted from products and individual participants to the social interaction during the collaborative process (Dillenbourg, Baker, Blaye & O'Malley, 1996). In focusing on the interaction, researchers try to understand what happens during the collaboration in order to design learning tasks and tools to support the interaction between students.

It is not always clear what collaborative learning is. Andriessen and Sandberg (1999) define three types of educational contexts in which collaborative learning plays different roles: the transmission scenario, the studio scenario, and the negotiation scenario. In the transmission scenario emphasis is put on knowledge as chunks of information that are more or less directly transmittable from an expert teacher to a novice student. Collaboration is mainly considered to be useful for learning and practicing skills (Luttik, 1998). If students collaborate, they do this by dividing rather than sharing tasks. In the studio scenario the focus is on knowledge as actively processed by learners instead of learning 'set' knowledge. The responsibility for learning resides more with the students. Collaborative learning is a goal in itself in this scenario, because collaboration requires active learning and thinking by the individual student. In the negotiation scenario, the emphasis is put on knowledge building as a process of collective interaction. The goal is not knowledge acquisition per se, but learning to participate in the discourses of knowledge domains. Collaborative learning is a natural and essential characteristic of learning in this scenario, because students need to communicate and negotiate others to understand and develop knowledge within the discourse community.

The innovation that secondary education in the Netherlands went through since 1999, can be described as a transition from transmission to negotiation scenario. Currently all upper secondary education schools have introduced the 'Study House', in which active acquisition and collaborative construction of knowledge in project-based settings is emphasised (Stuurgroep Profiel Tweede Fase Voortgezet Onderwijs, 1994). An essential part of the Study House is the use of ICT; one of its goals is for all students to be able to work with ICT applications individually and collaboratively. Students do not only need to learn to work with computers as a goal in itself, but computers can also be used as a means to reach the new educational goals (Stichting ICT op school, 2001). A short survey on teachers' ideas on ICT and collaborative learning (Deliverable 8, SCALE-team, 2002b) showed that they are very interested in learning more about collaboration and the possibilities of using computer tools to implement the educational innovations. They also were very eager to see and use our computer tool because they indicated there was a shortage of educational software.

Argumentative interactions in collaborative learning

The focus on collaborative processes is entirely in line with the new view on classroom practice. One characteristic of this educational innovation is that the problems students encounter in classroom practice are linked to the problems of daily life. These types of problems have been called wicked (Rittel & Webber, 1984; Van Bruggen & Kirschner, 2003), implying that there are many acceptable solutions, and many stakeholders whose views on the problem may vary even during the process.

Collaboration in such cases is often not guided by scripts or clear-cut solution criteria, since solving wicked problems requires many skills, such as negotiation about possible solutions. We see argumentation as one of the important activities for negotiation (Baker, 1994; Andriessen, Erkens, Peters, van de Laak & Coirier, 2003). Argumentation in this context is the production of opinions accompanied by reasons in favour or against, in combination with questioning, clarification, explanation and acknowledgement. It is not a mere confrontation of points of view (Baker, 2003), because in some cases a strict dialectic argumentation could be inefficient for learning. Clear defined opinions and indisputable attitudes towards a position may form an epistemological obstacle for students (Baker, 1999). Stein, Bernas, and Calicchia (1997) confirmed this idea in an experiment where they asked students to discuss two real life conflicts. It appeared that when students ended a discussion in a compromise, they gathered more knowledge of the content of arguments and had more balanced knowledge of both sides of a position. We also need to be aware of the fact that good argumentation does not necessarily imply a good learning process. Hence, 'bad' arguments can be a more important trigger for learning than good ones, because they require activities that play an important role in learning, such as redefining concepts.

In our research, the pedagogical objective is to create collaborative situations for argumentation-based learning (CABLE, deliverables 1&2, SCALE-team, 2002a). Students do not need to learn factual information, but rather the type of knowledge that is necessary to discuss a wicked topic. We want students to collaboratively acquire, refine, and restructure knowledge of a space of debate. Students might do so in a number of ways, e.g., enumerate arguments, or elaborate upon one or more arguments. The best imaginable situation is one in which students co-construct an understanding of the space of debate by exploring it thoroughly in breadth and in depth. Broadening the space of debate is defined as students using different epistemological and societal views with associated arguments. Deepening the space of debate is defined as students using many related concepts and modes of reasoning when exploring an argument or point of view.

Support of argumentative interactions

Recent research showed that students have problems with exploring the space of debate. Veerman, Andriessen and Kanselaar (2002) showed that students, when presented with assignments in which argumentation is needed to arrive at a solution, tend to focus on the solutions instead of arguing the space of debate.

One way to support the exploration of the space of debate is to provide representational tools. With these tools users can construct, research and manipulate their own representation of knowledge. Van Bruggen, Boshuizen and Kirschner (2003) mention several possible advantages of representations for argumentation. Firstly, the use of a representation forces students to make their opinions and arguments explicit. This sharing can stimulate students to negotiate and elaborate to come to a shared understanding of the space of debate (see also Suthers, 2003). Secondly, representations can help students to maintain focus on the task, by making the argumentation visible. Thirdly, representations can support the maintaining of consistency, accuracy, and plausibility of the argumentation, since a visible structure clearly shows which arguments, relations and backing information are missing.

There are different ways to represent and support argumentation. Van Bruggen and Kirschner (2003) distinguish discussion-based tools and knowledge representation tools. In discussion-based tools like CSILE (Scardamalia & Bereiter, 1994) and the Collaborative Notebook (Edelson, O'Neill, Gomez & D'Amico, 1995) the environment offers students the opportunity to exchange arguments, but the structure of argumentation is not explicitly represented. In knowledge representation tools like Belvédère (Paolucci, Suthers & Weiner, 1995) and the Knowledge Integration Environment (Bell, 1997) the structure of argumentation is explicitly represented, offering students an overview.

The ways in which representations can support argumentation are based on relatively scarce empirical research. Veerman (2000) found some evidence that Belvédère helps students to maintain focus, and stimulates constructive activities such as explaining and summarising information. Suthers (2001) compared three kinds of representations - texts, diagrams, and matrices - on the way students talk about concepts, how much they elaborate, and how much the representations trigger searching for missing information. He found that diagrams are best in supporting the ontology of users and the amount of elaboration and that matrices are best in triggering search for missing information.

These advantages of representations will not emerge automatically; other variables, such as the type of task used, also play an important role. Besides knowing *what* the tool supports, it is also important knowing *when* a tool is used in the task sequence. Baker (2003) used a representational tool to display an individual point of view *before* discussing an issue. Collaborating students were individually asked to give their opinions about a topic and both opinions were represented on screen to be compared. This task was based on the premise that students will argue more when they clearly see the things in which they differ. Baker found that students talk a lot about their opinions but quickly change their opinions without much argumentation. In contrast to Baker, Suthers (2003) used representational tools for collaborative construction *during* discussion. He found that students using diagrams and matrices talked more about evidential relations between arguments than students using a plain text representation. Comparing these results is difficult, because the researchers used different representations, tasks and variables. There is need for more systematic research to find out whether this indication is true.

Two experiments: SCALE and Twins

In this paper, two similar experiments are discussed in which an argumentative diagram is either used *before* or *during* discussion. The first study is part of the SCALE project and the second study is part of Twins. As stated earlier the pedagogical objective of the two projects is to create collaborative situations for argumentation-based learning. Both projects carried out a first experiment in which the same argumentative diagram is used; in the SCALE experiment students had to construct a diagram *individually before* engaging in the discussion, while in the Twins experiment students had to construct a diagram *together, during* discussion.

Context in both studies was a collaborative writing task. In this paper, we focus on the diagrams and the chat discussions in the two studies, but it may be assumed that the presence of a text window has an effect on discussion as well. The space of debate is extended to the text window; students might use the text to interact about concepts as well. Although the text production may cause argumentative interaction to serve the purpose of content generation, we decided to add the writing task to the experiment because the text gives students a reason for discussion. Also, the argumentative text gives us the possibility to compare chat and text to see what topics are discussed and which ones end up being put in the text, and shows us what has been put in the text that has not been discussed.

The scope of research

With SCALE and Twins, we want to find out which conditions in computer-supported collaborative learning lead to argumentative interaction, i.e., broad and deep understanding of the space of debate. More specifically, we want to know whether there is a difference in argumentative interaction when using argumentative diagrams *individually before* discussion or *collaboratively during* discussion. Thus, the main research questions are:

1. How are argumentative diagrams used during electronic argumentative interaction, in particular:
   (a.) An individual diagram constructed *before* the debate?
   (b.) A collaborative diagram constructed *during* debate.
2. To what extent do students collaboratively explore the space of debate in depth and breadth using these two kinds of diagrams?

We expect the role of the diagrams to be different before or during the task. Following the research of Baker (2003) and Suthers (2003), using representations *before* collaboration stimulates students to talk about their opinions and reflect on their own point of view, but does not stimulate elaboration on arguments, concepts and relations. Using a representation *during* collaboration helps students to elaborate on arguments and relations in depth and breadth of the space of debate, but does not help them to see the differences between their different opinions and arguments.

Method

Participants

In total, 126 pairs of 16/17-year-old students participated in the experiments, from five different schools for upper secondary education in the Netherlands. These schools volunteered to participate after a survey answered by 77 schools (Deliverable 8, SCALE-team, 2002b). Pairs were formed within classes, but worked at their own computer during the experimental sessions and, when possible, worked in different classrooms. For this article, we randomly selected 10 pairs from each experiment (N = 20).

CSCL Tool

Both studies used the tool TC3 (Text Composer, Computer-supported, and Collaborative). TC3 supports collaborative argumentative writing in dyads (Jaspers & Erkens, 2000). It consists of three main windows; the left one is for communication by chat, the upper-right window for information about the topic and aim of the task, and the lower-right window for collaborative writing of a text (Figure 1). Figure 2 shows the diagram tool in TC3. This is a representational tool in which students can construct an argumentative representation of the topic. There are two kinds of boxes and two kinds of arrows. One box is for representing opinions, the other for representing arguments to support or rebut the opinion. The arrows are green and red, respectively for indicating a positive relation ('in favor') and a negative relation ('against') between boxes. The diagram is kept simple, because Suthers (2002) found that a complex tool might distract students from the content of discussion.

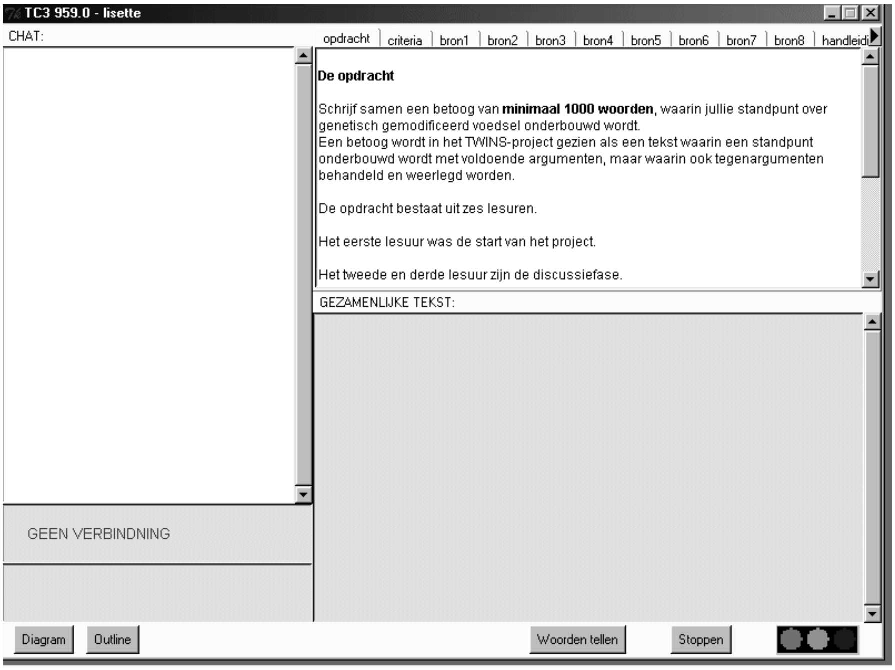


Figure 1. TC3

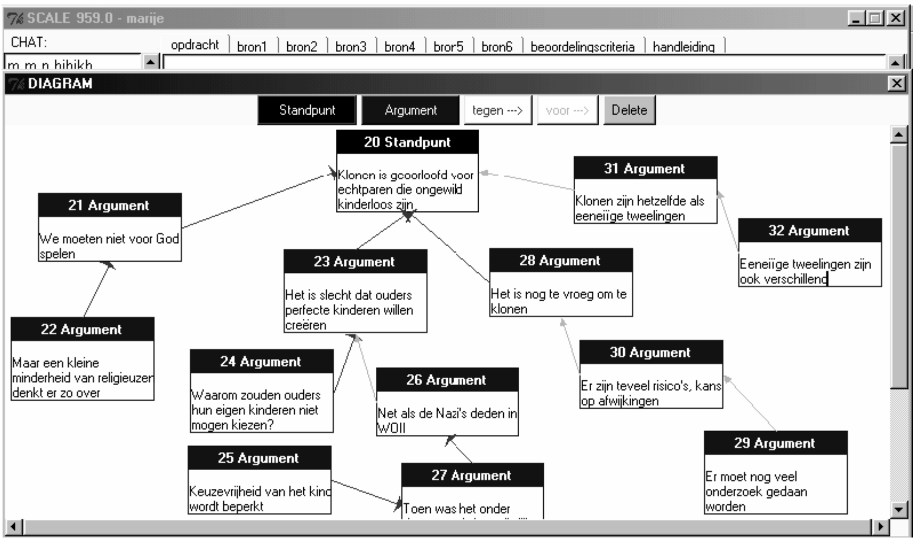


Figure 2. Diagram tool in TC3

Task and procedure

Both experiments consisted of six sessions of 50 minutes. Students were asked to discuss and write about the topic of genetically modified organisms (GMOs). The topic is part of the curriculum in upper secondary education, so the experiments could be conducted during regular hours in classes of Dutch language, General Sciences, or Biology.

Table 1
SCALE task sequences

Phase	Task	Duration (minutes)
Debate preparation	Individuals gain initial knowledge on the issue of GMOs by reading information, and form their opinion, supported with arguments and counterarguments, to put in a diagram.	50
Debate and collaborative writing	Based on their individual point of view, pairs of students are put together that think differently about the issue of GMOs. They then discuss GMOs and collaboratively write an argumentative text reflecting their joint opinion. Information is not available anymore, but the individually made diagrams of both students are.	150
Debate consolidation	Individuals go back to their individual diagram and can adjust this product to what they think and know about the topic after debate	50

Table 2
Twins task sequences

Phase	Task	Duration (minutes)
Debate preparation	Individual students gain initial knowledge on the issue of GMOs by reading information.	50
Debate and collaborative diagram construction	Students in pairs discuss the topic of GMOs and collaboratively construct a diagram reflecting their discussion. In this phase, students are not allowed to write the collaborative text yet. The original information is still available to the students	100
Collaborative writing	Students collaboratively write an argumentative text reflecting their joint opinion. Both the original information and the collaborative diagram are available.	150

Analysis

Analysis of interactions

Most of the studies in the domain of CSCL and collaborative interactions use coding schemes and frequencies to analyze students' individual utterances. For example Veldhuis-Diermanse (2002) tries to grasp the variable 'cognitive learning activities' by scoring students' utterances on categories like 'debating', 'using external information' and 'linking or repeating information'. Subsequent analyses are based on frequencies of codes in each category, reducing qualitative data to frequencies.

In our opinion these kinds of reductions do not say much about the quality of collaborative interactions. Counting the number of times students summarise information says little about the way they summarise information or about the quality of their summaries. We have tried to develop a way of analysing interaction in which we can grasp the quality of the interaction in a more extensive way than frequency counting.

The data collected are protocols in which all communication and actions of students are recorded. These protocols are analysed using a program called MEPA (Multi Episode Protocol Analysis), developed by Erkens (2001) at Utrecht University. With MEPA every utterance and action of students can be coded on several variables.

Rainbow

To order our data and get an overview, we firstly performed a functional and a content analysis of the utterances. The functional analysis is called the Rainbow framework and consists of seven principal categories, each represented by a color of the rainbow. These categories are shown in Table 3.

Some categories have subcategories. Task management, for example, consists of the subcategories 'management of the task in general', 'management of the discussion', 'management of the tool', and 'management of the information'. These subcategories are useful in the development of other variables, but beyond the scope of this article.

In the content analysis we distinguish topics and subtopics of the GMOs issue. The five main topics are worldview, health, environment, affluence, and other. These main topics are divided in fourteen subtopics, for example affluence – hunger/food or affluence – costs/benefits. All actions of students in categories five to seven (the content-related categories), and some in category four, were screened for these topics. The Rainbow and content analyses constitute the basis for further analyses on variables such as 'depth and breadth of the space of debate'.

Depth and breadth of the space of debate

The breadth of the space of debate is defined as the amount of topics and subtopics a pair mentions in the collaborative task. The breadth of the debate is calculated for the whole task as well as for the different parts of the task separately, so we can distinguish between topics taken up in the chat and topics actually put in the argumentative text students wrote collaboratively.

Table 3
Rainbow categories

Rainbow category		Explanation	Example
1	Outside activity	All interactions that do not have anything to do with the task	"How was the party yesterday?"
2	Social relation	All remarks about the social relation	"You are doing well!"
3	Interaction management	All remarks about communication, like checking presence, checking understanding	"Hello, are you there?"
4	Task management	All remarks and actions for managing the task	"It's your turn to write now"
5	Opinions	All statements about students' opinions	"I am in favor of GMOs"
6	Arguments	All arguments and counter-arguments students use to support or rebut a statement	"Because of Genetically modified food hunger in the third world will be banned"
7	Explore and deepen	All remarks that explore and deepen the (counter)arguments	"But hunger in the third world is not due to lack of food in the world, but to unequal division of food"

When students talk in depth about the space of debate, they relate different concepts, and elaborate upon their arguments. For the analysis of the depth of the debate, we developed a scoring system in which all content-related utterances are analyzed in their immediate context. Every utterance was rated 1, 2, 4, or 8. The rating of 1 is used for students stating an argument, 2 for giving an example or explanation of an argument, 4 for stating a support or rebuttal, and 8 for the explicit explanation of a relation between different arguments.

Table 4
Example of scoring the depth of the space of debate

Nr	Content of argument (with topics)	Who	From where	What happens	Depth
1	Health-nutrients; I am pro, because it is good for the 3rd world, they can use extra vitamins	1	Own Diagram	Argument and explanation	1+2
2	Affluence-division; no, third world cannot afford Genetic Modification, it is only meant for the rich West, and then nobody will buy product from the third world anymore	0	New	Rebuttal, explicit relation and explanation	4+8+2
3	Affluence-division; but the rich countries will help the poor countries with money and funding.	1	New	Rebuttal and explanation	4+2
4	Affluence-division; that happens already (funding), but with Genetic Modification nobody will buy things from the third world and they will become even more poor	0	New	Rebuttal and further explanation of argument #2	4+2
Total					29

Table 4 gives an example of a scored protocol. We look at episodes of content-related activities, e.g., a support or rebuttal can only be scores if an argument is scored first. Because the rating of utterances depends on their context, we are able to calculate averages to talk about the quality of the depth of the space of debate instead of only talking about quantity of arguments, rebuttals, examples and relations.

To obtain the absolute depth of the space of debate, all scored utterances on depth are added. This absolute score is obtained for every pair, and for every student and subtask separately. However, since some pairs worked longer than others the absolute depth might be distorting. To solve this problem we converted the absolute numbers to relative numbers by dividing the absolute numbers by the total number of utterances scored. The relative depth of the space of debate is used to compare the different subtasks and to compare Twins and SCALE.

Results

How do students deal with the task in general?

The Rainbow analysis gave us an overview of how students dealt with the task in general (i.e., Table 5).

Table 5
Mean frequencies and percentages of Rainbow categories in SCALE and Twins

	SCALE freq. (*SD*)	SCALE perc. (*SD*)	Twins freq. (*SD*)	Twins perc. (*SD*)
Off-task	23.1 (35.8)	4.6 (6.1)	51.7 (55.5)	5.3 (5.3)
Social relation	18.2 (11.3)	4.0 (2.8)	29.7 (21.5)	3.2 (2.1)
Interaction Management	47.7 (20.4)	10.1 (3.3)	52.7 (22.5)	5.9 (2.0)
Task Management	318.1 (93.5)	67.5 (10.4)	680.4 (128.1)	76.9 (4.7)
Opinions	18.0 (7.2)	3.9 (1.7)	18.1 (7.2)	2.2 (0.6)
Arguments	20.0 (10.9)	4.2 (2.0)	26.6 (10.2)	3.1 (1.3)
Explore and Deepen	25.1 (13.3)	5.74 (4.0)	29.5 (14.1)	3.4 (1.8)

In both studies students showed a lot of task management (67.5% in SCALE, 76.9% in Twins). A *t*-test showed that the difference in task management between the two studies is significant ($t = 2.62$, $p < 0.05$). Thus, in Twins students manage the task more than in SCALE. Students' activities are aimed at argumentative content (categories 5-7) 8.6% in Twins, and 13.8% in SCALE. In SCALE there is significantly more talking and writing about the opinions of the students (category 5; $t = -3.12$, $p < 0.01$), but there is no real difference on providing arguments and exploration and deepening (categories 6 and 7). The students are mostly working on the task in both projects, only about 5% of all interaction is outside-activity. Interaction on social relations is also scarce. On category 3, interaction management, there is a significant difference between the two studies ($t = -3.39$, $p < 0.01$). Students in SCALE manage their interaction more than students in Twins.

How are argumentative diagrams used in this exploration of the space of debate?
In SCALE there is a huge difference in how students constructed their diagram *before* discussion. The analyzed diagrams range in size from four to seventeen boxes. All diagrams have a 'standpoint' box in the middle or the top, and arguments around them. Most students have arguments in a random order scattered around the standpoint, others give a very structured overview. There are more arguments in favour of the standpoint (total of 137) than against (total of 56). It seems that students find it especially hard to rebut an argument.

The individual diagrams are mostly used as information sources. Many students look at their own diagram to gather arguments to use either in discussion or text writing. Others look at their partner's diagram to find out on what topics they differ. One pair of students was very structured in doing this:

Ann: *Hello Mary, what do you think about this subject?*
Mary: *Wait a minute ok? Because you can see what you have made and what the other has made*
Ann: *Ok, I'll look at your diagram first*
Mary: *Ok*
Ann: *The one about antibiotics is a good one, I agree with that*
Mary: *Yes, and I agree with your opinion on scarce products*
Ann: *Hunger can be banned that way, and that is necessary in the Third World*
…

Although the diagrams are mostly used as 'given' information, they can also give rise to an exploration of the space of debate that goes beyond the arguments presented in the individual diagrams. Oftentimes students start the discussion with an argument from their own diagram but discuss this argument with 'new' ones, not mentioned before (see also table 4).

In Twins the diagrams were constructed *during* the discussion. The number of boxes varies from 9 to 16 boxes, so there was less variation in the number of boxes than in SCALE. Most diagrams were very chaotic. It often happened that arguments that belonged together were not linked. Some diagrams were very structured but in that case just one student was in control of the diagram. As in SCALE, students use more arguments in favour (72) of their point of view than against (32).

Lisa and Gwen's fragment shows a special way of using the diagram. Lisa is communicating by chat, but oftentimes Gwen reacts on Lisa's arguments by putting a new box in the diagram (dia) with her counterargument or further elaboration:

Lisa:	*When there is too much genetic modification certain plants and animals can become extinct*
Gwen (dia):	*Some people say that GMO causes extinction of some plants and animals.*
Gwen (dia):	*But if we keep GMO under control, the consequences will be minimal.*
Gwen (dia)	*And solving the problem of hunger is more important than for example a specific kind of ants*

Three other functions of the diagram are showed in the discussion between Bob and Mike:

Bob (dia):	*GMO has advantages for the production of food. You get food that fits the demands of the consumers or you can produce food that you can keep longer, so less food is wasted.*
Mike:	*Shall I give the counter argumentation?*
Bob:	*Ok.*
Mike (dia):	*You can also get the desirable properties by crossing plants instead of manipulating genes.*
Bob:	*You wrote that nicely*
Mike:	*Shall I type another argument pro?*
Bob:	*I think we first have to rebut your argument: Crossing plants takes much more time than using GM, or not?*

Mike: *Oh yes you are right; with crossing it is much more difficult to get the desired properties.*

First the construction of the diagram creates input for further discussion. Mike puts something in the diagram and this causes a new discussion about crossing versus genetic modification. Secondly the diagram is used as a notebook to summarize the communication. After the discussion Mikes puts the conclusion in the diagram. Finally, Mike and Bob use the diagram as a way to discuss relations between arguments.

To what extent do students explore the space of debate in breadth and in depth?
Almost all pairs in both SCALE and Twins discuss the five main topics we distinguish in the debate on GMOs. Most pairs have a preference for certain topics in the debate that they discuss extensively, and only touch on other topics lightly. Of the 18 subtopics possible, students in SCALE discuss a mean of 11.9 subtopics ($SD = 1.3$), and students in Twins 9.7 subtopics ($SD = 1.8$). The tasks are too different to really compare these actual means so we calculated the percentages of events in which topics were mentioned. In SCALE this was a mean of 11% of all events, and in Twins a mean of 7%. A *t*-test showed this was a significant difference ($t = 2.71$, $p < 0.05$). This means students in SCALE talk and write more in breadth about the topic.

For depth of the space of debate in diagrams and discussion, we calculated absolute and relative depths. In SCALE, students deepen the individual diagram before discussion with an average of 25.1 points, compared with 58.2 in the chat. This difference is significant ($t = -2.475$, $p < 0.05$). However, the significant difference disappears when correcting for size of the diagram and chat (2.5. vs. 2.8). So, students say more about GMOs in chat, but relatively the depth is the same as in the average diagram. This means that students talk a lot about arguments and examples in the chat, but don't deepen these with rebuttals, supports or links. In the individual diagrams they do this more.

In Twins the collaborative diagram constructed during discussion is deepened with an average of 30.5, compared to 29.6 in the discussion. This was not a significant difference. In relative depth, we neither found significant differences between chat ($M = 2.3$) and diagram ($M = 2.6$). Overall, students in Twins mostly give arguments and explanations, but do not rebut, support or relate arguments much. The diagram shows the same picture.

In comparing SCALE and Twins, the difference in the absolute depth of the diagrams (M = 30.5 for Twins, M = 25.1 for SCALE) was not significant. The absolute depth of the discussion (chat) differed much more: 58.2 versus 29.6. However, because there was much more variation in the discussion of SCALE (SD = 39.75 versus SD = 29.7), this difference was not significant. The same results are obtained when comparing the relative depths of Twins and SCALE in diagrams and chat.

Finally, we looked at the depth of the text students had to produce in comparison with the diagrams they produced. In SCALE the average absolute depth of the texts was 64.6. This was significantly higher (t = -11.49, $p < 0.01$) than the depth of the diagrams. This difference remains significant (t = -3.36, $p < 0.01$) when correcting for size. Twins shows the same picture. The absolute depth of the texts was 64.7 and differed significantly (t = -5.81, $p < 0.01$) from the depth of diagrams. The relative depth of the texts was 3.3 and also differed significantly from the relative depths of the diagrams (t = -2.60, $p < 0.05$). These numbers show that in both SCALE and Twins students rebutted, supported, and related their arguments more in the text than in the diagrams.

Discussion

Supporting argumentative interactions with diagrams

In the theoretical background three possible advantages of supporting argumentative interactions during discussion with diagrams were mentioned: (1) Forcing to make opinions and arguments explicit and initiating negotiation, (2) maintaining focus, and (3) maintaining consistency, accuracy and plausibility of the argumentations. The results will be discussed according to these points.

Looking at the breadth of the space of debate, we found that both in SCALE and Twins students talk about a lot of different topics, but that students in SCALE talked more about opinions than those in Twins. This is in line with Baker's results (2003) and our predictions that an individual preparation stimulates talk about opinions. The individual representations provoke utterances such as 'I agree' or 'I don't agree'.

When making a collaborative diagram these utterances are provoked less, because all arguments are new for both students. However, in both SCALE and Twins it appeared that students easily take over each other's opinions and arguments. This was different from what we expected. As shown in the absolute and relative depth of the space of debate students talk about possible arguments and explain these arguments, but support and rebuttals are less frequently seen. Agreement and even disagreement are often followed by a quick acceptation of the other's ideas instead of negotiation. The task might be responsible for this behaviour; many students just want to construct the diagram or write the text. In SCALE the diagrams were mostly seen as a source of information in which arguments for the text could be gathered, and not as a representation of the other student's opinion that could be discussed. In Twins we found similar results. Many students saw the discussion phase as a phase of gathering content, and they used the diagram as a notebook in which all ideas for the text were gathered instead of discussed. This might also explain why the text is deeper than the diagrams. Students extent their ideas, that were put forward in diagram and discussion, in the text.

The second advantage, maintaining focus, is confirmed by the Rainbow analysis. In both studies we found little social talk. Students are mostly focused on managing the task, and on content. An explanation for this is that the task was complex and students had to look at information sources, compare each other's diagrams or construct a collaborative diagram, write the collaborative text, and discuss content. The question arises whether it is wise to let students write an argumentative text if discussing the domain is the main goal. It appears that writing and managing the writing of the text distracts students from discussing the content. In SCALE the individual diagrams helped to focus on content at the start of discussion, but the diagrams were quickly reduced to sources of information for writing the text. In Twins it is difficult to say in what way the diagram helps students to focus on the discussion, because a lot of the discussion happens through the diagram. In the results we saw an example in which one student chats her arguments and the other reacts in the diagram. Thus, comparing the depth of chat and diagram does not say much about the way the diagram stimulated the discussion. Veerman (2000) also found in her Belvédère-study that a part of the focus on discussion is maintained in the diagram.

However, it appeared that the focus on discussion disappeared as soon as students started writing the text.

Looking at maintaining consistency, accuracy and plausibility it was found that students do talk about what argumentation should look like. The fragment of Bob en Mike showed in which way the diagram stimulated looking at rebuttals and relations between arguments, but most diagrams were very unbalanced in the pro and counter arguments. The diagrams were very chaotic and many relations between arguments were missing or not accurate. It can be concluded that students know how to set up an argumentation, but they did not succeed in accomplishing this. In the text we found many more relations between arguments, but the balance of argumentation was still poor. Thus, the diagram provokes talk about how to argue, but does not support the right use of rebuttals, support and relations between arguments. Suthers' (2003) finding that Belvédère stimulated talk about relations between arguments was not confirmed in our studies. Students sometimes talk about the arrows they put in the diagram, but not about the meaning of these arrows. They just enumerate arguments and counter arguments without discussing their relations.

Classroom practice

In general, students really enjoyed the task. The Rainbow analysis showed they were indeed focused on the task. In a post-questionnaire not discussed here, we found that students especially liked the use of computers in this task, the collaboration with a classmate, and the chat function. Students are used to chat outside school, but they hardly ever use it for school tasks.

How and when to use computer-supported collaborative argumentation tasks such as the ones described in this article, largely depends on the goals and desired outcomes. When the main goal is to get students to discuss their opinions and arguments, an individual preparation with a diagram is helpful. When students need to learn to collaborate and negotiate, a collaborative diagram during discussion is more helpful. When the main goal for students is to collaboratively write an argumentative text, a diagram might be supportive in eliciting discussion on arguments and relations to be put in the text. In our studies, the text was indeed deeper than the diagrams. However, writing a collaborative argumentative text also interferes with discussing a topic, because the students are focused on the text product.

Even though students did interact argumentatively, and the diagrams were supportive, the discussions and diagrams are, in our opinion, not of very high quality. Using argumentation is very difficult for students, although they do seem to know how it should be done. Supporting and rebutting arguments is especially difficult, students merely exchange arguments instead of relating them. Content related sequences mainly consist of what students want to put in the text, and exploring what the other person means to say (Andriessen et al., 2003). This behaviour could be explained by current classroom practice. At this moment education puts emphasis on learning argumentation, and there is less attention for argumentation as a mean to learn. Also, products are often still the things students are graded for, so students focus on products, instead of really exploring the space of debate.

For classroom practice it might be interesting to combine both kinds of diagrams in a task. In forcing students to collaboratively reach consensus on a shared diagram, discussion might be triggered more because both students have constructed their individual diagram before. On the other hand, the task might be too complicated, or students might just combine the two individual representations into one. Students could also be forced to put only the most important arguments and relations in the diagram, so students really have to negotiate on what they consider really important and what not. Finally, the teacher could play a more supportive role in constructing diagrams or guiding discussion by emphasizing more the content of discussion instead the form of logical argumentation. SCALE and Twins will examine these suggestions further in future research.

Chapter 3

Supporting interactive argumentation: influence of representational tools on discussing a wicked problem††

Abstract

This study describes difficulties students can encounter when discussing a wicked problem and in what way two different representational tools can support interactive argumentation between students. About 55 pairs discussed in chat and wrote about genetically modified organisms in a groupware environment, supported by a text-outline or an argumentative diagram. The expectation was that students who were constructing a diagram would argue in a more thorough way, which is called the broadening and deepening in the space of debate. The expectations were partially confirmed. Diagrams help students to argue in a more thorough way, but only in the diagrams itself and not, as expected, in the discussion itself. This article shows the difficulty of supporting interactive argumentation with representational tools, because of the great amount of other variables in task and learning environment that effect the way students broaden and deepen an argument.

[††] Munneke, L., Andriessen, J., Kanselaar, G., & Kirschner, P. (2007). Supporting interactive argumentation: influence of representational tools on discussing a wicked problem. *Computers in Human Behavior, 23,* 1072-1088.

Introduction

The status of argumentation for learning can currently be described as controversial. On the one hand, research has shown that people reason better and make more progress in the construction of knowledge when they argue collaboratively (e.g., Billig, 1987; Leitão, 2000; Pontecorvo & Girardet, 1993; Voss & Means, 1991). Main idea is that students can mutually consider different sides and viewpoints about a topic, question each other, and clarify and explain issues. In this way they achieve a broader and deeper understanding of the topic being debated (e.g., Baker, 2003; Petraglia, 1998). On the other hand, it is quite possible that arguing does not lead to more understanding of the issue, for example when people stick to their own viewpoints, or when people do not advance very strong arguments (Andriessen, 2006; Kuhn, 1991). Next to this Veerman (2000) found that the relationships between argumentation and collaborative learning processes are neither simple nor predictable and thorough consideration of task characteristics and learning tools is necessary to provoke and support argumentation in the context of collaborative learning. This article is concerned with the question in which way argumentation during collaborative learning can be supported by different tools in a computer-supported collaborative learning (CSCL) environment in such a way that people really explore a complex issue and achieve a broader and deeper understanding of the topic at stake.

Interactive argumentation: broadening and deepening in the space of debate

In formal models, argumentation basically is seen as dialectical. Opponents attempt to establish the validity of two positions by convincing each other and trying to win points in the debate (Stein & Albro, 2001). Contrary to this approach, Chinn and Anderson (1998) define the aim of argumentative discourse in a collaborative learning situation as collective searching for reasons and evidence for different positions in the form of a conversation. They call this kind of argumentative discourse *interactive argumentation*. Following Chinn and Anderson interactive argumentation is defined in this article as at least two participants engaging in an argumentative discussion, whereby participants more or less equally contribute reasons and evidence for different viewpoints in order to build up a shared understanding of the issue of stake.

Leitão (2000) describes interactive argumentation as having a potential to set of processes of knowledge building and distinguishes two important argumentative processes that can promote learning, namely the justification of claims and counter argumentation. Theoretically, Baker (2003) compares the *justification of claims* to cognitive processes related to learning such as elaboration and self-explaining. *Counter argumentation* of opponents can stimulate participants in discussions to examine their views more thoroughly and rethink their initial arguments. Looking for quantitative measurements of the way students elaborate, explain and examine topics during interactive argumentation Chinn and Anderson (1998) propose, among other things, to measure breadth and depth of the conversations. They describe breadth as the extensiveness of the argument or discussion, the number of different positions people consider and the number of distinct individual arguments advanced for and against these positions. Depth is described as how extensively people elaborate distinct individual arguments. In this research these processes are called *the broadening and deepening in the space of debate* (Munneke, 2002).

Trying to grasp the macrostructure of interactive argumentation with the measurement of the breadth and depth, rises the question in what way the microstructure of interactive argumentation can be analysed. Because of the focus on the interactions, argumentation analysis cannot simply be carried out on the basis of established frameworks like Toulmin's model (1958). This model is the most frequently applied model for analyzing argumentative elements and consists of six basic concepts: data, claim, warrant, backing, qualifier, and rebuttal. Leitão (2000), however, argues that the model concentrates on describing the side of the proponent and assigns only a minor role to the opponent. The model becomes problematic when studying interactive argumentation as a learning process in which opponent and proponent are equally important and interdependent because it does not take into account the dialogical nature of interactive argumentation. Along with this, Kirschner, Van Bruggen and Duffy (2003) argue that the ontology of the problem being argued is critical for determining both the method of support for and the method of analysis of the argumentation. A design problem is radically different from an empirically solvable problem and thus requires different argumentation elements and thus different argumentation categories for their analysis.

In her book on the skills of argument Kuhn (1991) focuses on specific argumentative skills instead of Toulmin's (1958) basic concepts. In her opinion this skill approach makes it possible to study argument as *thinking*. She proposes five elementary skills of argument which entail the ability of reasoning namely, (1) the skill to offer causal theories which support claims (supportive theories), (2) the skill to offer arguments for supportive theories, which is called generating evidence, (3) the skill to generate alternative theories, that might be held by opponents, (4) the skill to envision conditions that would contrast with a supportive theory, which are called counterarguments, and (5) the skill to rebut an opposing line of reasoning, which is expressed in giving rebuttals to alternative theories or counterarguments. This study uses these skills as basic argumentative elements in analysis.

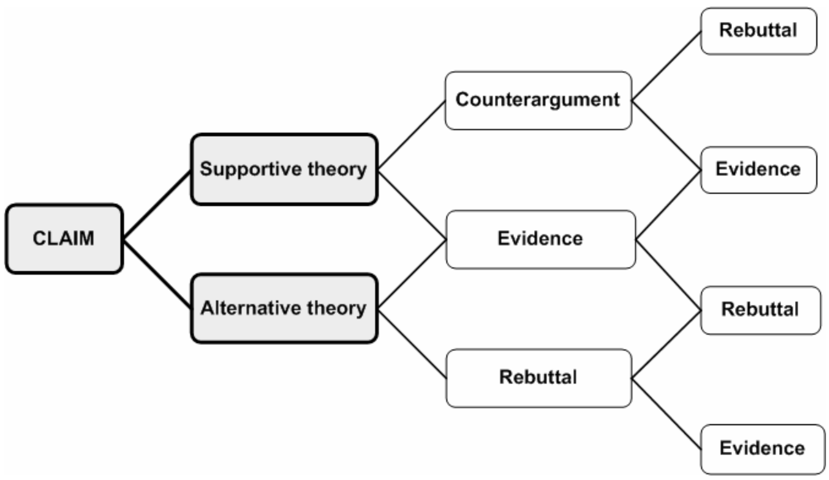


Figure 1. Skills of argument: broadening and deepening in the space of debate

Figure 1 shows the way this research models interactive argumentation. The model consists of the different skills Kuhn (1991) distinguishes and the possible sequences in interactive argumentation. Broadening the space of debate can be seen in Figure 1 as giving many theories to support or oppose a claim (i.e., a vertical slice of the figure). Deepening the space of debate can be seen as elaborating and supporting theories with evidence, giving counter arguments for supportive theories and oppose the counter arguments and alternative theories with rebuttals (i.e., a horizontal slice of the figure). The further people travel in a sequence the deeper the exploration of the space of debate. This study tries to determine if students broaden and deepen the space of debate in different ways when using supporting tools in a CSCL environment.

Difficulties in interactive argumentation

Although the assertion of this study is that argumentation leads to broadening and deepening in the space of debate by stimulating cognitive processes like elaboration, self-explaining, and rethinking concepts, several studies by Kuhn and colleagues (Kuhn, 1991; Felton & Kuhn, 2001; Kuhn & Udell, 2003) show the difficulties that people have in arguing. Kuhn studied the way people reason when they are asked to generate opinions and arguments about topics that are important for their own lives (e.g., causes of criminal recidivism or children's school failure). She encountered three problems. The first problem was related to the level of informal reasoning, namely that people take the correctness of their supportive theories for granted. The second was that most evidence given is not really evidence, but rather pseudo evidence, examples and descriptions that elaborate a theory, instead of genuine evidence that really supports a theory. Finally, she noted that thinking about alternative theories, counterarguments for supportive theories, and rebuttals is very difficult. In later studies on the development of argumentative skills in childhood and adolescent years (Felton & Kuhn, 2001; Kuhn & Udell, 2003), the results showed the same picture. Students easily generate supportive theories and pseudo evidence; but alternative theories, counterarguments, and telling why the other is wrong by giving rebuttals was very difficult for them.

These findings are in line with the findings of other researchers (e.g., Bennet & Dunne, 1991; Chan, 2001; Hightower & Sayeed, 1995) and point to the necessity of taking the way people argue into account, when designing tasks and tools to provoke broad and deep interactive argumentation. Collaborative tasks and tools for argumentation need certain characteristics to support justifying along with opposing of arguments and to stimulate students towards real engagement in the discussion.

Supporting interactive argumentation

In a review of different software for interactive argumentation, Veerman and Treasure-Jones (1999) describe several task characteristics and ways to structure the interaction between people that appear to provoke and support argumentation.

First, it seems important to offer a task in which multiple acceptable solutions exist. Serious argumentation can only emerge when serious problems are encountered. In this context Van Bruggen, Boshuizen, and Kirschner (2003) after Rittel and Weber (1973) talk about *wicked problems*. Wicked problems are a subset of ill-structured problems with two unique features. First, wicked problems have no right or wrong solutions that can be tested and revised. Second, they are problems which have many stakeholders who have their own views on both the problem and the solutions. These two features distinguish arguing about a wicked problem from arguing about a more structured or even a traditional ill-structured problem.

Second, Veerman and Treasure-Jones (1999) recommend asking students to produce an individual or a joint *product* as the goal of a discussion to motivate them to evaluate arguments in a thorough way. Because writing tasks can deepen students' knowledge and understanding, many studies ask students to write an essay as final product. (e.g., Erkens, Prangsma, Jaspers, & Kanselaar, 2002; Reznitkskaya, Anderson, McNurlen, Nguyen-Jahiel, Archodidou, & Kim, 2001; Schwarz, Neuman, Gil, & Ilya, 2003).

Third, Veerman and Treasure-Jones (1999) stress the importance of instructions that encourage students to be critical, use multiple perspectives, and be elaborative. They recommend an individual work-stage in which students construct or explicate their own stance or solution along with splitting the information required for carrying out the task between group members to stimulate positive interdependence.

Finally, Veerman and Treasure-Jones (1999) suggest to structure argumentative interaction by providing *representational tools* in a CSCL environment. Several researchers tried to support interactive argumentation with representational tools such as Belvédère (Paolucci, Suthers, & Weiner, 1995), SenseMaker (Bell, 2004), Drew (Baker, Quignard, Lund, & Séjourné, 2003), pro-con tables (Schwarz et al. 2003), and matrices (Suthers & Hundhausen, 2003). Most of these representational tools are integrated in CSCL environments where students communicate through chat. The main reason for using these tools is that they make thinking and arguing visible and thus could stimulate the collaborative exchange of ideas (Bell, 2004; Van Bruggen et al., 2003). They can force students to make their claims and arguments explicit and promote students consideration of all the evidence, because it becomes salient when units are missing or are in contrast (Suthers & Hundhausen, 2003). However, the precise ways in which representations actually support interactive argumentation, depend on the format they use to display information and the representational notations (Suthers & Hundhausen, 2003; Van Bruggen et al., 2003). So, representations with different formats can support broadening and deepening in a different way.

Representational tools to support broadening and deepening

Empirical research in which different representations are compared are relatively scarce. Suthers (2003) compared the effect of using a matrix, diagram, and text representation on the content and structure of participant's discussions. The matrix representation led to more talk about evidential relations because the empty cells triggered discussing missing information. However, the analysis of interactions was mainly on the topics and references to topics, which reveals little about the depth of the interactive argumentation. Schwarz et al. (2003) compared an argumentative map with a pro-con table and measured the type of arguments given in individual questionnaires and collaborative essays. It was hypothesised that an argumentative map would lead students to use counter arguments, and rebuttals and would foster discourse among students. A pro-con table would only help to sum up the supporting and opposing reasons without further elaboration. Schwarz et al., however, only compared the content of argumentative maps and pro-con tables without looking at the interactions. They found no significant differences between the two representations. So, it still remains the question in what way different representational tools can support interactive argumentation in terms of broadening and deepening.

Main aim of this research is to compare the support of a graphical representation with a non-graphical representation for interactive argumentation. A graphical representation like an argumentative diagram gives a two-dimensional format in which students can visualise their argument with boxes for arguments pro and contra and arrows for relations between arguments. This kind of representation is thought to support argumentation because visualising an argument stimulate to include evidential relations, to keep a balance between pro and contra arguments, to relate arguments, and to see inconsistencies and conflicts (Schwarz et al., 2003; Suthers & Hundhausen, 2003; Van Bruggen et al., 2003). A non-graphical representation like a pro-con table offers a linear format in which students can list their arguments pro and contra. In these kinds of representations it is possible to organise different arguments, but they discourage putting relations between arguments (Schwarz et al.; Suthers & Hundhausen).

By comparing an argumentative diagram with a textual outline this research tries to get more insight in how these two different representational tools support the broadening and deepening of argumentation in the space of debate. It is expected that a collaborative use of an argumentative diagram will trigger students to use more evidence, counterarguments and rebuttals, because the externalization of supportive and alternative theories shows whether the argument is in balance and whether all theories are supported with evidence. Along with this, the collaborative construction will stimulate students in their discussion to explicate unbalance and conflicts they see in their diagrams. Looking at Figure 1 this means the expectation is that students will both broaden and deepen their argument in the interactions as well as in the products (i.e., diagrams and final texts). When using a text-outline, the expectations are that students will gather supportive and alternative theories (i.e., broadening the discussion), but will elaborate less in their interactions as well as in the products (i.e., outlines and final texts) on their theories because the representation does not allow to link theories to evidences, counterarguments and rebuttals.

Method

Participants

Participants in this study were 175 pre-university students aged 15-17 (M = 15.6, SD = 0.61) from five classes in two different secondary schools. The study took place at the schools and lasted for six lessons during two weeks. The lessons were part of the standard curriculum and took place in either Dutch language or General Science classes. Students were randomly assigned to dyads and the dyads were randomly assigned to experimental conditions. Students worked behind their own computer, in most cases without being able to see their partner. All dyads in which one of the students missed a lesson were excluded from analysis, leaving 55 dyads for analysis. Because analyses were very time-consuming 40 dyads were randomly chosen and further analysed.

Task and procedure

The task was to discuss and write an argumentative text about genetically modified organisms (GMOs). This topic is part of the curriculum of the Dutch pre-university education and was chosen in collaboration with the teachers involved. The topic matched the research requirements because GMOs has the characteristics described for a wicked problem. There is no true or false or right or wrong answer for the question as to whether GMOs are a valuable biological development. There are many stakeholders with divergent views on the problem (e.g., Greenpeace, government, farmers, and consumers) and many different and acceptable solutions, though probably none which would satisfy all stakeholders.

The dyads were placed in two different experimental conditions based upon the computer tool available to them to support their discussion. In the outline-condition the students could make use of a text-outline tool to help them organise and structure a text. In the diagram-condition the students could make use of an argumentative diagram tool to help them visualise their discussion.

The task used was developed according to Veerman and Treasure-Jones' guidelines (1999) and consisted of two collaborative phases preceded by a class introduction and individual preparation.

In the first lesson (50 minutes) students were introduced to the task. After this they carried out an individual take-home assignment of approximately 40 minutes in which they had to read eight information sources on GMOs. These sources were popular, easy-to-read texts of between 100 and 350 words each and were written by different stakeholders, for example the government, Greenpeace, and an alliance of companies that produces genetically modified products. Within a dyad, students read a different set of eight information sources (thus, for each dyad a total of 16 information sources) which were complementary and contradictory, so they needed each other to get an overall picture of the problem. The sources were taken from the Internet and Dutch newspapers.

After the preparation students entered the first collaborative task-phase, consisting of two 50-minute lessons in which they were asked to discuss the topic of GMOs in a chat box and to use the tool they were provided when doing this. This phase will be referred to as the *discussion phase*. Students were instructed to discuss the topic and try to reach consensus (i.e., a joint opinion) about GMOs with help of the diagram or outline tool. During discussion they could enter the provided tool and put their arguments in it. They were explicitly instructed to use genuine evidence to support their theories, to think about what people who disagree with them might say, and how they would respond to these opponents. In addition they were explicitly told only to discuss the topic and not to start writing the final argumentative text.

The writing was done in the second task-phase which lasted for three lessons (approximately 150 minutes). This phase will be referred to as the *writing phase*. Students were asked to collaboratively write an argumentative text of 1000 words in the same computer environment as they worked in during the discussion phase. Communication was still carried out via chat and the diagram or outline constructed during discussion phase (depending on the experimental condition) was still available. Students were told that the text would not only be judged on the soundness of their argument and the originality of their ideas, but also on their contributions in the chat during the earlier discussion phase.

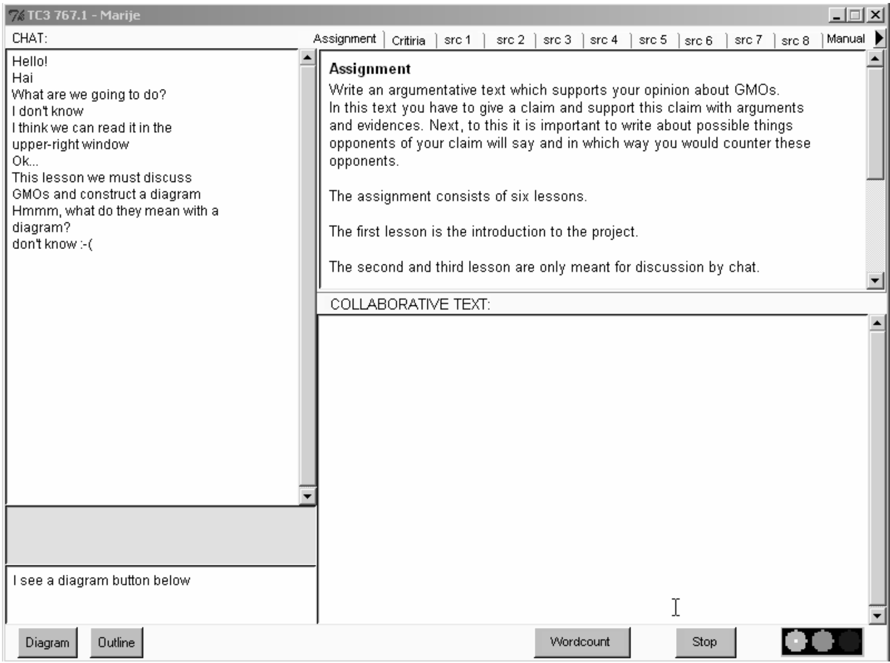


Figure 2. Screen capture of the main screen of the TC3 tool

CSCL tool

The computer environment used during the task was TC3 (Text Composer, Computer-supported, and Collaborative), an earlier version of VCRI (Virtual Collaborative Research Institutes), which is developed by Jaspers and Erkens (2002). TC3 was adjusted for the goals of this study and consisted of three main windows (see Figure 2); the left window was used for chatting and thus conveyed the communication carried out. The upper-right window was used for presenting information about the task and the topic. The lower-right window was used for the collaborative writing of a text. Only one of the students could work in the diagram, outline or text window at a time and students could take turns by using the traffic light at the lower right-hand corner of the text window. At the bottom of the chat window (see Figure 2) were two buttons 'diagram' and 'outline'. Clicking one of these buttons produced a pop-up window with either the diagram or the outline tool. Students could click on both of the buttons, but were clearly instructed and controlled by the experimenter on using only the tool of the assigned condition.

So, all students used only the tool of the condition they were assigned to. With the diagram (see Figure 3) students could construct an overview of their claim and their arguments with the boxes 'claim' and 'argument'. The arrows 'supports' (plus sign) and 'opposes' (minus sign) could be used to indicate whether an argument supports or opposes a claim. The design of the diagram was kept simple because research of Suthers (2003) indicates that a complex tool may distract students from the content of discussion. Figure 4 shows the outline tool. In this tool students could plan the structure and argumentative content of the text at the paragraph level.

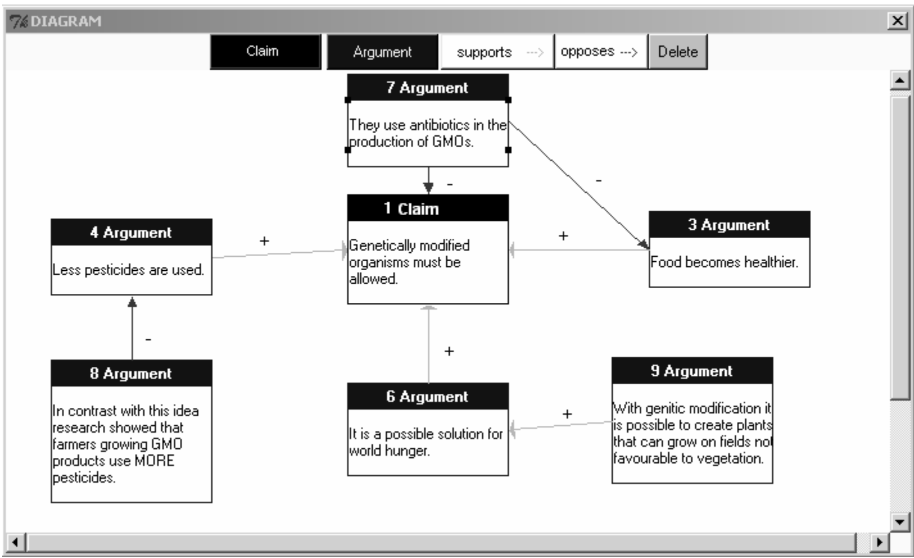


Figure 3. Screen capture of the diagram tool

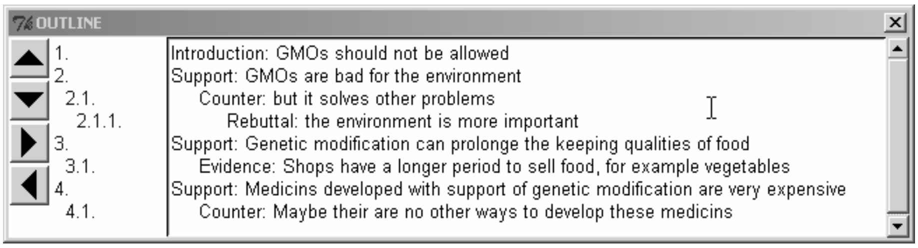


Figure 4. Screen capture of the outline tool

Analyses

To collect the data, every click in TC3 was recorded. This resulted in integrated activity protocols in which all chat communication, tool and source use, tool content (i.e., the outlines and diagrams produced), turn-taking, and the writing of the text was registered. For the analyses four spaces in which utterances and actions could take place were distinguished, namely the (1) chat-space during discussion, (2) tool-space during discussion, (3) chat-space during writing, and (4) text-space during writing. The chat-space consists of all utterances in chat. The tool-space consists of all of the content of the diagram or the outline, as well as all actions that were necessary to use the diagram and outline tools (e.g., putting boxes in the diagram and drawing arrows). The text-space contains all the content of the written text and all of the actions necessary for writing a text in TC3, such as the counting of words. In addition to these four spaces, a category of using sources and the traffic-light was also distinguished.

Essentially, the unit of analysis in the chat-space consisted of every separate utterance in chat, marked by clicking 'enter' or turn-taking. When an utterance required more than one code, the utterance was split. For example, when a student wrote "I am against GMOs, because it threatens the environment", the utterance was split into "I am against" and "because it threatens the environment". Also, when students clicked 'enter' before ending their message, the two chat utterances were merged. The utterances and actions in the tool-space and text-space, were coded when they were registered in the protocols and they were treated in the same way as utterances in chat. The coding of utterances and actions in the protocols was executed with *MEPA*, a computer program for Multiple Episode Protocol Analysis (Erkens, 2002).

To make sense of the long protocols, a first analysis of task acts was necessary. Based on the Rainbow method (Baker et al., 2003) a coding scheme was developed of which the main coding categories are shown in Table 1. The categories Interaction Management and Task Management were coded in subcategories. To define reliability, ten protocols of dyads that were excluded from analysis because of missing data were coded by two raters. Inter-rater agreement on ten protocols for this coding system of task acts was .80 (Cohen's Kappa).

Table 1
Main Codes for Task Acts

Categories of codes	Description
Outside Activity	Utterances and actions that are not constitutive of the interactive space imposed by the researcher.
Social Relation	Utterances about the students' interpersonal relation that relate directly to their carrying out of the task and collaboration.
Interaction Management	Utterances and actions to manage the communicative interaction itself such as checking presence, turn-taking and grounding.
Task Management	Remarks and actions concerned with managing different aspects of the task such as the use of TC3 and tools, the use of information sources, argumentation, and the writing of the text.
Argumentative Activity	Utterances and actions concerning claims and supporting and opposing those claims.
Conceptual Activity	Utterances and actions concerning the concepts in GMOs.

The task act Argumentative Activity was coded separately from the coding system of task acts. Based on the work of Kuhn (1991), every argumentative activity was coded with the categories shown in Figure 1. The place of one argumentative activity within a sequence of argumentative activities defined whether it was a claim, supportive theory, alternative theory, evidence, counterargument, or rebuttal. All codes were accompanied by the label 'asking' or 'giving' denoting whether for example a claim or evidence is asked for or given by a student. Again ten protocols were coded by two raters to define reliability. The inter-rater agreement on ten protocols was .82 (Cohen's Kappa), which can be considered fairly high.

The coding system of the task acts and argumentative activity constituted the basis for a more extended analysis of the breadth and depth of interactive argumentation. The breadth of the space of debate was defined as the number of argumentative sequences counted, including all single utterances which were not followed by argumentative elaboration. To define the depth of an elaboration the number of arguments in a sequence of related argumentative activities was calculated. For example, when students gave a claim, a supportive theory and evidence for this supportive theory, the sequence was Claim-Supportive-Evidence. The score on depth is three. In this way all sequences of elaboration on arguments are counted with respect to their depth.

Results

Performance of the task in general

The mean length of the protocols was 717.43 events, but varied greatly between dyads ($SD = 186.90$). A considerable percentage of the protocols consisted of task acts in chat-space (63.75), percentages for the chat-space of discussion and chat-space of writing were almost equal, 30.75 and 33.00 respectively.

In discussion phase the percentages for the task acts Outside Activity, Social Relation, Interaction Management, Task Management, Argumentative Activity, and Conceptual Activity were 4.64, 5.93, 19.81, 55.24, 12.85, and 1.18, respectively. In writing phase the percentages were 4.54, 5.28, 18.65, 62.40, 7.07, and 1.63, respectively. A paired-sample T-test showed significant more Argumentative Activity during the discussion phase ($M = 40.68$, $SD = 26.16$) compared to the writing phase (M = 29.13, SD = 12.55), $t(39) = 3.23$, $p = .00$ (two-tailed), $d = .56$.

Comparing conditions on Task Acts

To detect differences between the diagram and outline condition in the chat-space during discussion multivariate analyses of variance (MANOVA) was conducted with the task acts as dependent variables. There were no significant differences between the two conditions on the main categories of task acts, $F(7, 32) = 0.78$, $p = .61$, $\eta^2 = 0.15$. A separate MANOVA was run for the subcategories of Task Management which revealed several statistical significant differences. There was an overall significant difference between outline and diagram condition, $F(6, 33) = 2.99$, $p = .01$, $\eta^2 = 0.39$. Inspection of Table 2 shows that this effect is due to significant differences on the subcategories Task in General, Information and Text. Students asked to write a text-outline during discussion talked significantly more about the overall task that had to be carried out, the text that had to be written and about the given information sources than students asked to construct an argumentative diagram.

Table 2

Subcategories of Task Management in chat-space

	Outline (*n* = 20)		Diagram (n = 20)		
Task acts	*M*	*SD*	*M*	*SD*	*F*(1, 38)
Task in General	50.80	19.71	36.25	14.73	7.23**
Information	10.40	9.06	4.90	8.08	5.01*
TC3	12.55	8.92	17.40	17.08	0.51
Argumentation	15.25	15.14	19.40	13.01	1.023
Text	1.70	0.30	0.92	3.35	3.35*
Tools	35.85	23.39	21.75	12.48	2.40

$*p < .05$. $**p < .01$.

Because only the categories Task Management Argumentative Activity, and Conceptual Activity were used for coding the task acts in tool-space during discussion MANOVA on the main categories Task

Management (only consisting of Task Management Tools) and Argumentative Activity was performed. This showed an overall difference, $F(3, 36) = 28.54$, $p = .00$, $\eta^2 = 0.71$ Students discussing with support of a diagram needed more actions to construct the diagram ($M = 49.10$, $SD = 5.47$) than students who wrote an outline ($M = 4.40$, $SD = 0{,}98$), $F(1, 38) = 64.69$, $p = .00$, $\eta^2 = 0.63$. However, the content of the diagrams consisted of more argumentative acts ($M = 16.65$, $SD = 5.04$) than the content of the outlines ($M = 7.65$, $SD = 6.20$), $F(1, 38) = 25.37$, $p = .00$, $\eta^2 = 0.40$. Looking more specifically at the Argumentative Activity MANOVA was performed on the subcategories of Argumentative Activity. There was a significant difference between the diagram and outline condition, $F(6, 33) = 5.09$, $p = .00$, $\eta^2 = 0.41$. Table 3 shows the univariate effects of the different Argumentative Activities. Students who constructed a diagram used more argumentative activities reflecting the other side of a claim like alternative theories and rebuttals. Next to this they used more supportive theories and evidences in the diagram compared to students who wrote a text-outline.

Table 3
Argumentative Activities in tool-space

	Outline (n = 20)		Diagram (n = 20)		
Argumentative Activity	*M*	*SD*	*M*	*SD*	*F*(1, 38)
Claim	0.80	0.90	1.70	0.87	10.47**
Supportive theory	2.85	2.01	5.50	2.14	15.93**
Alternative theory	1.75	1.89	2.75	1.89	2.80*
Evidence	1.15	2.08	3.30	2.77	7.68**
Counterargument	0.30	1.13	0.90	2.05	1.32
Rebuttal	0.80	1.58	1.90	1.65	4.64*

*$p < .05$. **$p < .01$.

MANOVA showed a main effect of experimental conditions on the actions students performed during writing the text, $F(4, 35) = 5.06$, $p = .00$, $\eta^2 = 0.37$. This was due to a significant difference on the main category Conceptual Activity. Students who constructed a diagram during the discussion phase wrote less about concepts ($M = 1.55$,

$SD = 0.22$) than students who wrote an outline ($M = 3.60$, $SD = 0.62$), $F(1, 38) = 9.64$, $p = .00$, $\eta^2 = 0.20$.

For both conditions correlations were calculated between Argumentative Activity in chat-space, tool-space and text-space. It appeared that there was a higher moderate correlation between the argumentative activity in outline and text-space ($r = .63$, $p = .00$) compared to the correlation between the argumentative activity in diagram and text-space ($r = .57$, $p = .01$).

Breadth and depth of Argumentative Activity

The means and standard deviations of the breadth and depth for each condition as well as the student actions in the different spaces of discussion and writing phase are shown in Table 4. Separate MANOVAs on breadth and depth revealed significant main effects of conditions for both breadth, $F(4, 35) = 5.46$, $p = .00$, $\eta^2 = 0.38$ and depth, $F(4, 35) = 2.78$, $p = .04$, $\eta^2 = 0.24$.

Table 4

Breadth and depth of argumentative sequences

	Breadth				Depth			
	Outline (n = 20)		Diagram (n = 20)		Outline (n = 20)		Diagram (n = 20)	
Argumentative sequences in:	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Discussion								
Chat-space	9.20	1.22	6.90	0.81	2.54	0.17	2.09	0.17
Tool-space	4.85	0.77	8.85	0.59	1.34	0.19	1.85	0.09
Writing								
Chat-space	1.45	0.36	1.45	0.37	1.03	0.23	0.92	0.20
Text-space	10.65	1.01	9.25	0.93	2.19	0.15	2.13	0.16

The effect of conditions on the breadth of arguing was due to a significant difference in the tool-space during discussion. The students who constructed a diagram were more broad in their argumentation in the diagrams than students who wrote an outline, $F(1, 38) = 17.12$, $p = .00$, $\eta^2 = 0.31$. Also there was a notable, but non-significant effect found for students using an outline. In the chat-space these students tend to talk more broadly about GMOs than students using a diagram, $F(1, 38) = 2.46, p = .06, \eta^2 = 0.06$.

The difference between conditions on the depth of arguing was caused by the fact that students who were asked to write an outline in chat-space argued more in depth, than students asked to construct a diagram, $F(1, 38) = 3.35$, $p = 0.04$, $\eta^2 = 0.12$. However, although students in the diagram group have shorter argumentative sequences in chat they have deeper argumentative sequences in their diagrams compared to the outline group, $F(1, 38) = 5.93, p = .01, \eta^2 = 0.14$.

Interactive argumentation?

The last question to answer is whether the argumentative sequences were really interactive in nature. Results showed that of the total amount of argumentative activity in chat during discussion, 44% was interactive argumentation. 10% of the total argumentative activity in chat-space consisted of asking support or verifying arguments. In tool-space 21% of the argumentation was interactive and in text-space 18%. Two-tailed T-tests revealed that interactively constructed sequences during chatting in the discussion phase ($M = 3.07$, $SD = 1.41$) and using the tool-space ($M = 2.00$, $SD = 1.59$) in that same phase were longer (that is to say were deeper) than individually constructed argumentative sequences ($M = 1.24$, $SD = 0.59$; $M =°1.30$, $SD = 0.09$, respectively), $t(39) = 7.65$, $p = .00$; $t(39) = 3.06, p = .00$, respectively.

Discussion

In this study, students who participated in a discussion about a wicked problem supported by an argumentative diagram, constructed diagrams that contained significantly more claims, supportive theories, evidence, alternative theories and rebuttals than the outlines of students supported by a text-outline. In addition, the group supported by a diagram argued more in depth and breadth about the topic of GMOs. Thus, it can be concluded that diagrams support students in the elaboration of their arguments and are stimulated to think about their opponents' views.

However, we also expected the diagram group to have more argumentative activity in their chats and texts, because of the support by a diagram. Visualising and explicating the argumentation was thought to stimulate students to see inconsistencies and incomplete arguments. The data did not confirm this hypothesis. Students using an outline during discussion were more broad and deep in their arguments than students using a diagram. It seems that broadening and deepening in the space of debate in a diagram restrains the broadening and deepening in chatting. These findings are consistent with recent research on the effect of argumentative diagrams on how students discuss concepts and accomplish collaborative writing tasks (Erkens, Jaspers, Prangsma, & Kanselaar, 2005; Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005; Van Amelsvoort, Andriessen,& Kanselaar, 2005). Using a diagram seems to have some effects on argumentation, but often not the expected influence on chat discussions between students. Erkens et al. (2005) remark in this context: "Further analysis of the protocols showed that the diagram often functions as a visual representation and not as a basis for discussion or a tool for idea generation." (p. 486) The above mentioned researchers postulate that students lack experience with such tools and need specially adapted instruction to learn to use them. We agree with this, but based upon our results add that students can interpreter the function of tools in a different way than intended by the designer. They don not see the different tools as specific and shape them for their own use and misuse.

Returning to the results of this study, the results related to task acts showed that the task was very complex. Questions arise here whether the task of discussing, constructing tools, and writing a text is not to complex for students. Construction of diagram interfered with chat and while writing a text, the interactive argumentation in chat-space was almost absent. Writing a text requires complex skills and this may be too complicated for students to achieve together with the goal of broadening and deepening in the space of debate during discussion (Huk & Steinke, in press; Seufert, Jänen, & Brünken, in press). Results also showed that students saw the discussion phase and writing phase as two separate tasks and not as consecutive with discussion being a prerequisite to writing. Differences between the diagram and outline condition during discussion did not translate to the breadth and depth of argumentation in the texts. The same results were found by Janssen, Erkens, and

Kanselaar (in press), where students using a 'shared space' tool had higher performance scores in the part of task were discussion played the main role. In the writing part of the task scores of the students using the tool were equal with student in the control group.

It can be concluded that the instruction to students to be critical, to use multiple perspectives and to be elaborative did not really have the expected outcome for the chats. Students rarely question and overall they show the problems described by Kuhn (1991), namely that they use a lot of evidence and supporting theories, but have less attention for the opponents' view. Especially counter argumentation (i.e., thinking about what an opponent would say against their supportive theory) seems very difficult to achieve. Though, the instruction aimed at students arguing in a broad and deep way it remains the question as to whether students interpreter the instruction in the intended way. Nussbaum (2005) investigated the effects of goal instruction on the nature of students' interactive argumentation. Nussbaum points out that an instruction must trigger the appropriate argument frame. An argument frame represents a particular type of argumentative discourse (e.g., persuasive dialogues, inquiries, deliberations, negotiations). In this study the goal of argumentation was the exploration of the space of debate. It is possible that students used more adversarial frames, which can inhibit the exploration of the topic because the main goal is to persuade the other instead of explore together.

The results also showed that much argumentative activity was not really interactive. Students produced many sequences on their own especially in tool-space and text-space. A possible explanation may be that students are used to more traditional school tasks and to working for grades. They may have interpreted the wicked problem as a problem to solve quickly; aimed at a product (i.e., a text, a diagram, an outline), instead of understanding the space of GMOs. In context of this, Kirschner, Martens and Strijbos (2004) note: "it is not always clear to whom and to what extent an authentic task is really 'authentic'. (…) Is the problem that needs to be solved really 'our' problem or rather 'yours, hers or theirs'?" (p. 22) Students in our research were asked to discuss GMOs, a problem which may not really be authentic or interesting for 16/17 year old. Along with this, it can be noticed that we used a CSCL task in a traditional school environment, which is not used to this kind of collaborative argumentative tasks.

This study adds to a growing body of work on arguing to learn (e.g., Andriessen, 2006). It shows that using a representational format like a diagram supports the argumentative processes, but does not optimally provoke discussion between students. In addition, students appeared not to take full advantage of the collaborative setting. Possible causes can be sought in a lack of experience with tools and different interpretations of the intended way to use the tools. Along with this, it was noted that the task at hand seemed very complex and that students could interpret the task in different ways. Continued research is necessary to learn more about why students do not broaden and deepen arguments in their discussions and in what way they can be stimulated by representational tools, task instruction and learning environments to really engage in interactive argumentation in a broad and deep way.

Chapter 4

Interactive argumentation: impact of synchronous and asynchronous CMC ⌗

Abstract

This study examined the impact of different types of computer-mediated communication (CMC) on the way pre-university students argue about genetically modified organisms. A total of 39 dyads discussed the topic using either synchronous (chat) or asynchronous (discussion board) CMC, after which they collaboratively wrote an argumentative text in a synchronous groupware environment. Based upon the media synchronicity theory of Dennis and Valacich (1999) it was hypothesised that synchronous CMC would stimulate deep argumentation because of its immediacy of feedback, while asynchronous CMC would stimulate gathering arguments because of its allowing increased reflection time. Finally it was studied whether students who argue well during a discussion also wrote better argumentative texts. The results obtained partly confirmed the expectations. Students using synchronous CMC argue in a more elaborated way than students using asynchronous CMC. However, in contrast with the hypothesis students using asynchronous CMC produced more accurate argumentative texts. In the conclusion we try to shed more light on how synchronous and asynchronous CMC will be suitable for specific collaborative learning processes.

⌗ Munneke, L., Andriessen, J., Kanselaar, G., & Kirschner, P.A. (2007). *Interactive argumentation: impact of synchronous and asynchronous CMC.* Manuscript submitted for publication.

Introduction

Recently, there has been considerable research on argumentation in a collaborative setting (e.g., Anderson, Howe, Soden, Halliday, & Low, 2001; Andriessen, 2006; Felton & Kuhn, 2001; Schwarz, Neuman, & Biezuner, 2000). Chinn and Anderson (1998) describe argumentation within a collaborative learning situation as a conversation between participants in which there is collective searching for different positions, reasons, and evidence in an infinite space of debate. In this space, argumentation is considered a core activity which they refer to as interactive argumentation. The aim of interactive argumentation is not to establish truth or to win an argument, but rather to explore an issue at stake which Nussbaum (2005) defines as a co-constructive style of argumentation. Different studies have shown that engaging in this type of argumentative discussion enhances conceptual understanding (e.g., Mason, 2001; Zohar & Nemet, 2002).

However, research in this field also has revealed serious problems people may encounter while arguing. Felton and Kuhn (2001) found that young adults are unlikely to construct two-sided arguments, focusing largely on those arguments supporting their own position and not addressing the arguments of their opponents. These results were a confirmation of the results found in earlier studies (Kuhn, 1991; Voss & Means, 1991) indicating that people of all ages generally have difficulties with giving counterarguments for their supportive theories and generating alternative theories beyond their own opinion. These difficulties with arguing have potentially substantial implications for learning from interactive argumentation. Therefore, in response, studies have been undertaken which tried to support interactive argumentation (e.g., Schwarz, Neuman, Gil, & Ilya, 2003).

Specifically, a number of researchers have been attempted to support interactive argumentation with the use of computer-supported collaborative learning covering issues that concern the affordances and constraints of using representational tools and different types of computer-mediated communication (CMC) (e.g., De Vries, Lund, & Baker, 2002; McAlister, Ravenscroft, & Scanlon, 2004; Suthers & Hundhausen, 2003; Veerman, 2000). Benefits are derived form the time- and place independence of many CSCL environments which allows students to have more time to formulate their arguments and carefully reconsider and reconstruct their ideas (Marttunen & Laurinen, 2001; Weinberger & Fisher, 2006). Along with this, the written form of CMC is thought to be beneficial because this forces students to carefully explicating thoughts which may lead to more reflection and awareness (Veldhuis-Diermanse, 2002) and because the written form gives rise to the existence of a history of conversation which gives opportunities for reflection upon argumentation and collaboration (Veerman, Andriessen, & Kanselaar, 2000). Finally, the lack of non-verbal cues is thought to stimulate equal participation of students during collaboration because CMC participants experience less social pressure (e.g., Bordia, 1997).

However, these assumed affordances of CSCL, more specifically CMC, are not undisputed. Researchers take the same aforementioned characteristics of CMC –time- and place independence, written form, and the lack of non-verbal cues- as explanations for failures within collaborative processes. For example, some researchers explain the possible occurrence of unequal participation of students during CSCL with the lack of non-verbal cues in CMC which causes depersonalisation of the communication (e.g., Kreijns, 2004). It seems that the choice of explanation depends on the perspective taken of whether CMC stimulates or constrains the collaborative learning process (see Honeycutt, 1991; McAteer, Tolmie, Duffy, & Corbett, 1997).

In this study we try to establish how different types of CMC can support interactive argumentation. Answering this question is complicated by the discrepancies in the research into the effects of different characteristics of CMC on collaborative learning processes. Before describing what we know from specific CMC research and theories, we will first describe the relation between interactive argumentation and learning in more detail.

Interactive argumentation and learning

The empirical relation between specific argumentation processes and reaching understanding is still open to debate. There are several possible learning processes that can govern construction of knowledge as interplay between interpersonal and intrapersonal processes. Kuhn, Shaw, & Felton (1997) argue that in the case of interactive argumentation the conflict model has dominated, "on the assumption that the power of dialogue stems from discrepancy between viewpoints, creating the opportunity for each member of the dyad to be exposed to new perspectives that potentially be integrated into their own thinking" (p. 313). They propose a more complex picture where several interactive processes from both the conflict and cooperation collaborative learning models play a role such as students asking questions that lead them to develop their thinking.

Munneke, Andriessen, Kanselaar, and Kirschner (2007)[§§] present different opportunities for relations between interactive argumentation and learning which reflect this combination of conflict and cooperation collaborative learning models. A first learning opportunity during interactive argumentation is justifying claims with arguments and evidence which can promote cognitive learning processes such as self-explanation and elaboration (Baker, 2003). The expression of arguments could itself lead to reflection, refinement and restructuring of knowledge in a manner analogous to the mechanisms underlying the self-explanation effect (Chi, Bassok, Lewis, Reimann, & Glaser, 1989). A second opportunity is giving counterarguments which can stimulate knowledge building because this provokes participants to examine their own views and initial arguments and then negotiate with each other about the meaning of concepts and information (Leitão, 2000). These possible learning processes can be seen as cooperative exploration of the space of debate. To have an optimal effect on learning, students must extensively explore the space of debate with respect to both its breadth and its depth. (Baker, Andriessen, Lund, Van Amelsvoort, & Quignard, 2007; Munneke et al., 2007). Broadening has to do with gathering information from different points of view, assembling different subtopics, point of view and associated arguments, while deepening has to do with using evidence, counterarguments and rebuttals, and reaching some convergence on different pieces of information.

[§§] Chapter 3 of this dissertation

The effect of CMC on interactive argumentation

To derive which effect different characteristics of CMC can have on interactive argumentation two issues that arise are very important to attend to, namely (1) the distinction between different CMC technologies; and (2) ideas about the appropriate fit between different learning tasks and CMC technologies.

First, CMC is a very broad term and consists of many varieties such as chat rooms, MOOs, Instant Messaging, videoconferencing, e-mail, and discussion boards. A classical distinction made between different kinds of CMC is that between synchronous and asynchronous CMC applications. Although it is nowadays often difficult to discern between synchronous and asynchronous CMC, we define the difference as to whether someone is expecting a direct reaction of the communication partner or not. Synchronous CMC occurs in real time and requires simultaneous participation. In synchronous communication a person starts reading as soon as his or her partner types a message or pushes the 'enter' button. Asynchronous CMC is delayed and distributed in time so that participants can communicate any time they choose. It is possible for people to read messages immediately after a partner posted a message, but normally there is some time-delay and participants do not immediately expect reactions of each other, as opposed to synchronous CMC where participants expect immediate reactions.

Second, it is important to make a distinction between different goals and characteristics of the learning context in which CMC is used. Research by Branon and Essex (2001) has shown that educators have explicit ideas about the appropriate fit between learning tasks and CMC technologies. Asynchronous communication was reported as encouraging in-depth discussion in which all students had equal chances to participate. This is because the time delay allows learners who are not inclined to immediately responding a discussion to think more deeply and respond at a moment that they feel comfortable with. Synchronous communication was seen by the educators as useful for quick problem-solving, brainstorming, and creating a sense of presence which is absent in asynchronous communication. Quick response causes a feeling of teleproximity which, in turn, influences the feeling of social presence. In the field of CSCL and communication research several researchers conclude that asynchronous systems should be preferred when the goal is critical thinking and deep learning (e.g., Marttunen & Laurinen, 2001; McGrath & Hollingshead, 1993; Veerman, 2000).

Research systematically comparing synchronous and asynchronous CMC for interactive argumentation is relatively scarce. Veerman, Andriessen, and Kanselaar (2002) compared different studies in which college students carried out online collaborative discussions in three different CSCL environments, including NetMeeting® (a synchronous chatting tool), Belvédère (synchronous tool structured by the use of an argumentative diagram), and Allaire Forums™ (an asynchronous bulletin board system). These discussions were part of a course students had to take during their study Educational Sciences. The content of the discussions was characterised in terms of focus (i.e., do students have a shared focus on the same parts of the task), argumentation (i.e., checks, challenges, and counters) and constructive activities (i.e., interactions leading to construction of new knowledge such as adding, explaining, evaluating, summarising, and transforming). Veerman et al. (2002) found that synchronous discussions supported by an argumentative diagram (Belvédère) were the most argumentative discussions –students checked, challenged and countered each other's information most frequently. Yet, the asynchronous discussions were characterised by the production of more constructive activity and a conceptually oriented focus of the communication. On the basis of the data of this study, Veerman (2000) suggested that synchronous CMC is less effective for conceptually oriented and constructive argumentation due to the fast flow of communication and real-time pressures.

However, these results and suggestions can be questioned. First, Veerman's (2000) suggestions are based on the comparison of studies which used very different tasks, different CSCL environments, and different sizes of student groups. Thus, instead of the synchronicity of CMC there were many other variables that could explain the differences found between synchronous and asynchronous CSCL environments. Second, the way Veerman defined argumentation and constructive activity is different from the way we define interactive argumentation. The argumentative dialogue moves Veerman proposed, suit the more dialectical kind of arguing where the main goal can be defined as attacking the opponent to win the debate instead of arguing to learn. In our opinion arguing to learn automatically contains the proposed constructive activities -when students explore the space of debate according to breadth and depth they automatically should add, explain, evaluate, summarise, and transform information.

Along with this, despite the apparent lack of fit between synchronous communication and interactive argumentation, much research in CSCL aimed at reflective discussion is accomplished with chat tools (e.g., Baker & Lund, 1997; Veerman, et al., 2002; Walker, 2004). And finally, Valkenburg and Peter (2007) found that 88% of Dutch adolescents (12 to 16 years-old) use online communication - mainly Instant Messaging - with friends, which is making synchronous CMC a more and more common means for communication in everyday life for many preadolescents and adolescents. These issues raise the question as to whether using synchronous CMC for deep learning is really ineffective when compared to asynchronous communication. To answer this question, we want to return to some theories describing the effects of different characteristics of CMC on communication and interactions, in the hope to derive some expectations for the specific communication processes of interactive argumentation.

Approaches to CMC

A classical approach to the differential effects of media on communication is the media richness theory (Daft & Lengel as cited in Carlson & Zmud, 1999). Media richness refers to the ability of a medium to communicate information in such a way that uncertainty or equivocality in a message is minimal; that is, that a task or topic under discussion is unambiguous. The richness of a medium is based on four criteria, namely immediacy of feedback, transmission of multiple cues such as non-verbal signals and voice tone, use of natural language, and conveyance of personal emotions. Based upon these criteria, face-to-face communication is the richest medium due to its availability of immediate feedback and availability of multiple cues and non-verbal signals. Media richness theory argues that difficult tasks with a high level of uncertainty and equivocality do not fit lean media like CMC because the missing of non-verbal signals and multiple cues causes depersonalization (Carlson & Zmud; Walther, 1995).

However, this theory has been criticised on the grounds of its primarily technology-driven approach (Tanis, 2003). Fulk (1993), for example, argues that the effects of information and communication technologies (ICTs) are determined by the interaction between users, technology, and context and not only by the characteristics of the media. Carlson and Zmud (1999) and Walther (1995) accentuate the importance of the amount of experience that users have had, the sort of task accomplished, and the time users may need to communicate effectively through CMC. An approach that takes into account task types is media synchronicity theory (Dennis & Valacich, 1999). Dennis and Valacich developed this theory because of the aforementioned critical notes on media richness theory and argue that all tasks are composed of the communication processes conveyance and convergence which need different media characteristics.

Dennis and Valacich (1999) identify five media characteristics, which are comparable with the criteria of media richness theory. These characteristics, immediacy of feedback, symbol variety, parallelism, rehearsability, and reprocessability can affect the way users of media interact with each other. Immediacy of feedback is the speed of communication and the extent to which users can give rapid feedback on messages they receive. Symbol variety is the number of ways in which information can be communicated such as verbal and nonverbal cues. Parallelism deals with the number of same or different types of communication that take place in the same time, in the same medium. Rehearsability is the ability of users to rehearse and preview their message before actual communicating it. Reprocessability finally, is the ability to review and analyse sent messages more than once at different points in time. Rehearsability, symbol variety, and reprocessability are seen as dimensions which handle the equivocality of a task. When a message is complex and equivocal it is important to have time to reflect and to reprocess as message. For example, when information is complex, it can be important to compose a message with an exact meaning.

To determine which media suit which kinds of tasks, Dennis and Valacich (1999) distinguish two communication processes people have to accomplish when they are collaborating, namely conveyance and convergence processes. These two kinds of processes are also critical for interactive argumentation, more specifically for the breadth and depth of the space of debate. A conveyance process is the exchange of information, followed by deliberation on its meaning. It can be divergent, in that not all participants need to focus on the same information at the same time, nor is it necessary to agree on its meaning. It can be compared with the breadth of the space of debate, students gathering different supportive and alternative theories for and against their opinion. In general, low media synchronicity is preferred for conveyance processes because high parallelism and low immediacy of feedback is stimulating students to look at divergent points of view. High parallelism is convenient for keeping an overview of different points of view because asynchronous communication gives opportunities to make new threats for every different topic. Low immediacy of feedback is giving students the opportunity to search and read their information and gives time for carefully writing a message and reflecting on other messages. A convergence process is the development of shared meaning for information, which can be compared with the processes of establishing and maintaining common ground (Clark & Brennan, 1991). By definition it is convergent, in that participants strive to agree on the meaning of information and agree that they have agreed. This means that participants must understand each other's views. This can be compared with the depth of the space of debate, students elaborating different points of view and using evidence, counterarguments, and rebuttals. In general, high synchronicity is preferred for convergence processes, because for agreeing on one piece of information high immediacy of feedback is necessary and many parallel discussions are ineffective and distracting.

Research questions

This research investigates the effects of synchronous and asynchronous CMC on interactive argumentation, more specifically the breadth and depth of the space of debate, when student dyads are discussing a complex problem. As been shown, differential effects of CMC on communication between people coexist and there has been little research on the effect of CMC on specific processes such as interactive argumentation. Veerman's (2000) research indicates that asynchronous CMC - compared to synchronous CMC - is best for students engaged in critical discussion because of the reflection time asynchronous CMC allows in communication. However, from the point of view of media synchronicity theory (Dennis & Valacich, 1999) asynchronous communication is less advantageous for communication processes such as deepening the space of debate during interactive argumentation because of its lack of immediate feedback. In their opinion, asynchronous communication benefits the process of broadening the space of debate (i.e., gathering different points of view on a topic).

In this line of reasoning, the first two research questions of this study are: (1) what is the effect of synchronous and asynchronous CMC on broadening the space of debate and (2) what is the effect of synchronous and asynchronous CMC on deepening the space of debate? It is hypothesised that using synchronous CMC will result in fewer, but longer argumentative sequences of argumentation compared to asynchronous CMC. Comparing synchronous and asynchronous communication is methodologically complex because the amount of time students are communicating and what is happening between sessions may differ considerably between conditions. To this end, a third research question tries to establish what the effect of a synchronous or asynchronous discussion is on the way students perform on a subsequent writing task. Reznitskaya et al. (2001) found that students discussing an issue in a specific instructional setting (i.e., collaborative reasoning discussion) for a period of several weeks wrote essays with a greater number of relevant and accurate arguments. Based upon this, we hypothesise that students optimally supported by CMC with respect to the way that they elaborate on different points of view during the discussion phase (i.e., optimalisation of convergence processes), will write argumentative texts with higher quality, i.e. more accurate argumentation, during a subsequent writing phase.

Method

Participants

Participants in this study were 114 pre-university students aged 15-17 (*M* = 16.1, *SD* = 0.72) from two academic high schools in the Netherlands. The schools were situated in the same geographic area and were matched with respect to their demographics, including the socioeconomic background. Because of this, each school was assigned to one of the two treatment groups instead of carrying out the different treatments in both schools. This study was carried out in seven parallel groups taught by six different teachers who collaborated with the research team on the development of the argumentative task. Students worked on the task for three weeks, either during the classes planned for Dutch language lessons or at home in their own time dependent of the experimental condition.

Design

A post-test-only quasi-experimental design with two treatment groups (synchronous CMC vs. asynchronous CMC) was used to compare the argumentation in two different CMC situations. Students in the synchronous condition discussed the topic of genetically modified organisms (GMOs) with the help of an electronic environment that made use of a chat program, while students in the asynchronous condition discussed the topic in an electronic environment that made use of a discussion board. The students collaborated in randomly composed dyads, heterogeneous with respect to gender. To avoid student dyads that would have problems getting along with each other (i.e., the students knew each other and had a collective social history), teachers were requested to check the dyads with respect to compatibility. Eighteen pairs (10 synchronous and 8 asynchronous) were excluded from analyses either because they missed more than one lesson or because they posted less than three out of the six obligatory messages in the asynchronous condition (see Task and Materials). For analysis of the results 20 pairs of students remained in the synchronous condition and 19 pairs in the asynchronous condition.

As a post-test, students were asked to collaboratively write an argumentative text in which they described their opinions about GMOs. This text was written in class with help of an electronic environment and chat communication (see Task and Materials). This text was analysed on the accuracy of the argumentation (see Measures).

Task and materials

Dyads worked on an argumentative collaborative task in two phases, namely a discussion and a writing phase. These phases were preceded by an introduction to the task in the class and a period of individual preparation. During preparation, students were introduced to the subject of GMOs in the class and instructed about what argumentation entailed. After this, students received an individual take-home assignment which took approximately 40 minutes to carry out. Students had to read a number of source materials on the topic of GMOs. These source materials were popular, easy-to-read texts of between 100 and 350 words each and were written by different stakeholders, for example the government, environmental activists, and an alliance of companies that produces genetically modified products. Within a dyad, the two students read a different set of eight information sources (thus, for each dyad a total of 16 information sources) which were complementary and contradictory, so they needed each other to get an overall picture of the problem. Both students read sources with different points of view on the subject of GMOs, so neither student had all sources 'pro' GMOs or all sources 'con'.

The difference between the two conditions was created during the discussion phase. The discussion phase in the synchronous condition consisted of two 45-minute meetings where students were asked to discuss GMOs using the chat facility in TC3 (Text Composer, Computer-supported, and Collaborative; see Figure 1), developed by Jaspers and Erkens (2002).

In the asynchronous condition, the discussion phase lasted two weeks in which each student was asked to post six substantial messages in Blackboard Academic Suite™[***](Figure 2).

[***] Blackboard Academic Suite™ is a trademark of Blackboard Inc.

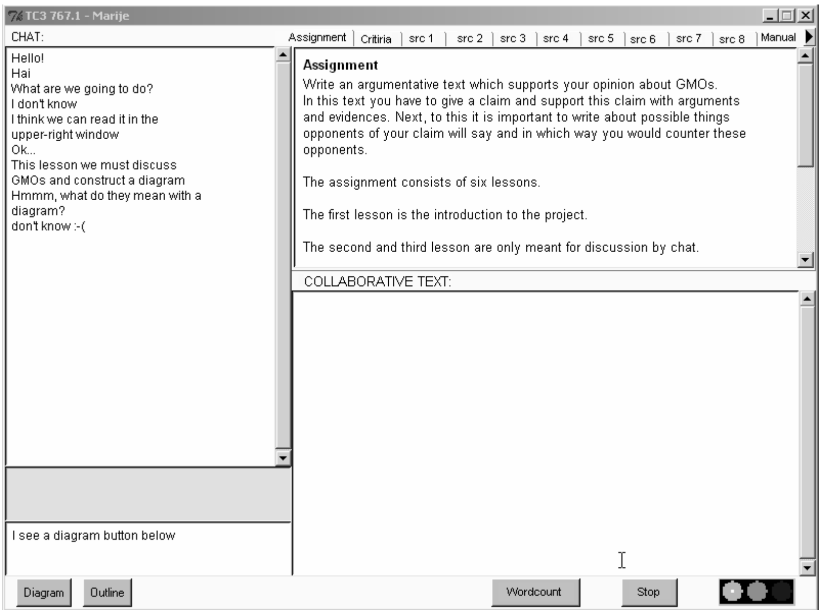


Figure 1. Screen capture of TC3

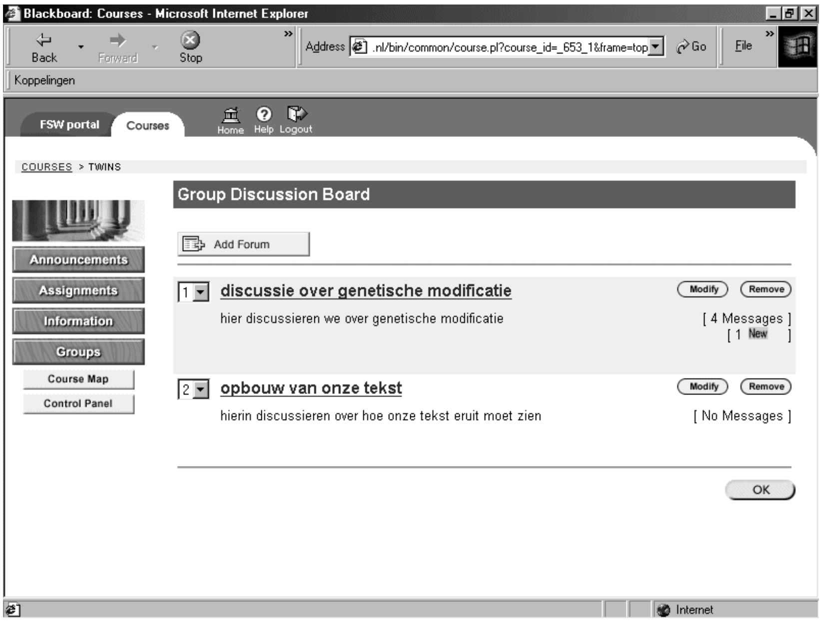


Figure 2. Screen capture of Blackboard Academic Suite™

A substantial message was defined as a message consisting of at least one argument. Students had to post their messages (i.e., work asynchronously) in their own time after or before school, or during free periods on school. There was one class meeting to help students who were having a problem with the task and/or who did not post enough messages.

The writing phase was equivalent for both conditions. All dyads wrote an argumentative text about GMOs using TC3 and communicated synchronously within the dyad, through TC3's chat facility during the writing phase. This writing phase encompassed three lessons (approximately 120 minutes).

Measures

The data consisted of all utterances in chat and discussion board. In principle, the unit of analysis in chat consists of every separate utterance in chat, marked by pushing 'enter' or turn-taking. When an utterance required more than one code, the utterance was split. Also, when students pushed 'enter' before ending their message, the two chat utterances were merged. The messages in the discussion board were split into units of meaning. The coding of utterances in the protocols was executed with the computer program MEPA (Multiple Episode Protocol Analysis; Erkens, 2002).

A coding scheme based on the Rainbow framework (Baker et al., 2007) was developed for determining different task acts. This scheme consisted of seven main categories of task acts, namely outside activity, social relation, interaction management, task management, argumentative activities, and conceptual activities, which are explained in Table 1. The main category Task management was also coded in three subcategories: (1) management of the task in general, (2) management of the way the computer program works, (3) management of the discussion. Inter-rater agreement on 10 protocols was .80 (Cohen's Kappa).

Table 1
Main Codes for Task Acts

Categories of codes	Description
Outside Activity	Utterances not constitutive of the interactive space imposed by the researcher, for example: 'what did you do this weekend?'.
Social Relation	Utterances about interpersonal relations that directly relate to the task and collaboration, for example: 'you have read the sources well'.
Interaction Management	Utterances about coordinating the communicative interaction itself such as checking presence, turn-taking and grounding, for example: 'I don't understand what you were saying'.
Task Management	Remarks concerning the coordination of different aspects of the task such as using the CSCL tools, using information sources, argumentation, and the writing of the text, for example: 'when are we going to write the text?'
Argumentative Activity	Utterances containing argumentative moves, for example: 'I am against GMOs'.
Conceptual Activity	Utterances concerning the meaning of concepts in GMOs, for example: 'genetic modification permits alteration of (…)'.

Argumentative activities were coded with a separate coding system based on Kuhn (1991) in the categories shown in Figure 3. Kuhn proposes five elementary skills of argument which entail the ability of reasoning namely, (1) offering causal theories which support claims (supportive theories), (2) offering arguments for supportive theories, which is called generating evidence, (3) generating alternative theories, that might be held by opponents, (4) envisioning conditions that would contrast with a supportive theory, which are called counterarguments, and (5) rebutting an opposing line of reasoning, which is expressed in giving rebuttals to alternative theories or counterarguments. This study uses these skills as basic argumentative elements in analysis. The place of one argumentative interaction within a sequence of argumentative interactions defines whether it is an opinion, supportive theory, alternative theory, evidence, counterargument, or rebuttal. All codes are accompanied by the label 'asking' or 'giving'; whether an opinion or argument is asked for or given by a student. This makes clear how often students question each other, a feature of constructive dialogue. Inter-rater agreement on ten protocols was .82 (Cohen's Kappa).

The coding system of task acts and argumentative activity formed the basis for a more extended analysis of the breadth and depth of interactive argumentation. The breadth of the space of debate was defined as the number of argumentative sequences counted, including all single utterances which were not followed by argumentative elaboration. Looking at Figure 3 this means that every new sequence starting (or immediately ending) with a supportive or alternative theory counts as one argumentative sequence. To define the depth of an elaboration, the number of arguments in a sequence of related argumentative activities was calculated. Looking at Figure 3, when students gave a claim, a supportive theory, and evidence for this supportive theory, the sequence was Claim–Supportive–Evidence and the depth score 'three'. In this way, all sequences of argument elaboration are tallied for their depth. Besides their depth score every argumentative sequence was scored as 'individual' or 'collaborative', indicating whether a sequence was composed by one student or composed by two students in collaboration.

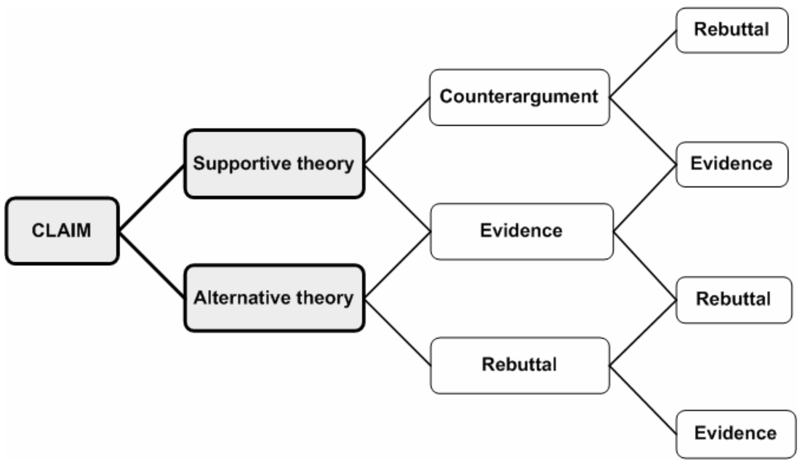


Figure 3. Argumentative activities

The quality of argumentation in the argumentative texts written by the dyads was examined in order to determine whether different modes of communication during the discussion phase resulted in different quality of argumentation in the text. For this purpose, an instrument was developed which assessed the quality of grounds used in the text and the conceptual quality of arguments used in the text. The instrument was based on the work of Clark and Sampson (2005) and Schwarz et al. (2003). The quality of grounds referred to the way students used evidence for forming their opinions. It is comparable to what Schwarz et al. calls the acceptability of an argument (i.e., the degree of realism and logical structure of an argument). Conceptual quality of arguments referred to the conceptual adequacy of arguments and counterarguments in the context of GMOs. A driving question in this respect was: Do students include correct concepts and information in their argumentation?

Quality of grounds was measured on a 4-point scale, with 0 indicating no grounds for the argument used, 1 indicating using a short explanation as a ground, 2 indicating that an elaborated explanation or example was used as a ground, and 3 indicating explicit reference to empirical data or everyday experiences as a ground. The conceptual quality of the arguments was also measured on a 4-point scale, with 0 indicating that the argument only contains conceptual incorrect components and 4 indicating that the argument contained several conceptual correct components. A component was considered incorrect when it did not correspond to the given information sources.

Results

Task Acts in discussion

The mean length of the protocols in both conditions differed significantly, $t(37) = 8.10$, p = .00. In the synchronous chat condition the protocols had an average of 246.47 (*SD* = 88.16) units of meaning (i.e., utterances) and in asynchronous discussion board condition the protocols had an average of 72.15 (*SD* = 37.87) units of meaning. Because of this significant difference proportions for the different Task Acts were compared instead of the frequencies of Task Acts.

Figure 4 shows the proportions of the different Task Acts. Because the dependent variables of the Task Acts were correlated and showed many outliers, Mann-Whitney *U* tests were performed. A Mann-Whitney *U*-test is the nonparametric counterpart of the independent samples *t*-test and robust for outliers and violation of the assumption of normality. Mann-Whitney *U*-tests showed significant differences ($\alpha = .01$, due to Bonferroni correction) between the chat-condition and the discussion board condition for the variables outside activity ($U = 80, p = .00$), social relation ($U = 44$, $p = .00$), task management ($U = 93$, $p = .01$), and argumentative activity ($U = 24$, $p = .00$). Students communicating by chat talked more about things not related to the task ($M = .06$, $SD = .08$) and their social relation ($M = .09$, $SD = .09$) during collaboration than students in discussion board condition ($M = .01$, $SD = .02$, and $M = .02$, $SD = .02$, respectively). Along with this, students in chat condition chatted more about the way they had to accomplish the task ($M = .51$, $SD = .13$) than students using the discussion board ($M = .34$, $SD = .20$). On the category of argumentative activity it was the other way around, with students communicating by discussion board acting more on the argumentative level ($M = .44$, $SD = .22$) than students using the chat ($M = .14$, $SD = .11$).

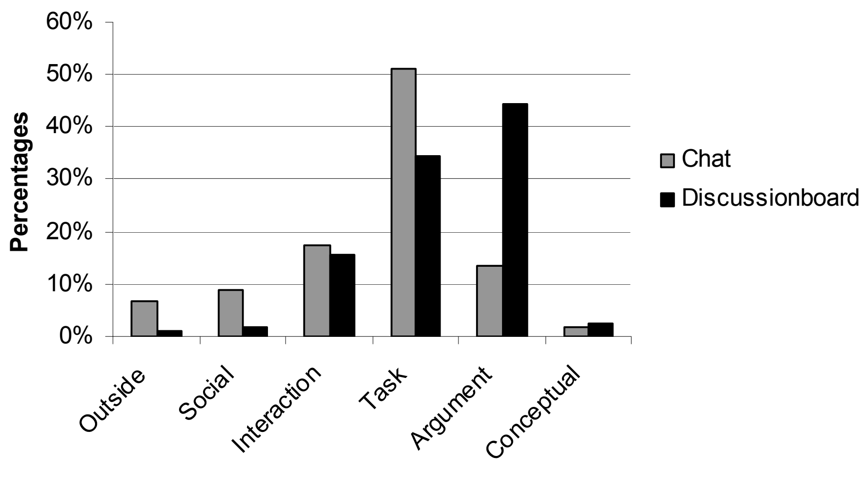


Figure 4. Task acts in percentages for both chat and discussion board condition

Argumentative Activity in discussion

The next step was the analysis of the Task Act category Argumentative Activity. Exploration of the different argumentative acts showed that almost all acts are non-normally distributed variables with many outliers. Transforming variables did not lead to normality, so Mann-Whitney U tests were also carried out on the proportions of these data. The Bonferroni correction set the alpha value again on .01. Table 2 summarises the results of these tests. The Mann-Whitney *U*-tests showed that students communicating asynchronously through the discussion board produce significantly more evidence and alternatives and that there is a trend towards using more rebuttals. Students communicating via chat show a trend towards checking their partner's contributions (verifying).

Table 2

Results of Mann Whitney U Tests:

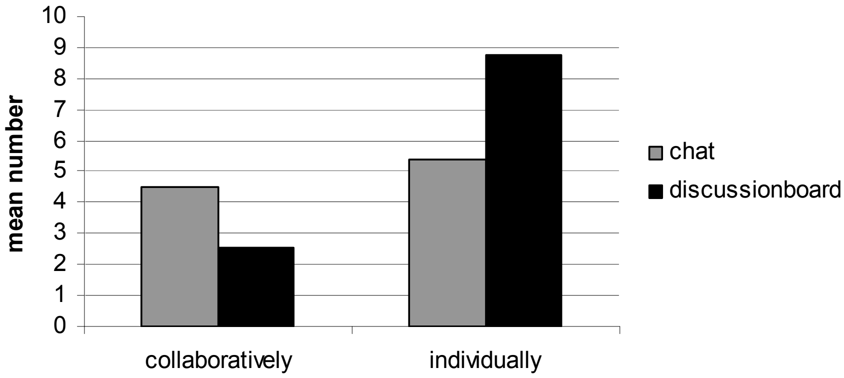
Comparing the Proportions of Chat and Discussion board conditions

	Chat condition (N = 20)		Discussion board condition (N =19)		Mann Whitney U		
	M	*SD*	*M*	*SD*	*U*	*z*	*p*
Claims	.13	.07	.11	.10	141.0	-1.377	.09
Supports	.19	.09	.14	.10	139.0	-1.434	.08
Alternatives	.09	.07	.16	.11	110.5	-2.235	.01
Counters	.04	.04	.03	.04	166.5	-0.695	.26
Rebuttals	.10	.11	.15	.10	129.0	-1.729	.05
Evidence	.14	.09	.22	.10	108.5	-2.291	.01
Verifying	.11	.10	.06	.06	121.5	-1.933	.03
Agreeing	.14	.08	.12	.13	145.5	-1.252	.11

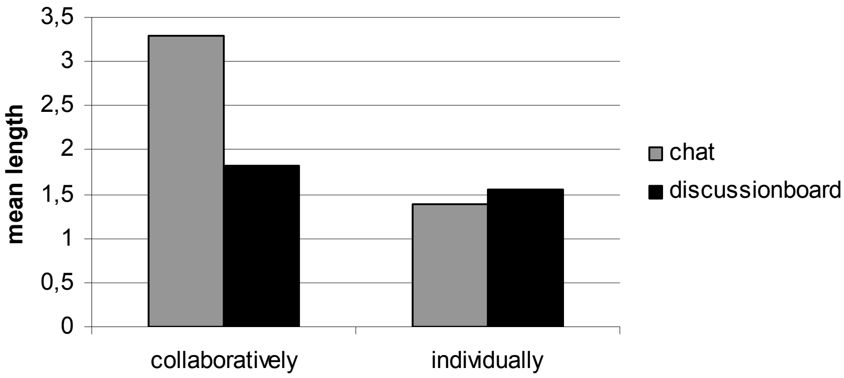
Note. *P*-values are onetailed

*p < .01.

Breadth and depth of discussion
The last step with respect to the analysis of interactive argumentation was the determination of the breadth and depth of discussion. Figures 5a and 5b show the breadth and depth of the argumentative sequences.



5a breadth (number of sequences)



5b depth (mean length of sequences)

Figure 5a and 5b. Number of argumentative sequences (breadth) and mean length of argumentative sequences (depth) in discussion phase

As stated, distinction is made between collaboratively and individually constructed argumentative sequences. A collaborative sequence is constructed by both students, while an individual sequence is constructed by just one of the students. Exploration of the total number of argumentative sequences (breadth) and the mean length of argumentative sequences (depth) showed non-normally distributed variables with many outliers.

According to the breadth of discussion, Mann-Whitney *U*-tests showed that there was no difference in the total number (breadth) of argumentative sequences between chat and discussion board, $U = 149.5$, $p = .13$. Distinguishing between collaboratively and individually constructed argumentative sequences it appeared that the total number of collaboratively constructed argumentative sequences was higher for chat ($M = 4.63$, $SD = 3.27$) than for discussion board ($M = 2.40$, $SD = 3.97$), $U = 86.5$, $p = .00$, while the individually constructed argumentative sequences showed the other way around. Students using the asynchronous discussion board produced more individually constructed argumentative sequences ($M = 9.00$, $SD = 6.17$) than students using the synchronous chat ($M = 4.74$, $SD = 3.28$), $U = 109.5$, $p = .01$.

According the depth of discussion results showed that the mean length (depth) of all the argumentative sequences in the chat condition was significantly greater ($M = 2.52$, $SD = 0.84$) than in the discussion board condition ($M = 2.52$, $SD = 0.84$), $U = 98$, $p = .01$. This difference was mainly due to the significant difference between chat ($M = 3.44$, $SD = 1.57$) and discussion board ($M = 1.74$, $SD = 1.86$) in the length of the *collaborative* sequences, $U = 102.0$, $p = .01$. Students using the synchronous chat constructed relatively longer sequences compared to students using asynchronous discussion board.

Quality of grounds and concepts in the argumentative texts

To establish whether there were differences in text quality between the synchronous and asynchronous condition a MANOVA was performed on the two conditions and the variables quality of grounds and quality of concepts, to detect the main differences on the quality of grounds and concepts of the texts. This analysis revealed an overall significant difference, $F(2, 38) = 2.50$, $p = .05$, $\eta^2 = 0.12$ which was due to an univariate effect on the quality of concepts ($F(1, 39) = 5.13$, $p = .05$, $\eta^2 = 0.12$). Students in the discussion board condition wrote conceptually better texts (*M* = 1.56, *SD* = 0.42) than students in chat condition (*M* = 1.31, *SD* = 0.30). Another MANOVA on the quality of concepts in the different argumentative acts, supportives, alternatives, counters, and rebuttals revealed an overall significant difference, $F(4, 36) = 2.10$, $p = .05$, $\eta^2 = 0.19$ and univariate statistics showed significant differences on the variables supportives ($F(1, 39) = 3.23$, $p = .04$, $\eta^2 = 0.08$) and rebuttals ($F(1,39) = 3.78$, $p = .03$, $\eta^2 = 0.09$). Students using a discussion board used more correct concepts in their supportives (*M* = 7.62, *SD* = 3.07) and rebuttals (*M* = 5.33, *SD* = 3.02) than students using chat (*M* = 6.55, *SD* = 4.00; *M* = 4.95, *SD* = 5.22).

Conclusion and discussion

Synchronous and asynchronous CMC was compared with respect to their influence on the way students argue in dyads and the quality of their argumentative texts. It was hypothesised that a synchronous mode of communication supports students in convergence processes. In other words, it supports the processes of collaboratively deepening a subtopic in the space of debate. An asynchronous mode of communication was thought to support conveyance processes, which entails the broadening of the space of debate, i.e. searching for different points of view.

Results showed that students discussing the topic of GMOs through a discussion board produced relatively more argumentative activity compared to students communicating by chat. This group also produced more alternative theories and use of evidence. However, despite this occurrence of more argumentative activity, more alternative theories and more use of evidence in the discussion board condition, students in the synchronous chat condition discussed the space of debate more in depth (i.e., on average had longer argumentative sequences), thus they elaborated more on the same supportive or alternative theory. This confirmed the first hypothesis, namely that convergence processes such as negotiation and elaborating on an argument is supported by synchronous CMC with high immediacy of feedback and low parallelism.

The second hypothesis that conveyance processes such as gathering different points of view are supported by asynchronous CMC due to low immediacy of feedback and high parallelism was partly confirmed by the results. Students communicating through asynchronous discussion board did construct more individual argumentative sequences. However, for the collaboratively constructed sequences it was the other way around. Students communicating through synchronous chat did construct a higher number of collaborative sequences compared to the students in the asynchronous condition.

The third research question dealt with whether there is a difference in the quality of a subsequently written argumentative text depending on whether students made use of the synchronous or asynchronous CMC. The hypothesis was that students who discuss more deeply will write texts with a higher quality of evidence and will make more accurate use of concepts. The results showed the opposite effect for the quality of concepts in the argumentative texts. Students who discussed the subject of GMOs with the help of a discussion board used more correct concepts in their arguments than students who discussed GMOs with the help of a chat box.

In contrast to earlier findings that synchronous CMC is not inducing deep learning and is less compatible with complex communication tasks, these results show that synchronous CMC has the ability to stimulate a deeper discussion compared to asynchronous CMC. It appears that the affordance of immediate feedback - the possibility of reacting directly on what another student is saying - stimulates students to negotiate and argue with each other. This can be explained by the way we analysed argumentation. Looking at the results for task acts, we see a greater occurrence of argumentative activity in discussion board and lesser occurrence of social talk and task management. This is in accordance with the results of other studies (e.g., Van der Pol, Admiraal, & Simons, 2006) which found meaning-oriented and efficient communication in asynchronous communication. However, when analyzing argumentation further into different argument skills and argumentative sequences, the picture is changing. Despite more social talk and talk about the task on hand, synchronous communication relatively supports the discussion of an issue in a more broad and deep way compared to asynchronous communication.

However, despite deeper conversations by synchronously communicating students, this did not lead to more accurate concepts in the argumentative text. It appears that students communicating through a discussion board have a better and more accurate understanding of the different concepts in the topic of GMOs. However, it is probable that this accuracy in the final texts is not due to the breadth and depth of the discussions, but rather the effect of the possibility to read and use information sources more carefully before posting messages because of the time delay.

Some possible limitations of this study should be considered. First, the results raise some interesting issues concerning how students use different media. It is possible that students use media in such a way that they do not make optimal use of CMC's affordances. For example Van der Pol (2002) shows that it is very difficult for students to react in a specific and relevant way to the messages of other students in a discussion board despite the time available for reflection due to the asynchronicity of communication. There is little research about how students use rehearsability and reprocessability in asynchronous CMC. It appears that rehearsability helps students processing information in a message, but the question remains as to whether they take their time to reflect on the messages of their partners and what kind of thinking processes take place during reflection on messages.

Second, the question arises as to whether comparing synchronous and asynchronous CMC is an adequate and valuable approach. Johnson (2006) concludes in a review of recent research on synchronous and asynchronous text-based CMC that both forms of online discussion have advantages and that there is evidence that both forms contribute to student learning outcomes. Johnson argues that systematic and objective research on the ways in which synchronous and asynchronous online discussion can be combined is required. It is possible that the effectiveness of different media is mediated by individual differences variables, such as the experience that students have had with synchronous and asynchronous CMC and how they use it. The fact that in this study, students argue deeply in synchronous CMC can be due to the experience they have with chatting as shown in the research of Valkenburg and Peter (2007).

Finally there are some methodological issues. The outcomes of this study are limited because the students used two different programs in the synchronous and asynchronous condition. In the synchronous conditions they used TC3 and in the asynchronous condition Blackboard Academic Suite™. Also, the situation in which students were during communication was different. Students in the synchronous condition were chatting during class, and so forced by the situation to communicate, while students in the asynchronous condition had to motivate themselves to communicate with each other in their own time. More research is needed where situation and software is really comparable. For example, research is possible in which one condition uses the chat facility of Blackboard Academic Suite™ and the other condition the discussion board. Both conditions can be asked to do the tasks at home in their own time. Complementary, it is very important to measure the total amount of time students spent communicating, which was not achieved in this research. Along with this, in this study the quality of argumentation during discussion is measured with breadth and depth of the argumentative sequences. However no relation is found between the breadth and depth of the sequences during discussion and the argumentative quality of the final product. This raises the question of whether the measurement of breadth and depth is sensitive to differences in the quality of argumentation or is measuring frequency differences in the argumentative sequences. In future research it may be a suitable approach also to look at the quality of grounds and concepts in the argumentative sequences and try to find out whether students construct specific sequences in different forms of CMC.

Chapter 5

Making students aware of their controversies and the role of epistemological beliefs during interactive argumentation [*]

Abstract

In this study the diversity of outcomes within argumentative learning dialogues is examined. Students that are instructed to argue together in small groups in order to solve a complex scientific problem (in the social realm) display a large variety of argumentative activities, even when supported by dedicated technology. Variations in the use of supporting tools or the instructional scenario only explain a small amount of this variance. We explore the roles of epistemological beliefs, argumentative knowledge, and the effects of raising awareness of controversy, on the ways students argue together in a CSCL setting. After pre-tests, assessing epistemological beliefs and knowledge about argumentation, 25 dyads of secondary school students held discussion on genetically modified organisms in a designed sequence of argumentative activities: reading source materials, writing and comparing lists of relevant arguments, discussing a case of sending modified grain to Ethiopia, answering awareness raising questions, discussing a case about genetically modified poultry, and answering post-test argumentative questions. Dialogues were analysed in terms of task acts: frequency of specific argumentative contributions and breadth and depth of discussion. Relations between post-test scores, pre-test-scores, and dialogue analyses were examined by using multilevel analyses. Outcomes reveal significant effects of awareness-raising on the depth of discussion. Epistemological beliefs and argumentative knowledge only have a small positive explanatory effect on the frequency of rebuttals. Their effect on the individual post-test scores was however, much larger. Implications for the explanation of diversity in argumentative learning interactions are discussed..

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[*] Munneke, L., Andriessen, J., Kirschner, P.A., & Kanselaar, G. (2007). *Making students aware of their controversies and the role of epistemological beliefs during interactive argumentation.* Manuscript submitted for publication.

This article reports a researching on one of the main skills in critical thinking and reasoning, - interactive argumentation (Chinn & Anderson, 1998)-, in a computer-supported collaborative learning (CSCL) setting. There is a growing body of research into the way CSCL can support the argumentation processes between students during collaborative problem-solving, covering issues that concern the affordances and constraints of using certain graphical argumentative tools and computer-mediated communication (CMC) (e.g., Andriessen, Baker, & Suthers, 2003; McAlister, Ravenscroft, & Scanlon, 2004; Suthers & Hundhausen, 2003; Van Amelsvoort, 2006; Veerman, 2000).

However, despite some positive effects of specific tools and CMC on the way students argue together there is an enormous variety in the elaborateness of discussions between student dyads (Munneke, Van Amelsvoort, & Andriessen, 2003[†]; Munneke, Andriessen, Kanselaar, & Kirschner, 2007a[‡]; Van Amelsvoort, 2006). We think this stresses the importance of examining other important variables along with the CSCL environment. In a study about students' dispositions to engage in argumentation Nussbaum and Bendixen (2003) argue that fostering stimulating classroom environments for argumentation may require explicit attention to a theoretical framework of individual differences that affect students' ways of arguing in addition to looking at instructional and environmental variables. The study presented here aims at explaining the variance in the way students argue together in a CSCL environment in terms of epistemological beliefs and argumentative knowledge (individual variables) and raising awareness about controversies (instructional variable). Below we describe the rationale for using these variables. In order to that, we first elaborate on the relation between argumentation and learning as we see it.

What about argumentation and learning?

In this study we see students' learning as knowledge construction. During collaborative events, students expand, refine, and construct their

† This is Chapter 2 in this dissertation

‡ This is Chapter 3 in this dissertation

own knowledge on a certain topic. This is an epistemological and social process with argumentation as one of the core activities, a process in which claims can be shaped, modified, restructured, and at times abandoned (Andriessen, et al., 2003; Petraglia, 1998; Schwarz, Neuman, Gil, & Ilya, 2003). Emphasis is put on argumentation as a collaborative reasoning-process, because research has demonstrated the superiority of collaborative over individual reasoning and argumentation (e.g., Kuhn, Shaw, & Felton, 1997; Roschelle & Teasly, 1995; Schwarz, Neuman, & Biezuner, 2000). Chinn and Anderson (1998) talk in this context about interactive argumentation to characterise the discussions where students collectively search for reasons and evidence, which sometimes leads them to changing their minds.

Despite of the empirical link between interactive argumentation and learning, students' discussing and talking about a topic is not automatically sufficient for individual knowledge growth. There have been suggested several possible collaborative activities that can govern construction of knowledge as interplay between interpersonal and intrapersonal processes. The first one is justifying claims which can promote cognitive learning processes such as self-explanation and elaboration (Baker, 2003). A second activity is giving counterarguments, which can stimulate knowledge building because when participants give counterarguments, they must first examine their own views and initial arguments and need to negotiate with each other about the meaning of concepts and information (Leitão, 2000). Students, while arguing about a topic, then reach a broader and deeper understanding of this topic (Munneke et al., 2007a; Van Amelsvoort, 2006) extending what we call the breadth and depth of the space of debate. To have an optimal effect on learning, students must extensively explore the space of debate with respect to both its breadth and its depth. Argumentation supports this exploration, by activities such as supporting opinions with arguments, giving evidence for these arguments, exploring alternative theories, and thinking about a way to rebut these alternatives (Kuhn, 1991; Voss & Means, 1991).

Supporting interactive argumentation with CSCL

Many studies have shown that people of all ages have difficulties while arguing in the context of learning. The ability to argue is not a mysterious talent people are born with, but is something people can learn and there are certain problems that can be identified, examined, and/or supported by instruction and computer-based representational tools. In this line, Osborne, Erduran, and Simon (2004) emphasise, on basis of the work of Kuhn (1991) that the use of a valid argument is acquired through practice and must explicitly be taught through suitable instruction, task structuring, and modelling. Stein and Albro (2001) found that children understand and generate the principle components of an argument by the age of three, but that this does not mean that they really understand what an opponent is saying. In a life span study of argumentative skills Kuhn (1991) found that people have many difficulties generating genuine evidence for their theories, generating alternative theories, and giving counterarguments and rebuttals. In particular the deficiency in these last two skills can be problematic while arguing to learn, because counter-argumentation is assumed to be one of the catalysts for learning processes.

To overcome these problems, several researchers have tried to support argumentation with representational tools such as Belvédère (Paolucci, Suthers, & Weiner, 1995), SenseMaker (Bell, 2004), DREW (Van Amelsvoort, Andriessen, & Kanselaar, in press), pro-con tables (Schwarz et al. 2003), and matrices (Suthers & Hundhausen, 2003). Most of these representational tools are integrated into CSCL environments where students communicate through chat and, supported by these tools, can construct their own visualisation of the discussion. Main assumptions for support of representational tools are that the tools help students to stay focused on the task, that students are stimulated through the tools to make their opinions and arguments about a topic explicit, and that such tools can support the maintaining of consistency, accuracy, and plausibility of argumentation (Bell, 2004; Schwarz et al., 2000; Van Bruggen, Boshuisen, & Kirschner, 2002). An empirical base for these assumptions is growing, but is still inconclusive. Research by Suthers and Hundhausen demonstrated that representational tools can stimulate students to elaborate on previously presented information and to focus more on providing deliberate evidence, but that these results can not - without problems - be generalised from a laboratory to a classroom setting due to many other variables that play a role in such contexts. Van Amelsvoort et al.'s study into the way DREW stimulated students in their discussion, showed that students use counter-argumentation and rebuttals quite regularly, but that they do not explicitly structure and relate the arguments that they use. In addition, in Munneke et al.'s (2007a) study comparing argumentative diagrams with pro-con lists, the authors found that students using a diagram discuss a complex topic more elaborately, but that this elaboration is done only in the diagram. There was only a limited amount of elaboration in the concurrent chat and the use of diagrams even seemed to inhibit interactive argumentation in the chat. They also found that measuring the influence of representational tools is very complex due to the influence of other variables such as task and instruction.

A second line of research into supporting interactive argumentation with CSCL deals with the way the design of specific kinds of CMC affects dialogic argumentation. For example, Baker and Lund (1997) found that flexible structuring the CMC with sentence-openers promotes more reflective interaction during discussion. Another example is the research of Munneke, Andriessen, Kanselaar, and Kirschner (2007b)[§] into the differences between synchronous (i.e., chat) and asynchronous (i.e., web forum) CMC for interactive argumentation. This study showed synchronous CMC to be better in promoting the exploration of the depth of the space of debate as compared to asynchronous CMC, probably because of the immediacy of feedback provided by chat. However, despite some clear results of the facilitating effects of CMC on argumentation there still was a great amount of unexplained variance between collaborating groups of students.

Student behaviour during interactive argumentation – argumentation frames

To understand more about the unexplained variance between student dyads in the way they argue during collaborative problem-solving, Munneke (2004) carried out an in-depth case study in which she

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[§] This is Chapter 4 in this dissertation compared a dyad with little breadth and depth in their discussion to a dyad with great breadth and depth in their discussion. This comparison showed that a possible explanation for the differences between students could be the way students tackle controversies during discussion. The dyad displaying little breadth and depth solved their conflicts in a way that is described by Chan (2001) as "stonewalling" and "patching". They solved a conflict of opinions quickly by ignoring differences or exchanging some arguments and making a quick decision without really considering the implications for their own opinions. The dyad displaying greater breadth and depth in their discussion solved controversy in a way which Chan describes as "problem-centred inquiry". Students really tried to solve the given problem by discussing the given information. Independent of the use of representational tools and certain kinds of CMC, students seems to differ in the way in which they are willing to argue about a topic. This is confirmed by De Vries, Baker, and Lund (2002) who conclude, after a study into the factors that must be taken into account in designing a CSCL situation, that "putting students together with different viewpoints is not a sufficient condition. Students must notice their differences and want to discuss them" (p. 98).

In this line, Munneke et al. (2007a) also showed that instructions to students to be critical, to use multiple perspectives, and to elaborate, do not always have the intended effect on their argumentation. Many students exhibit the problems found by Kuhn (1991), namely that they use a lot of pseudo evidence and have less attention for the opponents' views. Especially counter-argumentation (i.e., thinking about what an opponent would say against their supportive theory) seems very difficult to achieve. In a study on the effects of certain instruction on the nature of students' interactive argumentation, Nussbaum (2005) points out that an instruction must trigger the appropriate argument frame, which represents a particular type of argumentative discourse (e.g., persuasive dialogues, inquiries, deliberations, and negotiations). It is possible that students interpret an instruction in a different way than intended and use more adversarial frames instead of the negotiation frame. More attention to this instruction and making students aware of the kind of argument frame that is intended (i.e., negotiating controversies) may have a positive effect on broadening and deepening the space of debate during discussion.

Student behaviour during interactive argumentation – epistemological beliefs

Along with attention for precise instruction, Nussbaum and Bendixen (2003) advocate more attention for individual factors related to argument avoidance. In a study about students' dispositions to engage in argumentation, they conclude that individual epistemological beliefs are related to argument avoidance during discussion. This kind of research on the effects of epistemological beliefs on learning and cognition has recently been stimulated to a significant degree by a review article of Hofer and Pintrich (1997) and a later volume about epistemological beliefs and learning (Hofer & Pintrich, 2002). They assume that the way students view knowledge (i.e., as a set of accumulated facts or as integrated sets of constructs) and see themselves as learners (i.e., as passive receptors or as active constructors of knowledge) affect the comprehension and interpretation of new information. A number of studies have been carried out to verify this link between epistemological beliefs and learning. They show that thinking about knowledge as absolute, stable, and transmissible, is associated with lower performances in ill-defined problem solving (Schraw, Dunkle, & Bendixen, 1995), transfer of learning (Jacobson & Spiro, 1995), and conceptual change (Dweck & Leggett, 1988; Sinatra & Pintrich, 2003).

Epistemological beliefs and the exploration of the space of debate

Along with studies into the link between epistemological beliefs and learning there is also attention for the specific link between epistemological beliefs and argumentation (e.g., Kuhn, 1991; Mason & Boscolo, 2004; Mason & Scirica, 2006). Conceptually, the development of epistemological beliefs and understanding can be assumed to be critical for learning through interactive argumentation. It is only upon attaining an advanced level of epistemological beliefs that justification of claims, exploring alternative theories, and giving counterarguments and rebuttals, becomes a meaningful enterprise. If facts can be ascertained with certainty and are readily available to anyone seeking them - as people with simple epistemological understanding believe - there is no point expending the intellectual effort that the justification and debate of claims and arguments entails.

One of the studies Hofer and Pintrich (1997) review is Kuhn (1991) who identified a relation between the level of epistemological belief and argumentation skills. She developed this relation further into a developmental model of epistemological thinking (Kuhn, Cheney, & Weinstock, 2000) where "the developmental task that underlies the achievement of mature epistemological understanding is the coordination of the subjective and objective dimensions of knowing" (p. 310). At the absolutist level of epistemological development, the objective dimension of knowledge dominates while subjectivity is excluded. Knowledge comes from external sources and consists of an accumulating body of facts that are correct or incorrect in their representation of reality. At the multiplist level, people (often within adolescence) progress to an attitude of 'everyone can be right'. Knowledge now consists of uncertain opinions generated by all sorts of people and becomes freely chosen and accountable only by the owners of those opinions. All opinions are equally correct and people at the multiplist level of epistemological belief see no reason for discriminating between competing knowledge claims. At the evaluativist level, which people reach with much more effort than the multiplist level, the objective dimension of knowing is reintegrated and people see knowledge as generated by human minds and susceptible to evaluation. Knowledge consists of judgements that can be evaluated and compared according to argumentation criteria and evidence. Following Kuhn's model, Mason and Scirica (2006) performed a study on the effect of epistemological understanding on students' argumentation skills. They found an association between generating valid argumentation and higher levels of epistemological understanding. However, this association was established at the individual level and does not fully answer the question as to whether and how epistemological beliefs affect interactive argumentation.

Although Kuhn (1991) did not research the influence of epistemological beliefs in a dialogical argumentation setting, the model Kuhn et al. (2000) developed, gives some indications for the association between different levels of epistemological development and the way people would argue during controversies. Kuhn et al. indicate that people at an absolutist level of epistemological understanding see arguing as a way of comparing assertions to reality and determining their truth and falsehood. If there is conflicting information, they resolve the matter by locating the facts. Finding a source to support an assertion is enough and questioning evidence is not necessary. So, supporting a claim with one supportive theory (low breadth) is, in such a case, enough and when necessary they give some evidence from arbitrary sources (low depth). For people at a multiplist level, arguing is irrelevant. Everybody can have their own opinion so when someone says something is 'a' and another thinks it is 'b', then that is acceptable. During interactive argumentation it can be expected that everybody gives several supportive theories (medium breadth) for their own claims, while those supportive theories are not questioned or countered (low depth). For someone at evaluativist level, arguing is the vehicle that promotes deeper understanding of a topic. Next to supportive theories, alternative theories are explored and eventually rebutted to come to a balanced overview of the topic (great breadth) and evidence given for supportive theories is questioned and rebutted (great depth).

Research questions of this study

As stated, earlier research found some effects of variables at the instructional level and through the use of computer environments on both argumentation breadth and depth. However, these variables only explain a limited amount of the variation in argumentative skills between dyads of collaborating students. The aim of this study is threefold. Firstly, in accordance with the results of De Vries et al. (2002) and Nussbaum (2005) on the necessary awareness of students of conflicting information during discussion and the kind of argument frame that is asked for, this study examines whether making students aware after a first discussion task will have an effect on the way they argue together in a subsequent task. Secondly, this study examines the contribution of the level of epistemological beliefs on different aspects of argumentation during collaboration and the breadth and depth of individual argumentation after the collaborative task sequence. Thirdly, this study also takes into account the extent to which students are able to identify structures of argumentation. When a student is not able to identify claims, supportive theories, evidence and other parts of an argumentation it can be difficult to produce these kind of elements during discussion (Oostdam, 1990).

In summary, this study attempts to answer the following questions:
(1) To what extent do students improve interactive argumentation when made aware of their controversies?
(2) Is there a relationship between epistemological beliefs held by students and argumentative activity, taking into account the argumentative knowledge of students?
(3) Is there a relationship between the breadth and depth of the discussion in dyads and the breadth and depth of individual argumentation after the collaborative task sequence, taking into account the epistemological beliefs and argumentative knowledge of individual students?

Method

Participants

Sixty students, 31 girls and 29 boys (aged 15 to 17) from two upper secondary schools in the Netherlands participated in this study. Students attended three different classes during Dutch language or biology lessons. Dyads of students were heterogeneous with respect to gender and randomly formed within classes, with each student working at her or his own computer. The compatibility of dyads was checked by the teachers in order to avoid dyads who really could not work with each other due to a problematic collective social history. Dyads that differed in composition during the study due to the absence of students were excluded from the sample. This resulted in the statistical analyses of 25 dyads (50 students).

Task and procedure

Dyads participated in an argumentative collaborative task on the topic of genetically modified organisms (GMOs), which was chosen in collaboration with involved teachers. The topic of GMOs is a complex one with many stakeholders which gives students the opportunity for serious and elaborate discussion. The task sequence took six lessons of 45 minutes each and roughly consisted of a preparation, discussion and closing phase. Details of the six lessons are described in Table 1.

During preparation phase, each individual student in a dyad received a different set of ten sources to read. These sources were complementary and contradictory, following the ideas of Johnson and Johnson (1995) about positive interdependence being a crucial element for collaborative learning and deliberate discourse during discussions. The sources were popular easy-to-read texts of approximately 200 words each that reflected the points of view of different stakeholders in the topic of GMOs. To provoke thorough reading students were asked to generate a comprehensive list of all arguments for and against GMOs that they read about. In the next lesson, each dyad was asked to compare and discuss lists with their partner's to make them aware of contradictions in the sets of sources. This assignment took place in the computer environment so that the students could also get used to working with the environment.

The discussion phase consisted of the dyads discussing two specific cases about the use of GMOs. The first case was about whether to send genetically modified grain to Ethiopia and the second case was about whether to genetically modify chickens for more flesh, more eggs, and less behavioural problems when confined in cages.

In the closing phase, students participated in a whole-class debate. The class was divided into two groups of debaters and observers that switched roles during the lesson. The debaters were divided in a pro and con group and were given the assignment to win the discussion. Observers were given the assignment to assess the way the debaters presented their arguments and evidence. Students were graded on the basis of these assessments and teacher's observations of students. We choose to close the task sequence in this way for two reasons. The first reason was to motivate students to evaluate arguments in a thorough way Veerman and Treasure Jones (1999) recommend having a joint product as the goal of a discussion task. The second reason was to introduce a competitive element which would stimulate students to argue in a more thorough way during the discussions in dyads (Johnson & Johnson, 1995).

Table 1
Task Sequence, Students Activities, and Instruments

Hour	Phase	Student activities	Instruments
1	Preparation	Introduction of the task Introduction on argumentation	Questionnaires: Epistemological Beliefs Argument. Knowledge
2	Preparation	Introduction on the topic with video Reading information sources Making list of arguments	
3	Preparation	Introduction to computer environment Dyads compare and discuss individual lists of arguments in computer environment	
4	Discussion	Dyads discussed Case 1	End of lesson: awareness raising questionnaire
5	Discussion	Dyads discussed Case 2	End of lesson: individual posttest on argumentation in the topic of GMOs
6	Closing	All students participated in a whole-class debate.	

CSCL environment –DREW

Students worked on the task sequence with help of the interactive web-based tool DREW developed during the IST project SCALE (Corbel et al., 2002). This tool enables students to interact with each other while working at different physical locations (see Figure 1). Students can exchange and discuss their ideas in a chat box (left hand frame) while they can support their discussion by creating an argumentative diagram (right hand frame) The argumentative diagram gives students the opportunity to create boxes with text and to draw arrows to reflect relations between the boxes. DREW was embedded in a pedagogical website which contained the different assignments students had to accomplish for this study.

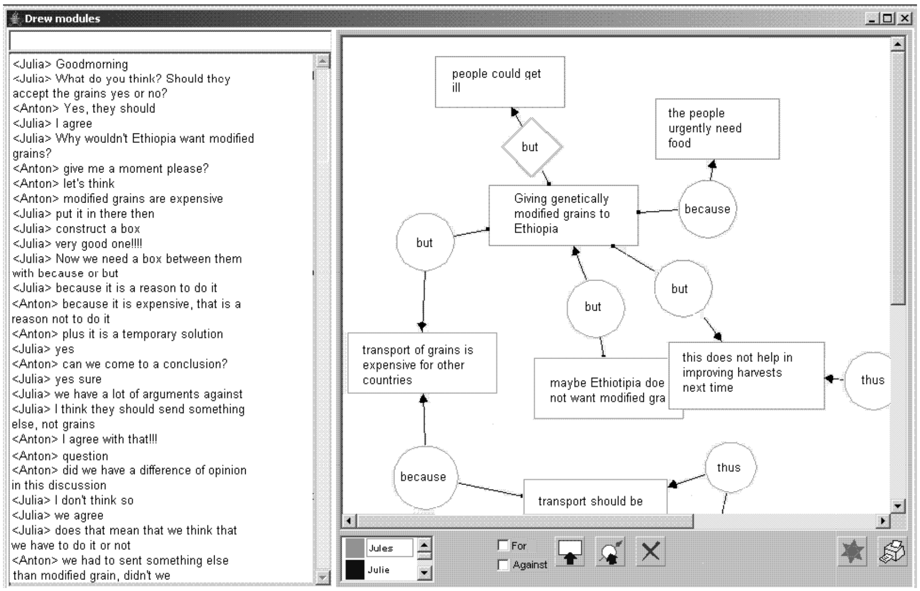

Figure 1. Screen capture of the computer tool DREW

Design

As described, students were asked to discuss two different cases about GMOs. In order to answer the first research question of whether students improve their interactive argumentation when made aware of controversies, students were asked to complete a questionnaire immediately after discussing the first case (see Table 1). In this questionnaire, they were individually asked to indicate their controversies and the way they solved them. Due to software limitations, the order of the cases could not be randomised. Due to the limited number of participants we choose not to use a control group without the awareness-raising questionnaire. Not using a control group makes interpretation of the results more complicated due to the effect of experience with tool and task. To handle this problem, analysis of the data will also focus on the occurrence of controversies in the different cases.

To answer the second and third research question about the relationship between epistemological beliefs and interactive argumentation taking into account argumentative knowledge, all participants were administered a number of instruments and questionnaires at different moments during the study (see Table 1). During the first lesson students completed two questionnaires measuring their epistemological beliefs and argumentative knowledge. Immediately after discussing the second case a post test was administered on the number of elaborated argumentation individual students could generate after the task. These specific measures are described below.

Measures of epistemological beliefs

Epistemological beliefs were measured with the 15-item instrument developed by Kuhn et al. (2000). This instrument was developed to identify the transitions from absolutist to multiplist, and from multiplist to evaluativist positions in different judgment domains (i.e., judgments of personal taste, aesthetics, values, truth about the social world, truth about the physical world). It is assumed that an individual can hold different epistemological beliefs in different judgment domains. Each judgment domain is measured with three pairs of contrasting statements attributed to two individuals. An example of a pair of statements in the judgment domain of truth about the physical world is "Robin believes one book's explanation of what atoms are made up of. Chris believes another book's explanation of what atoms are made up of". Following each pair of statements the question "Can only one of their views be right, or could both have some rightness?" was posed. Response options for this question were as follows: "Only one right; both could have some rightness". Students were asked to circle one of the response options. The immediately following second question was "If both could be right: could one view be better or more right than the other?" (quoted from Kuhn et al., 2000, p. 316-317).

For each of the judgment domain scales the alpha reliability coefficient was computed. The coefficients were .73, .70, .53, .25, and .63 for judgment of personal taste, aesthetics, values, truth about the social work, and truth about the physical world, respectively. Because of the low coefficients in the judgments of truth and values domain also an alpha reliability coefficient on all items was calculated, which was .62. After deletion of 5 items with a low inter-item correlation the alpha reliability coefficient on the remaining 10 items increased to .71 which can be considered as a moderate reliability. With these 10 items a total score on epistemological beliefs was computed which was used in further analyses.

Measures of argumentative knowledge

Oostdam (1990) developed three subtests to measure receptive argumentative knowledge, namely identification of (a) singular argumentation, (b) multiple argumentation, and (c) subordinate argumentation. Because completing all subtests would be too time-consuming participants were given a condensed form of the identification of subordinate argumentation subtest. This subtest was chosen because it measures the extent to which students are able to identify structures of complex subordinating argumentation which is comparable to the active task of arguing about a complex problem and producing claim-supportive-evidence sequences during arguing. Due to the available amount of time, the test was shortened to 20 items in which the positions of the initial point of view (IP), subordinate point of view (SP), and the sub argument (SA) varied. The next sequences were included in the test: IP-SP-SA, SA-SP-IP, SP-SA-IP, and IP-SA-SI. Each sequence was represented by five items. Students were asked to underline the segment of a topic that was both opinion and argument. An example of an item is: He is ill-mannered. A while ago I heard him call the waiter names in a restaurant. I don't want him to attend your birthday party. The underlined part is the component that is both opinion and argument. To demonstrate how the questions must be answered some example-items were given. Oostdam found a sufficient reliability (Gulliksen's Split-Half = .86) for the identification of subordinate argumentation test.

Measures of interactive argumentation

In order to measure the interactive argumentation of dyads every utterance and click of the students in DREW was recorded which resulted in integrated chat and activity protocols. Dyads performed different activities during the task, for example reading the sources, discussing the arguments in those sources, and discussing the two cases about GMOs. The data taken up for analysis were the utterances of dyads in chat and the diagram while discussing the two cases during the fourth and fifth lesson of the task. The unit of analysis was a separate utterance in chat, marked by pushing 'enter' or turn-taking. In the diagrams, the units of analysis were the contributions in the boxes. When a contribution contained more parts, each part was coded separately. Also, when students pushed 'enter' in the chat box before ending their message, the two chat utterances were merged. The process of interactive argumentation in these protocols was analysed with help of MEPA (Multi Episode Protocol Analysis; Erkens, 2001).

Measures of individual argumentation after discussion

To measure the effect of the tasks on students' argumentative knowledge after discussing the two cases, a test was partly based on a test described by Schwarz et al. (2003). Students were asked to answer four questions about GMOs in general: (1) Do you think GMOs should be forbidden or allowed?, (2) What reasons can you give that support your opinion?, (3) If your friend does not agree with your reasons, which counterarguments he/she might use?, (4) How could you convince your friend that you are right?. The arguments had to be written down in three columns: the first column for arguments to support the student's opinion, the second column for arguments rebutting their opinion, and the third for arguments to rebut the rebuttals. To calculate a score for the way students answered the questions in the post-test the amount of arguments were multiplied by the amount of columns students could fill for each argument. Thus, when a student could mention two arguments and filled along with the column for the supportive theories also the columns of counterarguments and rebuttals the total score was six.

Table 2
Main Codes for Task Acts

Categories of codes	Description	Example
Outside Activity	Contribution that do not have anything to do with the task.	"How was your weekend?"
Social Relation	Contributions about the st interpersonal relation durin collaboration.	"You're a quick writer!"
Interaction Management	Contributions about interaction itself such as checking presence and turn-taking.	"Wait a minute; I'm going to the bathroom."
Task Management	Contributions about managing the task such as the use of DREW and task goals.	"I'll put this in the diagram."
Argumentative Activity	Contributions concerning claims and supporting/ opposing those claims.	"I'm in favour of GMOs because it can solve the problem of hunger."
Conceptual Activity	Contributions concerning the concepts in GMOs.	"How does genetic modification work?"
Indefinable	Contributions impossible to code	"kdfji"

Coding discussion protocols

An important variable in all the research questions is interactive argumentation which is specified as broadening and deepening the space of debate. In order to measure this, several steps in coding the contributions in the discussion protocols were necessary. A first step was coding the contribution on task acts in order to distinguish between contributions with and without argumentative content. A coding scheme based on the Rainbow framework (Baker, Andriessen, Lund, Van

Amelsvoort, & Quignard, 2007) was developed determining different task acts. This scheme consisted of seven main categories which are explained in Table 2. Task Management was coded in subcategories which were for Task Management: (1) management of the task in general, (2) management of the way DREW works, (3) management of the discussion, and (4) management of the construction of the diagram. For reliability analysis, 10 protocols were scored by two raters. Inter-rater agreement on these 10 protocols was .80 (Cohen's Kappa).

A second step was the analysis of the contributions with argumentative content on the kind of argumentative activity. All argumentative acts were coded on the kind of Argumentative Activity. This coding scheme consisted of eight categories: (1) making a claim, (2) giving a supportive theory, (3) giving a alternative theory, (4) giving a counterargument, (5) giving a rebuttal, (6) giving evidence, (7) verifying (asking for arguments and evidence), (8) agreeing or disagreeing with statements or arguments. Alternative theories are theories that contradict one's original opinion. Rebuttals are arguments that rebut counterarguments and alternative theories. See also Figure 2. The inter-rater agreement on ten protocols was .82 (Cohen's Kappa), which can be considered fairly high.

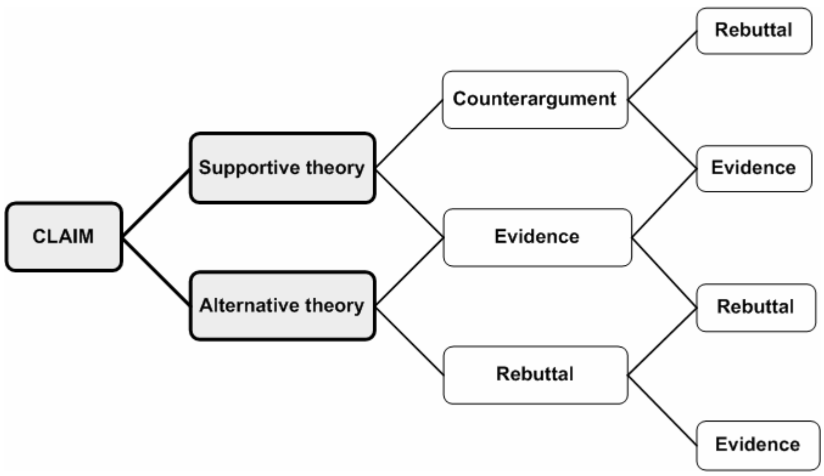

Figure 2. Argumentative Activities

To establish the amount of broadening of deepening a third and last step was the composing of argumentative sequences. To measure the extent to which the topic of GMOs is discussed, sequences were constructed based on student argumentative activity. The breadth of the space of debate is defined as the total number of argumentative sequences (i.e., each new start with a supportive or alternative theory, see Figure 2), while the depth of the space of debate is defined as the mean length of those sequences. A sequence with depth consists of different argumentative acts that deepen the discussion. For example, a dyad had the following conversation:

Aaron: I'm in favour of genetically modifying chickens. (Claim)
Aaron: Eggs laid by GM-chickens are healthier for humans because of less cholesterol in the eggs (Supportive Theory)
Bailey: Yes, but I don't only want to think in favor of humans, what about the chickens they also have the right of taken care of. (Counterargument)
Aaron: It is the chickens' fate to be food. (Rebuttal)
Aaron: Because chickens can't think while humans can. (Evidence)

Aaron puts up a claim which is the starting of an argumentative sequence. He supports his claim with a supportive theory in the subtopic of 'health'. Bailey reacts on this with a counterargument about the rights of chickens followed by a rebuttal of Aaron including a piece of evidence. The result is the sequence of Claim – Supportive Theory – Counterargument – Rebuttal – Evidence (see also Figure 2) which is a sequence of five argumentative turns and a depth score of five. In this way all sequences were evaluated for depth.

Statistical analyses

To answer research question 1, paired t-tests were used to compare the ways of arguing between Case 1 and Case 2. Regression analyses are generally used to identify the hypothesised relations in research question 2 between the independent variables epistemological beliefs and argumentative knowledge and the dependent variable argumentative activity. An important assumption for such kind of analyses is that the sampled units are independent of each other. However, in this research the measurements of the dependent variables are non-independent because students worked in dyads (Kenny, Kashy, & Cook, 2006). The same is true for answering question 3 as to whether there is a relation between breadth and depth of the space of debate and post-test scores. The data sets comprise several types of units of analyses at dyad and individual level. In order to deal with these problems and because dyads can be viewed as groups composed of two persons (Kenny et al., 2006), multilevel analyses were used to examine the relations between variables. Multilevel analysis is a general term referring to statistical methods appropriate for the analysis of data sets comprising several levels of units of analyses, with one single outcome variable that is measured at the lowest level, and explanatory variables at all existing levels (Hox, 2002).

Multilevel analysis involves the estimations of different models which explain the variance of a dependent variable to a different extent. By comparing the deviance of a model with an empty model (i.e, without predictors) a decrease or increase in variance can be calculated. A $\chi2$-test can be used to establish whether the differences between the empty model and model with predictors are significant. Each predictor variable within the model has its own estimated parameter (β-coefficient) which can be tested for significance with a t-test. When such an estimated parameter is significant this means that the variable can be seen as one of the variables that explain the variance of the dependent variable.

Results

Research question 1: improvement of interactive argumentation

In order to determine the extent students improved their interactive argumentation during the task sequence after completing the awareness raising questionnaire, the data of the two cases was compared on Task Acts, Argumentative Activity, and the breadth and depth the space of debate with help of paired t-tests. To determine whether both cases were comparable it is important to know if protocols for both cases are equally in length. Paired-sample t-tests were run on the means and variables shown in Table 3. T-tests showed no significant differences between the numbers of utterances in Case 1 as compared to Case 2.

Table 3

Number of Chat and Diagram Contributions in Cases 1 and 2 (N = 25)

	Case 1		Case 2			
Contributions	*M*	*SD*	*M*	*SD*	*t*(24)	*p*
Chat	64.84	33.16	66.40	41.22	-0.20	.85
Diagram	11.68	4.79	13.44	7.20	-1.53	.14

All utterances in the chat and the diagram were first coded on the level of task acts. Figure 3 shows the percentages of the different task acts for Cases 1 and 2 separately.

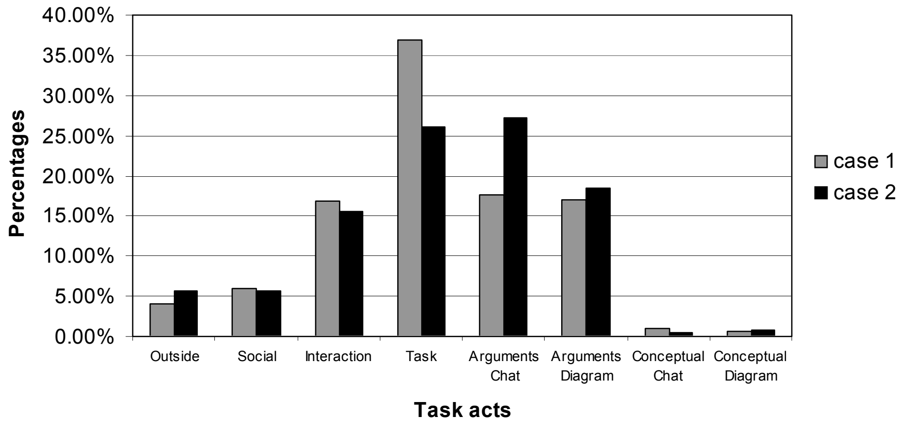

Figure 3. Percentages of communicative task acts in Cases 1 and 2 (*N*=25)

A distinction is made between the Argumentative Acts and Conceptual Acts in the chats and in the diagrams. A set of paired t-tests was carried out at the level of the dyads to determine whether there were statistically significant differences in task acts between the Cases 1 and 2. The paired *t*-test on Task Management showed a significant difference between Case 1 en Case 2. Figure 3 shows that in Case 1 ($M = 25.36$, $SD = 18.70$) students talked a little bit more about how to manage the task than students in Case 2 ($M = 19.00$, $SD = 11.94$), $t(24) = 2.21$, $p = .04$ (two-tailed), $d = 0.44$. Analysis of the differences at the level of subcategories showed that an explanation for the overall difference on task management can be found in the subcategory management of the task in general. During Case 1 ($M = 14.12$, $SD = 11.33$) students talked significantly more about the way the task should be carried out than during Case 2 ($M = 5.56$, $SD = 5.35$), $t(24) = 4.14$, $p = .00$ (two-tailed), $d = 0.82$. The subcategories management of the way DREW works, management of the discussion, and management of the construction of the diagram showed no significant differences between Case 1 and Case 2. Along with this, the paired *t*-test on Argumentative Activity in chat exposed a significant difference between Case 1 and Case 2. Students argue significantly more in chat in Case 2 ($M = 19.88$, $SD = 22.52$) compared to Case 1 ($M = 12.12$, $SD = 16.76$), $t(24) = 2.51$, $p = .02$ (two-tailed), $d = 0.50$. In the next paragraph we attend to the subcategories of Argumentative Activity.

The category Argumentative Acts was coded into subcategories before determining the breadth and depth of discussion. Table 4 displays the different argumentative acts at the dyad level in chat and diagram for Cases 1 and 2 separately. For chat, Table 4 shows significant differences for the argumentative activities giving claims, giving supportive theories, rebuttals, and giving evidence. Dyads apply these activities more in their discussions of Case 2 than in their discussions of Case 1.

Table 4

Subcategories of Argumentative Acts: Mean Frequencies, SD's, and t-values

	Chat (*N* = 25)					Diagram (*N* = 25)				
	Case 1		Case 2			Case 1		Case 2		
Arg. Acts	*M*	*SD*	*M*	*SD*	*t* (24)	*M*	*SD*	*M*	*SD*	*t* (24)
Claim	1.24	1.59	3.08	3.38	2.94**	1.68	1.25	1.88	1.48	0.71
Supportive	0.88	2.11	2.12	2.79	2.62*	2.96	1.79	3.96	1.79	2.47*
Alternative	0.84	1.68	1.28	1.62	1.02	3.04	2.19	2.80	1.80	0.51
Counter	0.60	2.02	0.84	1.14	0.67	0.28	0.46	0.72	0.94	2.68*
Rebuttal	1.28	2.97	4.04	7.25	2.17*	0.84	0.46	2.08	3.63	2.01
Evidence	1.80	4.12	3.32	4.26	2.10*	2.36	1.91	3.28	6.56	1.99
Verifying	1.12	1.39	1.56	2.24	0.83	-	-	-	-	-
Agreeing	1.32	1.52	1.94	2.96	1.25	-	-	-	-	-

$*p < .05$. $**p < .01$.

For the diagrams Table 4 displays significant differences for the argumentative activities giving supportive theories and giving counterarguments. In Case 2 dyads produced more supportive theories and counterarguments in their diagrams as compared to Case 1.

The scores in chat and diagram on both breadth and depth were tallied for both cases. Figure 4a shows the breadth (number of sequences) and 4b the depth (length of sequences) of the space of debate and makes a distinction between individually and collaboratively constructed argumentative sequences. Of the total number of the argumentative sequences 33 % were collaboratively constructed in Case 1 and 40% were collaboratively constructed in Case 2

Looking at the individual sequences there were no significant differences in the breadth and depth of the space of debate between Cases 1 and 2, whereas the collaborative sequences show a significant difference in the depth of the space of debate.

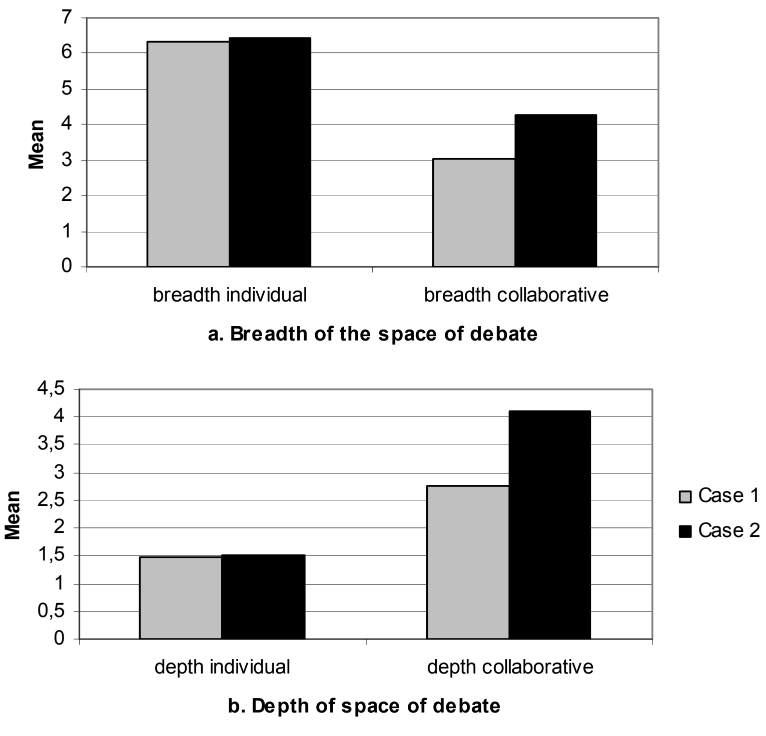

Figure 4a and 4b. Breadth and depth of Cases 1 and 2

Students discussed the issue of genetic modification of chickens (Case 2) more elaborately ($M = 4.12$, $SD = 1.30$) than they did the issue of genetically modified grain in Ethiopia (Case 1, $M = 2.75$, $SD = 2.05$), $t(24) = 2.69$, $p = .01$ (two-tailed), $d = 0.54$.

The collaborative sequences were distinguished in sequences with controversies and sequences with refinement through presentation of evidence. Sequences with controversies were all collaborative sequences in which students used counterarguments and/or rebuttals while sequences with refinement through presentation of evidence were collaborative sequences with only evidence. Paired t-tests were carried out to compare the different types of sequences between Cases 1 and 2 which showed a significant difference in the number of controversies between Case 1 ($M = 1.16$, $SD = 1.37$) and Case 2 ($M = 1.96$, $SD = 1.67$), $t(24) = 2.67$, $p = .01$ (two-tailed), $d = 0.53$.

Conclusions research question 1

Research question 1 asked whether making students aware of their controversies would influence their way of arguing in a subsequent case. Results showed that dyads focus more on collaborative arguing in Case 2. There is less task management and more argumentative activity in the chats. During discussion of the second case dyads used more claims, supportive theories, rebuttals, and evidence. Along with this the analysis of the breadth and depth of discussions show that students explore the space of debate in a more elaborated (i.e., with more depth), interactive (i.e., with more collaborative sequences), and confronting (i.e., with more controversies) way during the discussion of the second case. These results could indicate that making students aware of their controversies had a positive effect on the way they argue together. However, because we used a design without control group and without randomised cases, we will discuss the effects in a more elaborate way in the discussion section.

Research question 2: Influence of individual characteristics

Participants' total score on epistemological beliefs ranged from 11 to 25 with a mean of 20.33 ($SD = 3.23$, $N = 50$). A total score of 10 would reflect an overall absolutist position, while a total score of 30 would reflect an overall evaluativist position. Results showed students differed in their epistemological position varying from absolutist (score 10-16), multiplist (score 17-23), to evaluativist (score 24-30) positions. Most students fell into the category of multiplist (n = 28).

On the identification of subordinate argumentation test, participants had a mean score of 48.07 ($SD = 18.84$). Scores were normally distributed and ranged from 10 to 80 with a possible maximum score of 100. Thus, there were no students who obtained the maximum score on the test and scores were very different for students.

There was no significant correlation ($r = .02$, $p = .93$) between participants' scores on epistemological beliefs and scores on the subordinate argumentation test.

To measure the relations between the independent variables epistemological beliefs and argumentative knowledge and the dependent variables (i.e., different argumentative acts), multilevel analyses for each of the argumentative acts were carried out. Before running these analyses the scores on argumentative acts was disaggregated to the individual level; instead of a dyad score, each individual student had his/her own score on each argumentative act. Table 5 lists the results of the analyses for Cases 1 and 2. The $\chi 2$-tests show better fit of all the models with epistemological beliefs and argumentative knowledge as predictors for each argumentative activity compared to the empty models. However, in most cases there are no significant β-coefficients which indicate that the coefficients together explain a significant part of the large variance of an argumentative act, but individually do not have a predictive value.

An exception to this was the multilevel model for the number of rebuttals in both cases. In Case 1, epistemological beliefs and argumentative knowledge were significant predictors of the total number of rebuttals used. ($\beta = 0.10$, $p = .05$ and $\beta = 0.03$, $p = .02$, respectively). The same is true for Case 2 where thus beliefs and skills influence the amount of rebuttals ($\beta = 0.09$, $p = .03$ and $\beta = 0.02$, $p = .04$, respectively).

There also were some marginally significant results in Case 1 and Case 2. It appeared that in Case 1 the variable epistemological beliefs was a marginally significant predictor for the number of alternative theories,

$\beta = .10$, $p = .06$, and argumentative knowledge was a marginally significant predictor for the number of supportive theories, $\beta = 0.02$, $p = .09$. In Case 2 there was one marginally significant result for argumentative knowledge as predictor for the number of agreeing during discussions, $\beta = 0.02$, $p = .07$.

Table 5

Results of Multilevel Analyses for Cases 1 and 2

	Case 1 (N = 50)			Case 2 (N = 50)		
	β	*SE*	$\chi^2(2)$	β	*SE*	$\chi^2(2)$
Claims						
Epist. beliefs	-0.03	0.05		0.03	0.07	
Argum. knowledge	0.00	0.01	24.97**	-0.01	0.01	25.76**
Supportive theories						
Epist. beliefs	0.03	0.05		0.03	0.08	
Argum. knowledge	0.02[a]	0.01	34.74**	-0.02	0.02	43.84**
Alternative theories						
Epist. beliefs	0.10[a]	0.06		0.07	0.07	
Argum. knowledge	0.00	0.01	40.40**	-0.01	0.01	34.12**
Counterarguments						
Epist. beliefs	-0.02	0.02		-0.01	0.09	
Argum. knowledge	0.00	0.01	21.99**	0.01	0.02	25.93**
Rebuttals						
Epist. beliefs	0.10*	0.06		0.09*	0.05	
Argum. knowledge	0.03*	0.01	25.32**	0.02*	0.01	57.60**
Evidence						
Epist. beliefs	-0.05	0.07		0.01	0.12	
Argum. knowledge	-0.01	0.01	63.93**	-0.03	0.02	43.84**
Verifying						
Epist. beliefs	0.01	0.04		0.02	0.05	
Argum. knowledge	0.00	0.01	16.35**	0.01	0.01	27.26**
Agreeing						
Epist. beliefs	0.02	0.05		0.04	0.05	
Argum. knowledge	0.00	0.01	13.02**	0.02[a]	0.01	27.02**

[a] $p < .10$. * $p < .05$.
** $p < .01$.

Conclusions research question 2

Multilevel analysis showed only a significant influence of epistemological beliefs and argumentative knowledge on the amount of rebuttals individual students generated during discussion, for both cases which indicate that students with a higher score on epistemological beliefs and argumentative knowledge produced more rebuttals. However, the predictors explained a significant, but limited amount of the variance of the occurrence of rebuttals. A marginally significant influence of epistemological beliefs on the number of alternative theories was found, which indicate that students with a more complex view of epistemology bring more alternative views to their own claims. However, also in this analysis the predictor only explained a small amount of the variance.

Research question 3: Influence on individual breadth and depth of argumentation

Third research question was whether there is a relationship between the breadth and depth of the discussion in dyads and the breadth and depth of individual argumentation (i.e., as measured in the post-test), taking into account the epistemological beliefs and argumentative knowledge of individual students. To establish the effect of breadth and depth during discussion on the individual post-test scores a multilevel analysis was run with breadth and depth as predictors at the group level. To control for individual effects, epistemological beliefs and receptive argumentative skills were included in the model as predictors at the individual level. Epistemological beliefs ($\beta = 1.36$, $p = .05$) and receptive argumentative skills ($\beta = 0.04$, $p = .02$) were significant predictors of the post-test scores of individual students with an associated $\chi 2(4) = 100.31$, $p < .01$. Depth of discussion was an important predictor in this model, but only marginally significant ($\beta = 8.64$, $p = .09$). These results show that epistemological beliefs and receptive argumentative skills show no relation with the way students argue together during discussing GMOs, while the individual argumentation about GMOs after discussions is significant related to individual epistemological beliefs and receptive argumentative knowledge.

Discussion

The first aim of this study was to determine whether giving students a questionnaire about their controversies during the discussion of a first discussion case before they begin discussing a second case would improve their interactive argumentation. Results showed several differences in argumentation between a first case that preceded the awareness-raising questionnaire and a second case immediately following the questionnaire. In the second case, there was more argumentative activity (i.e., more claims, supportive theories, rebuttals, and evidence). Along with this, students explored the space of debate more in depth. There was more interaction expressed in more collaborative sequences and students tried to solve more controversies.

Because the cases were not randomised and no control group was used, the question arises as to whether the difference found between the two cases can be attributed to the instructional event of making students aware of their controversies, or whether it must be attributed to other causes such as the differences between the topics discussed in both cases and/or student appropriation of the CSCL environment and task. If a difference between the topics was the cause, that is that the second topic of genetically modifying chickens were to provoke more argumentation than the first on genetically modified grains for Ethiopia due to its containing more information and arguments, then one would expect to find more (i.e., breadth) and longer (i.e., depth) argumentative sequences. The results, however, showed only improvement of the depth of sequences. If the latter is the case, namely that there is a difference due to appropriation of the CSCL environment and task, then the same argument can be used. When students get used to working in a CSCL environment we would expect an improvement of both breadth and depth of individual and collaborative sequences would be expected, which was not the case. However, results showed that students improve only the depth of discussion of only the collaborative sequences. Along with this, they tried to solve more controversies which could indicate that students were more aware of what was expected of them during discussion (i.e., solving controversies instead of winning the debate).

It is, thus, justifiable to conclude that making students aware of their controversies could have a positive effect on the way they argue. In other words, student goal orientation and argument frames (Nussbaum & Bendixen, 2003) appear to be influenced by an intervention as simple as an awareness-raising questionnaire. This is confirmed by research into the way students' goal orientation within the classroom can be influenced. Teacher evaluation and feedback has been shown to be very influential in altering student goal orientation (Ames, 1992; Pintrich & Schunk, 2002).

However, there are still some limitations in the progress of interactive argumentation. Results showed only progress with respect to claims, supportive theories, rebuttals, and evidence which might indicate that students still argue to support only their own claims instead of thoroughly exploring their opponents' side (i.e., presenting alternative theories and counterarguments) during the discussion of the second case. Linking the results of this study to Osborne, Erduran, and Simonis (2004) statement about explicit instruction during argumentation, it would be valuable to continue research on the effects of more explicitly instructing students on the difference between argumentation 'to win a debate' and argumentation 'to learn'.

The second aim of this study was to determine whether there is a relationship between the epistemological beliefs held by individual students and argumentative activity during collaboration, taking individual argumentative knowledge into account. Results showed no significant relation between individual epistemological beliefs and argumentative knowledge on the one hand and argumentative activity during collaboration on the other. Only a limited amount of the variance in giving rebuttals is significantly explained by epistemological beliefs and argumentative knowledge while we expected to find positive relations between more complex epistemological beliefs and the number of argumentative activities during collaboration. One possible explanation could lie in other variables at the collaborative/social level such as the dynamics of peer collaboration and the experience of meaningful conflicts, heterogeneity of participation, and processes of reaching common ground. In further research, it may prove fruitful to relate the Chan's (2001) research to that of Nussbaum and Bendixen (2003). On the one hand it is important to elaborate the work of Chan and to precisely establish which kind of argumentative sequences (e.g., with help of sequential analysis) can be seen as 'stone walling', 'patching', and 'problem-centered'. On the other hand, it is important to develop more knowledge about the student motives when approaching or avoiding arguments in a CSCL-situation as well as how social relations influence broadening and deepening the space of debate. This social dimension of learning within CSCL is also emphasised by other researchers (e.g., Andriessen, Baker, & Van Der Puil, in press; Kreijns, Kirschner, & Jochems, 2003; Weinberger & Fisher, 2006).

The third research question was whether there is a relationship between the breadth and depth of discussion in dyads and individual argumentation after the collaborative task sequence, taking the epistemological beliefs and argumentative knowledge of individual students into account. Remarkably, the results showed only a marginally significant effect of the breadth and depth of the collaborative discussion on the individual argumentation in the post test, while the basic assumptions for this research were that individual students will broaden and deepen their knowledge about a scientific topic when arguing together. Other research also showed the difficult transfer of broadening and deepening the space of debate on the collaborative level to argumentation on the individual level (e.g., Van Amelsvoort et al., in press; Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005). More research is needed into the exact way students use information given to them and the development of specific subtopics and individual knowledge about a topic during collaborative learning. A fruitful approach could be the analyses of the way information is or is not transformed during collaboration as advocated by Van Amelsvoort (2006).

It is also worth making some methodological remarks about the measurement of epistemological beliefs as it was carried out in this study. We used Kuhn et al.'s (2000) approach of measuring epistemological beliefs. This approach can be criticised because the simplicity of the instrument sacrifices the examination of many of the nuances and ranges of thinking about epistemological beliefs. Kuhn et al. recognise this limitation but argue that there is a practical advantage due to the simplicity, and along with this empirical evidence for the correspondence between this instrument and other instruments measuring epistemological beliefs. However, this study also showed problems with the reliability of the instrument. We could not establish reliable scales for all of the different domains of judgment and were forced to shorten the instrument to 10 overall items. These results were not in accordance with the reliability coefficients found by Mason and Boscolo (2004) which were much higher for each judgment domain. This difference could be due to the fact that Mason and Boscolo used more participants in their study. More research is needed to establish whether Kuhn's instrument is a valid and reliable instrument of epistemological beliefs and whether the same results are obtained when other instruments for measuring epistemological beliefs are used.

To conclude, this study showed the importance of taking individual and instructional explanatory variables into account when studying how CSCL can support interactive and individual argumentation. Results showed that both epistemological beliefs and argumentative knowledge of individual students were significant predictors of the individual argumentation the students show in the post tests after discussion, while influence at the collaborative level was only marginal. It seems that individual beliefs and argumentative knowledge are separated or suppressed by more important social processes at the moment of collaboration and negotiation. Maybe, students feel impeded to express their opinions and arguments due to social processes during collaboration, which is a possible explanation for why it remains unclear whether and how epistemological beliefs affect interactive argumentation. Along with this, this study showed the role that raising awareness can play to clarify the task goal for students and to orient them on a more negotiation argument frame. However, more research is needed to establish how students can be provoked to let go of the adversarial frame of argument and to explore their opponents' claims in a thorough way. More research is also needed for determining precisely which learning processes are provoked or can be stimulated or facilitated during interactive argumentation. To establish in how students learn when arguing together, more knowledge is needed about what exactly is happening with contrary information and in what way students use and transform information during interactive argumentation.

Chapter 6

General discussion

Bob: *What is your opinion?*
Martin: *In my opinion, genetic modification is dangerous. It can disturb the biological system.*
Bob: *Why do you think it disturbs the biological system?*
Martin: *I have read a report of Greenpeace about how genetically modified crops can affect wild populations. The pollen of these crops can blow over to the wild populations and change hereditary predispositions in such ways that only the genetically modified crops survive.*
Bob: *Oh, but that is the opinion of Greenpeace. There are other sources that claim that the reverse is true .The biggest threat to biodiversity is the loss of viable habitats and genetic modification can be used to preserve fragile environments.*
Martin: *Can you elaborate on that?*

Introduction

This dissertation started with a dialogue between two boys which was an example of problems students can encounter during arguing. The boys quickly and simply agreed with each other, and were unable to elaborate and to support their arguments with genuine evidence. The dialogue above is an (made up) example of how we imagined *arguing to learn:* a specific type of argumentation in which students are stimulated to explore a topic for all different kinds of views with an open mind, which we termed *exploring the space of debate in breadth and depth.* The principal premise underlying this dissertation is that arguing to learn is a process of interaction and collaboration which promotes and supports individual reasoning, and helps students to advance their knowledge.

The dialogue at the beginning of Chapter 1 showed the difficulties student can encounter during arguing to learn. Aim of the studies in this dissertation was to support arguing to learn with help of computer-supported collaborative learning (CSCL) tools in such a way that students would overcome some of the mentioned problems and argue about a topic in as much as breadth and depth as possible. The main research question was: *What are the effects of different characteristics of CSCL environments on interactive argumentation; more specifically on the breadth and depth of the space of debate, and how can we explain these effects?* In three studies, two characteristics of CSCL environments were examined namely (1) representation of argumentation by argumentative diagrams and (2) synchronicity of computer-mediated communication (CMC). The results of these three studies showed a large variety between student dyads in the breadth and depth of their discussions. A fourth study was carried out to explore the association between this variation and individual epistemological beliefs of students. Along with this, the fourth study researched the question, of whether raising student awareness of their controversies would positively influence the breadth and depth of the space of debate.

In this final chapter we give an overview of the results and we compare the different studies while discussing the results. We examine the results of Chapter 2, 3, 4 and 5 in relation to the theoretical concepts described in Chapter 1. Reflecting on and comparing the results of different studies can shed some light on the overall topic of supporting arguing to learn with the use of CSCL. First, we present an overview of the studies and their general results. Following this, we discuss several intertwined issues that come up with the results. Finally, we give some methodological considerations and educational implications of this dissertation.

Overview of the studies

Study 1: using diagrams before or during discussion?

Chapter 2 focused on the different ways argumentation diagrams in CSCL environments can be used during discussion of wicked problems. The main question was whether student dyads (age 16/17) *collaboratively* constructing a diagram *during* their discussion of a wicked problem, would argue more broadly and deeply than student dyads who could only compare the differences between their *individually* constructed diagram *before* the discussions started.

Twenty dyads of two different studies were compared. In the first study (SCALE), both students in ten dyads were asked to individually prepare an argumentative diagram representing their individual opinion and to compare their individual diagrams during discussion. In the second study (Twins), ten student dyads were asked to collaboratively construct a diagram during their discussion. In both studies, students carried out the same discussion task about genetic modified organisms (GMOs) and were asked to collaboratively write an argumentative text representing their joint opinion of the topic under consideration. In both studies, the task was carried out in the CSCL writing environment TC3, communicating through a chat tool. Before students entered the discussion, they were asked to read several sources about GMOs.

Because diagrams are thought to stimulate, elaborate and refine discussion by forcing the users (1) to make their opinions and arguments more explicit, (2) maintain focus, and (3) maintain consistency and balance, it was expected that collaboratively constructing a diagram during discussion would result in broader and deeper discussion, compared to individually constructing a diagram before discussion. The discussion were first analysed with a functional analysis called Rainbow, which was developed within the SCALE-project. Breadth of discussion was measured by counting the number of topics that dyads discussed. Depth of discussion was measured by scoring all content-related utterances such as either giving an argument, giving an example or explanation stating a support or rebuttal, or giving an explicit explanation for relations between arguments. These kinds of utterances were respectively rated with 1, 2, 4, or 8. All ratings within one dyad were added and divided by the total number of utterances scored, which resulted in a relative depth score.

Results showed no confirmation of the overall expectation that students who collaboratively constructed diagrams during discussion would argue more broadly and deeply as compared to students individually constructing diagrams before discussion. Overall, results showed that both ways of using diagrams did not force students to negotiate their opinions and arguments. Students constructing individual diagrams before discussions exchange more opinions about GMOs. However, in both studies it appeared that students easily take over each other's opinions and arguments. They did not discuss the topic very deeply, gave little genuine evidence, and seldom questioned the contributions of their partners to the discussion. The argumentation could be characterised as merely exchanging arguments instead of arguing to learn – exploring the breadth and depth of the space of debate. Further analysis of the way students used the diagrams in the two studies showed that students mainly use a diagram as a kind of notebook in which all ideas for the argumentative text were gathered which could be an explanation for the superficial discussions. In both studies, we found little off-task talk between students which could indicate that the diagrams helped to maintain focus on the task. Both the individually constructed diagrams before discussion and collaboratively constructed diagrams during discussion helped students focus on the content of discussion, but were quickly reduced to sources of information used for writing the text, instead of a basis for discussion. The results also showed that diagrams stimulated students to talk about what argumentation should look like. In both studies, students talk about what good argumentation should look like, however the diagrams stayed very chaotic, unstructured, and inaccurate. In other words, diagrams stimulate talk about *how* to argue, but students do not succeed in applying this knowledge when arguing.

Study 2: How do diagrams support arguing to learn?

In Chapter 3 we further examined the ways diagrams, collaboratively constructed during discussion, can support arguing to learn. The study compared two conditions of 20 student dyads using a text outline and 20 student dyads using an argumentative diagram during discussion, with respect to the breadth and depth of their discussions. The dyads accomplished a collaborative task comparable to the task in Chapter 2. They first were asked to discuss the wicked topic of GMOs and following this, to write an argumentative text that represented their opinions about the topic. Students used the CSCL environment TC3 and communicated through a chat tool. Again students were asked to read several information sources on the topic of GMOs before entering the collaborative discussion.

Because of the previously mentioned possible advantages of diagrams we expected that students using a diagram during discussion would outperform students using a text outline on the breadth and depth of the space of debate in their interactions as well as in the products (i.e., comparing diagrams and text-outlines; texts). To measure breadth and depth of the space of debate the task acts were first analysed with help of a functional method based on the aforementioned Rainbow method. Following this, breadth and depth was measured with a method which was further developed after the study described in Chapter 2. Based, on the work of Kuhn (1991) the argumentative acts of students during the task were analysed taking into account the possible different argumentative moves people can take during discussion, such as giving supportive theories, alternative theories, evidence, rebuttals, and counterarguments. These moves were sequenced, which determined the depth of the space of debate. The longer the sequences, the deeper the sequences were coded. The total number of sequences constructed during the task determined the breadth of the space of debate. In this study we also made a distinction between argumentative sequences that really were constructed by both students (i.e., collaborative sequences) and sequences constructed only by one student during the collaboration (i.e., individual sequences).

Results partially confirmed the expectations. Students using a diagram during discussion argue more deeply compared to students using a text outline. Students in the diagram condition used more claims, supportive theories, evidence, alternative theories, and rebuttals in the overall task. Diagrams, thus, supported students in elaborating and negotiating their opinions. However, results also showed that this advantage of the diagram condition over the text outline condition is caused by what is happening in the diagrams themselves and is not due to more extended discussions in chat. Remarkably, the electronic chat discussions of the students who used the text-outline tool contained more and longer argumentative sequences, while the chat discussions of students using the diagram stay superficial. It appeared that with the support of diagrams, students felt a lesser need to discuss the topic in the chat box and used the diagrams as medium for elaborating on the topic. This resulted in many individual constructed argumentative sequences constructed in the diagrams instead of the expected collaborative argumentative sequences. Results also showed that there overall is much more to gain with respect to the breadth and depth of argumentation.

Very often, students show the same picture as shown in the dialogue between the two boys at the start of this dissertation. They quickly and simply agree and do not elaborate on differences in opinion or inconsistencies in their partner's argumentation. Considering the large number of individually constructed argumentative sequences it can be concluded that students do not take full advantage of the collaborative situation.

Study 3: Impact of synchronous and asynchronous CMC on arguing to learn

Chapter 4 reported a study researching the impact of different types of computer-mediated communication (CMC) on the way students argue. Again the topic of GMOs was discussed by student dyads (age 16/17) after which they wrote an argumentative text about their opinions on this topic. The discussion phase of the task was carried out with two different types of CMC. Twenty dyads discussed the topic using synchronous chat communication while 19 dyads used an asynchronous discussion board for discussion. Students prepared for the discussion by individually reading different information sources on the topic of GMOs. After discussion they collaboratively wrote an argumentative text using the CSCL environment TC3.

Our expectations about the way different types of CMC would affect the argumentation of the dyads were based upon the media synchronicity theory of Dennis and Valacich (1999). They argue that many collaborative tasks consist of two communication processes conveyance and convergence which need different media characteristics (i.e., immediacy of feedback, symbol variety, parallelism, rehearsability, and reprocessability). Conveyance processes are related to the breadth of a space of debate and deal with gathering several different perspectives on an issue. Convergence processes are related to the depth of a space of debate, and deal with elaborating a perspective and developing shared understanding. Because convergence processes, in the opinion of Dennis and Valacich, need a high immediacy of feedback, synchronous CMC was expected to stimulate deep argumentation. Because conveyance processes are stimulated by media with high rehearsability and high parallelism asynchronous CMC was expected to stimulate the breadth of discussions. Breadth and depth was measured in the same way as described in Chapter 3. Analyses were extended with an analysis of the text quality of the collaboratively written text to measure the effects of discussion in different types of CMC on the final product.

The results obtained partly confirmed the expectations. Students using a discussion board produced relatively more argumentative activity than students communicating by chat. However, looking at the argumentative sequences with respect to the breadth and depth of the discussion, results showed that students using chat produced more and deeper argumentative sequences during their discussions. Thus, high immediacy of feedback seems to support the depth of discussions. However, the results showed the opposite effect for the quality of the final texts. Students who discussed the subject of GMOs with help of a discussion board produced texts with more accurate argumentation as compared to students who communicated by chat.

Study 4: Role of individual epistemological beliefs and raising awareness of controversies

In the last study we investigated individual epistemological beliefs and argumentative knowledge as possible explanations for the large variety in the breadth and depth of argumentation we found in study 1-3. After completing pre-tests to assess their epistemological beliefs and assess their knowledge about argumentation, 25 student dyads (16/17 age) discussed the topic of GMOs. The task in this study differed from the tasks in preceding studies. Students in this study were not asked to discuss the topic of GMOs in general, but to discuss two cases in which GMOs were involved. Case 1 dealt with the impact of GMOs on a third world country such as Ethiopia and Case 2 dealt with genetically modifying chickens. Between Cases 1 and 2, students were asked to answer some awareness raising questions about the way they discussed the first case. The cases were discussed in the CSCL environment DREW which contained a tool for constructing an argumentative diagram and a chat box for synchronous communication. Before discussing the cases, students individually read different information sources about the topic and started with an assignment to exchange their arguments on the topic. Compared to the tasks in preceding studies, another difference was the final product produced after discussions.

Instead of a collaboratively written argumentative text, students ended the task with a debate in class.

Based on the ideas of Kuhn, Cheney, and Weinstock (2000) we expected students with more complex epistemological beliefs to produce broader and deeper discussions. Kuhn et al. distinguish three different levels of beliefs which can develop within a person, namely the absolutist, multiplist, and evaluativist level. People at the absolutist level see arguing as a way of presenting assertions on reality and determining their truth and falsehood. They resolve problems by locating the facts and do not question the tenability of those facts. Supporting a claim with one arbitrary supportive theory is enough, which results in low breadth and depth of the space of debate. People at the multiplist level see arguing as irrelevant. Many different views are possible and valid and it is not necessary to explore those views in depth. Thus, great breadth is possible but discussions stay superficial. People at the evaluativist level see arguing as the vehicle that promotes deeper understanding of a topic which stimulates the breadth and depth of discussions. Along with this, we expected students with more knowledge about arguing (i.e., passive knowledge about claims, supports and evidence) to discuss the space of debate in more broadly and deeply. Finally, we expected students to argue more broadly and deeply in Case 2, after answering the awareness raising questions about the way they discussed while they worked on Case 1. These questions were thought to stimulate more depth in the discussion because they guided students to argue to learn instead of to argue to convince. To measure the effects after the collaborative task, students were asked to give their individual opinions, supportive arguments, and the way other people would react to their opinions and arguments. Answers were scored with respect to breadth and depth.

Results showed no relationship between individual epistemological beliefs and the breadth and depth of the collaborative discussions. However, we found a positive relationship between the complexity of epistemological beliefs and the individual argumentation of students after the collaborative task. Along with this, the presence of argumentative knowledge yielded the same results. We found no relationship at the collaborative level while knowledge of students about arguing was found to be a predictor for breadth and depth of the individual argumentation after the collaborative task. Finally, results indicated a positive effect of raising awareness of the way students argued about Case 1 on the breadth and depth of discussing Case 2. In Case 2 students improved the depth of the collaboratively constructed argumentative sequences which could indicate that students were more aware of what was expected of them during discussion.

Interpreting the results: supporting arguing to learn

This dissertation aims to answer the question about how certain different characteristics of CSCL environments affect interactive argumentation, or more specifically arguing to learn. In Chapter 1 we defined arguing to learn as a collaborative search within an indefinable space of debate that can be explored in breadth and depth. Interactive argumentation aimed at collectively searching for reasons and evidence, gives students the opportunity to learn because this kind of arguing allows them to produce, explicate, articulate, verbalise their opinions and arguments, and construct and/or reconstruct knowledge through disagreement. The different studies showed that students are capable of discussing a topic; giving supportive theories with evidence, and rebutting alternative theories. The aforementioned results of our studies indicate that argumentative diagrams and synchronous CMC can support students in broadening and deepening a discussion.

However, students still showed a number of the problems with arguing that were described in Chapter 1, such as generating genuine evidence for their opinions, critical reflection on their own opinions, and having an open mind for one another's claims and arguments. Despite the support of a CSCL environment, students do not critically reflect on supportive theories and often do not question the supportive theories of their fellow students; not even when they have a different opinion about the subject. Leitaõ (2000) describes the potential of argumentation as a knowledge building cycle in which students construct arguments and are prompted by counterarguments to rethink their initial argument. Thus, still many discussions of students in our studies can be characterised by what Chan (2001) describes as 'stonewalling' or 'patching'. They quickly resolve their disagreements and do not show real engagement. The effectiveness of interactive argumentation or of collaborative learning in general depends upon multiple variables which interact with each other in a very complex way. Kirschner, Martens, and Strijbos (2004) refer to this as the probabilistic nature of collaborative learning. This probabilistic nature implies designing educational settings for arguing to learn to be a very complex task.

In the next sections of this chapter we will reflect on what the results of the different studies add to the knowledge about the way students argue and can be supported by a CSCL environment. We will reflect on the issues of (1) the way representational tools can support arguing to learn, (2) the way different types of communication influence arguing to learn, (3) social factors that foster or restrain arguing to learn, (4) the influence of the way students interpret the task and the task goals, (5) the influence of task complexity, and (6) motivating students with authentic tasks.

Supporting arguing to learn with representational tools

We expected the use of representational tools such as argumentative diagrams to scaffold and to stimulate student's chat discussions by making the student's thinking and arguing visible. Argumentative diagrams are thought to stimulate elaboration of the discussion, to maintain the focus on the content of the task, and to maintain consistency and balance in the discussion. Results of study 1 and 2, reported in Chapter 2 and 3 showed mixed results with respect to the breadth and depth of the space of debate.

Study 1 showed that diagrams help students maintain focus on the topic under discussion and talk about the structures of good argumentation. However, despite these beneficial effects, the discussions remained superficial. A possible explanation could lie in the way students used diagrams. In study 1, individually constructed diagrams before discussion functioned as summaries of the information sources from which arguments could be picked during text writing. The diagrams that were collaboratively constructed during discussion often function as notebooks in which students individually gathered their arguments, without discussing them together.

Study 2 showed that when taking into account all communication in chat and tools, students in the diagram condition produced broader and deeper discussions as compared to students in a text outline condition. However, this dominance of the diagram condition over the text outline condition was caused by individually constructed argumentative sequences in the diagrams and not by collaboratively constructed argumentative sequences or more and longer sequences in the chat discussions of the diagram condition. Thus, diagrams in our studies mainly gave rise to individually constructed argumentation and scarcely gave rise to interactive argumentation in the communication by chat; which was the main idea of how diagrams would support students. It seems that the notion of diagrams stimulating argumentation in the chat discussion is too simple, while this translating between two representations (i.e., diagram to discussion and vice versa) is thought to be beneficial for students (see also Van Amelsvoort, Andriessen, & Kanselaar, 2007).

Considering our results, it seems that there are several possibilities to make progress in the domain of arguing to learn while students are supported by argumentative diagrams. The first question that arises is whether or not the tools are appropriate to support arguing to learn. In the studies of this dissertation we used a tool focusing on the argumentative structure and possible argumentative moves in a discussion. Results showed that the tools triggered conversations about 'good' argumentation in terms of convincing one another. It could be possible that such tools do not facilitate the specific processes of arguing to learn, but arguing to-win-or-lose the debate (see e.g., Veerman, 2000). Maybe, it is necessary to develop other kinds of tools that better matches the processes of arguing to learn (i.e., exploring different views, elaborating arguments) and along with showing the argument structure, make students aware of inconsistencies, unbalance, or insufficiently supported arguments by showing these problems to students in other representations of the discussions. An example of a promising and a valuable approach could be the shared space tool (Janssen, Erkens, & Kanselaar, 2007), developed within the VCRI (Virtual Collaborative Research Institute) environment which is a program for research projects and inquiry tasks (Jaspers & Broeken, 2005). The shared space tool visualizes agreement and disagreement during discussions by moving the chat history to the left (disagreement) or to the right (agreement).

Janssen et al. showed that the tool helped students with their online communication and had a positive influence on their perception of collaboration. More research is needed to investigate what the effects of the tool are on the breadth and depth of discussions when students are made aware of their agreements or disagreements.

A second question that arises is whether students can and must learn how to use these kinds of representational tools in order to profit more from the support they give. Students could be considered relatively inexperienced with these kinds of representational tools and with their intended meaning (see e.g., Erkens, Jaspers, Prangsma, & Kanselaar, 2005; Van Drie, Van Boxtel, Jaspers, & Kanselaar, 2005). Students in our studies use the tools for only a few hours, without prior experience. As suggested by Andriessen and Schwarz (in press) a different and valuable approach would be to integrate the use of representational tools in longer term courses in order to have them become part of the class culture and educational context. Andriessen and Schwarz (¶15) conjecture that "several argumentative norms will be instilled in classrooms dedicated to fostering dialogic thinking" mediated by representational tools in a CSCL environment. Research in which students use representational tools in longer term courses, has to show whether student's ways of using representational tools really changes in the course of their use and whether students develop norms dedicated to arguing to learn.

Finally, the question arises as to whether the tools fit with the context of the whole task. As the results showed, diagrams help students maintain the focus on the content of the task. However, results also showed that students mainly aim their attention at writing the argumentative text instead of discussing the topic. This focus on writing could have caused a superficial use of the argumentative diagram, which we described as 'using the diagram as notebook'. For students, this may be an appropriate way of using the diagram because in their opinion their main task was to produce a text instead of discussing the topic. This interpretation is supported by the results of study 4, reported in Chapter 5, in which students only had to discuss two cases and used DREW, a CSCL environment especially designed for discussing a topic, while TC3 specifically was designed for collaborative writing tasks. Results of this study show much more argumentative activity in the chat discussions as compared to the chat discussions in the other studies. Thus, it can be concluded that it is very important to consider the specific context of the task when using representational tools and to determine whether the instructor's goals of using a representational tool are compatible with the way students appropriate a tool in context of a specific task (see also Van Amelsvoort, 2006). In the next sections we will elaborate on the effects of the task on the way students argue together.

Immediacy of feedback as main concept

The second characteristic of CSCL environments investigated in this dissertation was different types of communication in the CMC. Using CSCL, the computer mediates the communication which is very different from face-to-face communication because the computer lacks the non-verbal signals we see during face-to-face conversations. As described in Chapter 4, this lack of non-verbal signals can cause problems understanding each other during interactions. However, the media characteristics of different types of CMC also are thought to support and stimulate certain interactions between students. Asynchronous computer-mediated communication normally is regarded as a suitable context for interactive argumentation (Andriessen, Baker, & Suthers, 2003; Veerman, 2000), because students have time to both compose their own messages (i.e., rehearsability) and reflect on their fellow student's messages before answering (reprocessability).

However, the results of study 3 (Chapter 4), in which we compared synchronous and asynchronous communication, showed that synchronous communication supported the broadening and deepening of the space of debate better then asynchronous communication. It seemed that immediacy of feedback is of more importance for broadening and especially deepening the discussion than rehearsability and reprocessability. Maybe this is due to the fact that immediacy of feedback also seems to create a sense of social and cognitive presence, which is necessary for argumentative interaction (Garrison, Anderson, & Archer, 2001). At the same time, results of study 3 also showed that students discussing asynchronously wrote texts with more accurate argumentation. A possible explanation would be that rehearsability and reprocessability gave them more opportunities to process and use the given information sources (read before discussion) in their messages, which was beneficial for the accuracy of their arguments. This indicates that only looking at what is happening *during* argumentative interactions is not enough to conjecture about the ways CMC can support the broadening and deepening the space of debate. It seems important to consider the quality of argumentative utterances and to consider longer term effects and developments.

It can be concluded that immediacy of feedback appears to be an important characteristic for supporting argumentative interactions within a CSCL environment. This means that synchronous chat can be a valuable tool to help students to argue together and especially to deepen their discussion. Along with this, chat is a very popular medium for communicating in the student's daily life which can motivate them to accomplish learning tasks. However, this does not mean that we should not use asynchronous communication during arguing to learn. In the first place the results showed rehearsability and reprocessability to have some positive effects on the accuracy of the argumentation the text. In the second place, it can be argued that students probably do not optimally use the opportunities (i.e., take time for reflection) asynchronous media offer. These two reasons make it probably valuable to combine both types of CMC and to research whether different parts of an argumentation task can be best carried out in different types of CMC.

Interaction between students

In study 1-3 we found large differences between student dyads in the breadth and depth of their discussions which could not be explained by the differences between conditions. We explored individual epistemological beliefs and knowledge about arguing as two possible explanations for the large differences between student dyads. Results of study 4 showed that these two variables also could not explain these differences. Individual epistemological beliefs and argumentative knowledge seem not to influence the argumentative activities during interactions, although the individual argumentation after discussions showed relations between individual epistemological beliefs and depth of individual argumentation. These results show that epistemological beliefs are important at the individual level, but do not play a part at the collaborative level which is rather strange. Possibly, the influence of individual epistemological beliefs at the collaborative level is suppressed by social aspects of the interactions between students. This possible explanation is also supported by other result such as that many dialogues still could be characterised as 'stone-walling' and 'patching', indicating avoiding conflicts and disagreement with fellow students and the relatively great number of individually constructed sequences in the studies.

The difficulties students encounter during their interactions are not unique or unknown. For example, Barron (2000) showed that many patterns of interactions between students are marked by individual rather than joint work. In her opinion these patterns reflect norms of schools that focus on competition and comparison rather than mutual engagement and reaching mutual understanding. Also, other researchers emphasise the importance of social processes during collaboration – being a conditional variable for real engagement and elaborative discussion (e.g., Andriessen, Baker, & Van der Puil, in press; Buchs, Butera, Mugny, & Darnon, 2004; Kreijns, Kirschner, & Jochems, 2003; Weinberger & Fisher, 2006). The interpersonal relationship between students, their confidence about knowledge being sufficient, and the way social and cognitive conflicts are understood and solved can be seen as important factors that can foster or restrain argumentation (Andriessen & Schwarz, in press).

Conceptions of the task

Study 4 (Chapter 5) showed that a simple questionnaire about the way students argued in Case 1 had a possible positive effect on the way students broaden and deepen their discussions. Just asking certain questions showed to raise awareness of what is being asked of them by the instructors. Schwarz and Glassner (2003) as cited by Andriessen and Schwarz stated in this context that the form and content of argumentation are highly sensitive to goals of the discussants. Nussbaum (2005) investigated the effects of specific goal instruction during arguing. He stated that, in previous research on goal instructions, only the general goal "to persuade" was investigated and that it is necessary to investigate other kinds of goal instructions. His study showed that a goal instruction to "generate as many reasons as possible" during interactive argumentation, resulted in deeper, more contingent arguments. He concluded "finding the right goal instructions to trigger the appropriate argumentation frame is important in creating interactive discourse that is educationally productive" (p. 309).

As stated before students in our studies often seem to argue in a quick and easy way. Along with the mentioned possible inhibiting influence of social processes on the broadening and deepening of the space of debate another explanation can be the way students perceived the argumentative tasks or what kind of argumentation frame is triggered by instruction. In this dissertation we defined arguing as being beneficial for learning because it is a way, to have students negotiate each others' views with an open mind as opposed to argumentation as a formal debate in which the goal is to convince the partner. However, as described, the results show that many student dyads not really engage in arguing to learn, but try to reach quick agreement. Along with the aforementioned problem of students seeing the task as 'writing an essay' these results also indicates that student's conceptions of the task maybe arguing to convince instead of arguing to learn.

A possible explanation why students interpret the task as arguing to convince, despite the instructions to explore the space of debate, is offered by Morgan and Beaumont (2003). In an article about dialogical argumentation they state that in educational contexts argumentation often is presented to students as debate instead of dialogue. This emphasis on argumentation as debate causes many students to equate argumentation with dispute instead constructive dialogue. Often, students are taught debating in a way similar to parliamentary debate, organized as it is in two sides; pro and con. For example, schools participate in television programs in which schools compete in rule-based debate and the goal is to show best debating skills and win the contest. A possible consequence of this emphasis on dialectical argumentation is that students interpret the instructions for *dialogical* argumentation as *dialectical* and stay too much in argumentation as formal debate where somebody is wrong or right and consequently decrease the depth of discussion.

It would be valuable to investigate the explanation Morgan and Beaumont offer and to determine the ways students interpret argumentation tasks and whether this can be changed by instruction and educational context. Good instructional design would require designing situations to match the argument frame that is necessary. Along with this, it is important to work on the perceptions of students. The results of study 4 (Chapter 5) indicated that students easily are influenced by questions that force them to reflect on the way they argue. Probably we can apply the same idea described about the use of tools, doing research in longer term courses where arguing to learn is a normal part of the curriculum, and where students reflect on the way they argue.

Complexity of tasks

In the studies in this dissertation we tried to develop tasks with a topic optimal for supporting interactive argumentation. GMOs is a complex, wicked problem, and had multiple acceptable solutions. Students were interdependent because sources of information were distributed such that they needed each other to accomplish the task. Along with this, we attempted to motivate students to evaluate arguments in a thorough way by giving them the joint goal of writing an argumentative text or holding a debate in class, and by giving them clear and explicit instructions to be critical and balanced in their argumentation.

As stated before, comparing the results of study 1-3 (Chapter 2,3, and 4) and study 4 (Chapter 5) showed that students in the last study construct relatively a larger number of argumentative sequences and that the sequences are longer. These results indicate that an explanation for the behaviour of students could be sought in the complexity of the tasks. Chatting, construing a diagram, and writing a text apparently were too complex for students, because study 4 showed relatively more breadth and depth in the discussions. We hoped that explicitly separating the discussion and writing phase would have the same effect, but we found that students also talked a great deal about the writing task during the discussion phase. Thus, although we want them to focus on argumentative discourse and explicitly instructed them that they had to translate their discussions into the text, they immediately direct their activity at the writing of the final argumentative text instead of the argumentative discourse. This is in accordance with other research. For example Blumenfeld, Mergendoller, and Swarthout, 1987) report students to short-circuit the difficulty of the task to decrease cognitive requirements. Apparently, despite of the well-structured task, students did not experience the discussion phase as being important for balancing their discussion and learning. Based on these results it could be recommended to design CSCL environments and tasks where the focus is clearly on arguing about a wicked problem.

Motivating students with authentic tasks

In Chapter 1 we stated that arguing to learn can only emerge when serious problems are encountered. Teachers participating in our studies also showed the desire to use 'important' issues which were part of the curriculum, like the chosen topic of GMOs. As Kuhn (2005) puts it:

> As educators our goal is twofold: to improve the quality of students' arguments and to expand the range of topics they regard as worth arguing about. Yet their own arguments about everyday matters offer a valuable point of entry. Yet, teachers are likely to be uncertain about what classroom debate should accomplish. As a result, they tend not to be comfortable devoting classroom time to discussion of 'trivial' topics like music groups or even dress codes. At least students should be airing their views on something important, a teacher might think, a topic that will contribute to their education. (p. 116)

As this fragment shows the question arises as to whether issues that teachers regard as important are similarly seen by the students and will, thus invite students into meaningful interactive argumentation. As Zohar and Nemet (2002) put it, the nature of the task can be very important and what we see as authentic tasks might not be part of what students consider as authentic – part of their daily lives, where they have access to inside information of key players within a complex topic (e.g., Gulikers, 2006). The argumentation patterns might have been different if students could argue about difficult and wicked problems, which concern their own lives.

Methodological considerations

Measuring Argumentative Interactions

In Chapter 1 we indicated that the focus of this dissertation was on the argumentative interactions, because we started from the idea that knowledge is situated in a social context and is dialogical in nature, either with somebody else or within oneself. Measurement of individual learning effects is therefore very complex and very difficult. To grasp these effects is very difficult because of the interdependency of the individual with her or his social context.

However, despite this complexity of measuring individual learning effects there is always the question 'what did they learn?', which is a very legitimate question since the overall goal of the educational system is to certify as many individual students as possible. As Chan and Van Aalst (2004) state, "there is need to consider ways to capture, assess, and characterize both individual and collaborative aspects of knowledge construction in CSCL" (p. 87). It may be a valuable approach to combine researching the effects *with* CSCL with the approach of researching the effects *of* CSCL (Salomon, Perkins, & Globerson, 1991). Kolodner and Guzdial (1996) explain that the effects of learning *with* CSCL means to answer the question what students are able to do in collaborating by using the technology that is difficult without it, what we tried to reach in this dissertation. Effects *of* CSCL describe how the student is changed by the experience of using the software or participating in interactive argumentation.

Because of this, we included in the last two studies some measurements of the effects of discussions on the collaboratively written argumentative text (study 3, Chapter 4) and on the short individually written opinions (study 4, Chapter 5). In chapter 4 we described the measurement of the argumentative quality of a collaboratively written text after discussing the topic of GMO and in chapter 5 we described a measurement of the way students individually argue after the collaborative task. In both cases we found no significant relationships between these effect measurements and the breadth and depth of the preceding collaborative discussion. Other researchers have also tried to measure the effects of CSCL after discussion. For example, Van Drie, Van Boxtel, Jaspers, and Kanselaar (2005) measured both the effect on the quality of collaboratively written texts and improvement of individual subject-matter knowledge after the collaborative construction of external representations within a CSCL environment. They found few effects of the different representational tools on text writing and all students improved their subject-matter knowledge regardless of the kind of representation tool they used. Van Drie (2005) raises the question of whether the fact that students were actively involved in the information was probably more important for improvement of individual knowledge than the effect of different representational tools within CSCL.

During our studies we developed our method of measuring breadth and depth of discussions and with it determined individual and collaborative sequences. The total number of sequences represented the breadth of discussion and the average length of the sequences the depth of discussion. These measurements give more information about the quality of arguing than only counting the frequency of different argumentative acts. However, our method could be extended with sequential analysis as proposed by Jeong (2001). With sequential analysis we could examine patterns in student interactions which consequently helps to answer questions such as: (1) What happens when an opinion is followed by a supportive theory or followed by an alternative theory? (2) What kinds of interactive argumentation can be expected to immediately follow a supportive theory? (3) When and how often do students follow-up supportive theories with counter arguments or evidence with rebuttals? Answering these kinds of questions provides much information about the ways students argue. Knowing more specifically how students behave during arguing, consequently leads to better possibilities to design adequate tasks and CSCL environments.

Reflective remarks concerning design

Several reflective remarks to the design of this dissertation need to be addressed. First, the studies in this dissertation used the same topic. This was a conscious decision in order to keep the studies comparable.

However, this also gives some limitation in generalising results. The question arises as to whether results would have been different if different topics had been chosen. We already mentioned this in the section about the authenticity of the tasks. However, the studies in this dissertation are embedded in the context of a group of researchers, who do different kinds of studies into the effects of CSCL on student interactions (e.g., Janssen et al., 2007; Van Amelsvoort, 2006; Van Drie, 2005). These studies cover a large variety of wicked problems (i.e., history, economics, and medical studies). In most of these studies argumentation also is analysed and they all show students arguing superficially and avoiding disagreements. Thus, despite of the limitations due to one topic over all studies, or results are in line with studies using other topics.

Another limitation is due to the context in which the studies were carried out, at high schools with students aged 16/17. Choosing such an ecological valid setting for the studies leads to studies very close to the actual school learning situation and makes results more usable for practice. However, doing research in an ecological valid setting is also complex and difficult. There are so many variables that affect student behaviour that interpreting results and comparing studies is difficult and diffuse. Thus, caution is needed in generalising the findings to other contexts than upper secondary education, to other CSCL environments, and other topics.

Finally, in our studies we looked at the effect of CSCL on interactive argumentation within dyads. No comparison was made with face-to-face interaction or larger groups. Results even suggest that students first have to overcome some social problems during interaction and have to learn about the differences between arguing to learn and arguing to debate before they can benefit from tools. More research is needed in which students who are experienced with arguing to learn work with CSCL tools and CMC. Taking into account this premise, probably it is valuable to compare the interactions of students supported with CSCL with those of students working face-to-face.

Educational implications

There are three major educational implications that can be drawn from the results of this research. First is the issue of the way schools teach argumentation. In most Dutch schools, argumentation is taught as a technique in the Dutch language lessons where there is much attention for different kinds of genuine and pseudo evidence and the way to convince opponents. As we noted, this can strengthen the argument frame of 'argumentation as debate' which can lead to the effect of students who are triggered to quickly resolve their disagreements and just gather different arguments without elaborating them. When the goal is to draw students into arguing to learn, they need to learn that there are different kinds of argumentation, dependent on the goal they have to reach with a discussion. Schools can play a major role in this by explicitly teaching students this and by teaching this not only in language lessons, but also by using it during science and history lessons, because these domains contain many wicked and complex problems with no correct answer.

Second, in this study we left out the teacher since we wanted to simplify the learning context. However, teachers play an important role during argumentation tasks such as locating conflicts and disagreements, stimulating students to solve them, stimulating students to elaborate on supportive or alternative theories, and giving feedback on the accuracy of arguments. CSCL environments can give opportunities for teachers to this. During collaboration teachers can follow the student communication, read the chat that was produced, and provide feedback were necessary.

Finally, we raised the issue of the social and pedagogical context in which argumentation tasks take place. It is important to have contexts in which students feel safe and discuss with real engagement. Teachers can help students to overcome the avoidance of conflicts, by making these conflicts explicit to then and by supporting them in their solution.

Final conclusion and reflection

The studies in this dissertation have shown that CSCL tools can support arguing to learn, but that there are several issues that intertwine and that need to be overcome before CSCL can function optimally. Looking back at the conversation between the two boys at the beginning of this dissertation we have to conclude that more research is needed to help students to advance their knowledge by arguing. Many more questions appear on different kind of topic such as:

(1) What happens to the broadening and deepening of the space of debate when students make continual and long-term use of representational tools within CSCL environments for carrying out argumentative tasks aimed at arguing to learn in their normal course work?
(2) What happens to this broadening and deepening when using tools for raising awareness of disagreement instead of tools representing the structure of argumentation?
(3) How can we combine different types of CMC to support different interactive processes during argumentation?
(4) What kind of argument frames do students use during different kinds of argumentative tasks and can this eventually be changed by instruction and the educational context?
(5) Does experience with discussing more everyday topics help students to discuss scientific problems?

At the end of this dissertation it is very important to call to mind what we try to accomplish. This chapter started with a made up conversation between Bob and Martin, showing the ideal picture. Arguing to learn is about exploring a space of debate which means that students can make meaning of their own of a difficult topic. We want engaged and motivated students who can help each other to explore different views on a difficult topic. This brings instruction to a higher level. Along with designing the educational context and CSCL environment we have to find out what it is that students may be motivated to discuss with real engagement (i.e., Andriessen & Schwarz, in press; Kuhn, 2007) and how we can create a learning context where they feel 'safe' to build knowledge together and can use arguing to learn as means for knowledge building (i.e., Kreijns, Kirschner, & Jochems, 2003). For CSCL, the question is how we can develop environments in which students are optimally stimulated to really explore a topic instead of just following the instructions. However, this is not only due to the CSCL environment itself, which is a rather technology driven way of thinking, but also a matter of using CSCL in a sound pedagogical context which corresponds to the view of learning as collaboratively exploring the space of debate (i.e., Andriessen & Sandbergen, 1999; Strijbos, Kirschner, & Martens, 2004).

Arguing to learn is complex, maybe even more complex than the skill of debating, because we need an open mind for broadening our perspective and need persistence to deepen every different view on a topic. We hope this dissertation offered some theoretical and empirical notions for helping students to learn 'arguing to learn' and for further developing CSCL to support these processes.

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Samenvatting

Vandaag de dag is debatteren een vaardigheid die veel leerlingen op school leren. Veel scholen nemen deel aan Tv-programma's als 'Op weg naar het Lagerhuis' waar het gaat om welke school de best debatterende leerlingen aflevert. In het vak Nederlands is er veel aandacht voor wat degelijke argumentatie is, op welke manieren je een betoog moet schrijven en op welke manier je een tegenstander kunt overtuigen van jouw gelijk. Het kan dus geconcludeerd worden dat de gemiddelde HAVO/VWO leerling tegenwoordig wel heeft geleerd om te argumenteren.

Echter, in dit proefschrift willen we laten zien dat leerlingen toch veel problemen ondervinden tijdens argumenteren, voornamelijk als het gaat om *argumenteren om te leren*. In dit proefschrift maken we onderscheid tussen deze vorm van argumenteren en *argumenteren tijdens debatteren*. Onderzoek heeft aangetoond dat wanneer het doel is dat leerlingen leren van een onderwerp, deze laatste vorm van argumenteren minder effectief is. Om te leren moeten leerlingen op een open manier een onderwerp vanuit verschillende perspectieven kunnen bekijken en met elkaar ieder perspectief goed kunnen uitdiepen. In deze dissertatie noemen we dit *het verkennen van de debatruimte in breedte en diepte*. Onderliggende gedachte is dat argumenteren om te leren een interactief en collaboratief proces is, individuele leerprocessen ondersteunt en studenten helpt om hun kennis over een onderwerp te verbreden en te verdiepen. De debatruimte bestaat uit alle meningen, argumenten, en feiten die bij een bepaald onderwerp horen. Verbreden heeft te maken met alle standpunten plus bijbehorende argumenten die te onderscheiden zijn binnen een onderwerp. Verdiepen is de uitdieping van één bepaald subonderwerp binnen de debatruimte.

Vaak vinden studenten discussiëren en argumenteren erg moeilijk. Veel discussies blijven daarom oppervlakkig en studenten hebben duidelijk moeite zich te verdiepen in het perspectief van een ander, met het geven van tegenargumenten en het onderbouwen met goed bewijs. Doel van deze dissertatie was uit te vinden of computer ondersteund leren (CSCL: computer-supported collaborative learning) studenten kan ondersteunen tijdens argumenteren om te leren op een zodanig manier dat ze minder last hebben van genoemde moeilijkheden. De hoofdvraag van dit proefschrift was daarom: *Wat zijn de effecten van verschillende karakteristieken van CSCL omgevingen op interactieve argumentatie en dan meer specifiek op de verbreding en verdieping van de debatruimte, en hoe kunnen deze effecten verklaard worden?* In drie studies zijn twee karakteristieken van CSCL omgevingen onderzocht: (1) het gebruik van argumentatieve diagrammen en (2) verschillende soorten computer ondersteunde communicatie (CMC: computer-mediated communication). De resultaten van deze studies lieten zien dat er een grote variatie is in de manier waarop paren studenten met elkaar discussiëren. Daarom is een vierde studie uitgevoerd, waarin bekeken is welke relatie er bestaat tussen individuele epistemologische opvattingen en de manier waarop studenten in een collaboratieve taak discussiëren. Ook werd in deze vierde studie onderzocht of het gedrag van studenten ten opzichte van argumenteren veranderde wanneer ze halverwege de taak een vragenlijst kregen die hun aandacht richtte op wat voor soort argumentatie er verwacht werd.

Studie 1: het gebruik van argumentatieve diagrammen voor of tijdens een discussie?

Het tweede hoofdstuk van deze dissertatie richtte zich op de vraag hoe argumentatieve diagrammen gebruikt kunnen worden bij het bediscussiëren van een complex probleem. Meer specifiek of studenten baat hebben bij het maken van individuele diagrammen *voor* de discussie vergeleken met het maken van collaboratieve diagrammen *tijdens* de discussie.

Twintig paren studenten uit twee verschillende onderzoeken (SCALE en Twins) werden vergeleken. In het eerste onderzoek werd aan tien paren gevraagd om zich voor te bereiden op een discussietaak door het maken van een eigen argumentatieve diagram dat hun mening weergaf. Deze diagrammen moesten ze dan tijdens de discussie met elkaar vergelijken. In het tweede onderzoek werd aan tien paren gevraagd om tijdens de discussie in de CSCL omgeving samen een diagram te maken. In beide onderzoeken voerden studenten dezelfde discussietaak over genetische modificatie (GM) uit en werden gevraagd om na de discussie een gezamenlijke argumentatieve tekst te schrijven die hun mening van dat moment weergaf. In beide onderzoeken werd de taak uitgevoerd in de CSCL schrijfomgeving TC3. Studenten communiceren in deze omgeving met behulp van een chat box. Voordat studenten gingen discussiëren werd ze ook gevraagd om verschillende bronnen over GM te lezen.

We verwachtten dat diagrammen de discussies zouden verbeteren doordat ze gebruikers stimuleren om expliciet te zijn over hun mening en argumenten, stimuleren om de aandacht te richten op de taak en stimuleren om consistent en genuanceerd te zijn. Uiteindelijk zou het gebruik van een diagram tijdens de discussie dus moeten leiden tot een bredere en diepere discussie. De uitkomsten van de studie laten zien dat dit niet het geval is. In beide onderzoeken lijken diagrammen wel studenten te stimuleren hun aandacht op de taak te richten, maar tot echt brede en diepe discussie leidt het gebruik van diagrammen in beide gevallen niet. In het onderzoek waarbij studenten tijdens de discussie ook samen een diagram maken, blijkt dat het diagram vaak gereduceerd wordt tot een notitieblok om je goede argumenten in te noteren. Discussie aan de hand van het diagram vindt nauwelijks plaats. In beide onderzoeken is de argumentatie tussen leerlingen nog steeds meer een kwestie van het uitwisselen van argumenten dan dat de discussies gekarakteriseerd kunnen worden als diep. Wel blijkt dat het gebruik van diagrammen tijdens de discussie het gesprek over wat goede argumentatie is stimuleert. Echter, dit heeft geen positief effect op wat studenten uiteindelijk *doen* tijdens het argumenteren.

Studie 2: hoe diagrammen het argumenteren om te leren kunnen ondersteunen

In de tweede studie wordt de mogelijke rol van diagrammen verder onderzocht. Twee condities met ieder twintig student paren worden met elkaar vergeleken. In de ene conditie worden de paren ondersteund door een argumentatief diagram en in de andere conditie door een outline tool waarin de opbouw van de tekst weergegeven kan worden. De paren studenten voerden dezelfde taak uit als in studie 1. Eerst werd ze gevraagd om the discussiëren over GM en daarna een betoog te schrijven. Studenten gebruikten weer de CSCL omgeving TC3 en communiceerden via chat. De taak werd voorbereid met het individueel lezen van verschillende informatiebronnen.

Gezien de eerder genoemde voordelen van diagrammen werd verwacht dat de studenten die een diagram maakten tijdens hun discussie het beter zouden doen wat betreft het verbreden en verdiepen van de discussie dan de paren studenten die de outline tool gebruikten. De resultaten bevestigden dit deels. Paren die een diagram maakten hebben een diepere discussie dan paren die een outline tool gebruikten wanneer de inhoud van de diagrammen en outlines werd meegenomen in de analyse. Paren doen het echter beter met een diagram door wat er in de diagrammen zelf gedaan wordt en niet omdat de chat discussies uitgebreider zijn. Het lijkt er op dat studenten die een diagram tot hun beschikking hebben het niet meer nodig vinden om via chat met elkaar te discussiëren en de diagrammen gebruiken als medium voor discussie. Dit resulteerde dan wel in relatief veel individueel geconstrueerde argumentatieve sequenties.

Studie 3: De impact van synchrone of asynchrone CMC op argumenteren om te leren
De derde studie beschreven in hoofdstuk vier onderzoekt wat de impact is van verschillende vormen van CMC, specifiek het verschil tussen synchrone (chat) en asynchrone discussie (discussion board). Paren studenten verdeeld over twee condities voerden dezelfde taak uit als beschreven in de tweede studie. Twintig paren gebruikten daarbij chat en negentien paren een discussion board. De paren die chat gebruikten, discussieerden in de CSCL omgeving TC3 en de paren die het discussion board gebruikten in Blackboard Academic Suite™. De schrijffase werd door beide condities in TC3 uitgevoerd.

Op basis van de media synchronicity theory werd verwacht dat baat hebben bij de mogelijkheid om meerdere discussies naast elkaar te voeren (parallelle discussies) wanneer zij informatie moeten verzamelen of zicht moeten krijgen op meerdere perspectieven (verbreden). Op basis van dezelfde theorie wordt verwacht dat in deze situatie van verbreden het krijgen van directe feedback van de gesprekspartner niet nodig is. Daarnaast werd verwacht dat een proces van verdieping (uitdiepen van een perspectief, het eens worden) baat heeft bij een medium waarin er sprake is van onmiddellijke feedback van de gesprekspartner. De resultaten van de studie bevestigden deels deze verwachtingen. Studenten die chat gebruikten tijdens de discussiefase waren breder en dieper in hun discussies dan studenten die het discussion board gebruikten. Onmiddellijke feedback lijkt een erg belangrijke voorwaarde wanneer studenten argumenteren om te leren. Echter, in deze studie werd ook voor het eerst gekeken naar de kwaliteit van de argumentatie in de uiteindelijke teksten. Daaruit bleek dat de argumenten in de teksten van leerlingen die asynchroon hadden gediscussieerd beter van kwaliteit waren dan die van leerlingen die synchroon hadden gediscussieerd. Voor de kwaliteit van het eindproduct lijkt daarom de tijd voor reflectie die een asynchroon medium geeft van belang.

Studie 4: Invloed van epistemologische opvattingen en de invloed van bewustwording van controversies

Uit de eerste drie studies werd duidelijk dat er een grote variatie is in hoe leerlingen in de debatruimte hun discussie verbreden en verdiepen. De invloed van de karakteristieken van CSCL kon veel van die variatie niet verklaren. Daarom werd in de vierde en laatste studie de invloed van individuele epistemologische opvattingen en de kennis van argumenteren op de breedte en diepte van discussies onderzocht. Daarnaast werd bekeken welke invloed een vragenlijst over het verloop van de discussie over een eerste casus, zou hebben op de discussie over een tweede casus. Na een aantal individuele voortesten op het gebied van epistemologische opvattingen en kennis van argumenteren, werden 25 paren van studenten gevraagd te discussiëren over GM in de CSCL omgeving DREW. In deze studie werden studenten niet meer gevraagd om te discussiëren over het onderwerp GM in zijn geheel, maar om twee casussen over deelonderwerpen te bediscussiëren. Na de eerste casus kregen de leerlingen een vragenlijst met daarin vragen over de manier waarop ze in de eerste casus met elkaar gediscussieerd hadden. Deze vragen waren er gericht op studenten bewust maken van wat er van hen gevraagd werd op het gebied van argumenteren. Na de tweede casus vulden de studenten individueel een posttest in waarmee gemeten werd hoe breed en diep hun argumentatie over GMOs na de discussie was.

Er werd verwacht dat leerlingen die meer complexe epistemologische opvattingen hebben, betrokken zouden zijn bij bredere en diepere discussies en daardoor ook een betere score zouden behalen op de posttest. Daarnaast werd verwacht dat de vragenlijst studenten zou stimuleren om breder en dieper met elkaar te discussiëren. Uit de resultaten bleek dat studenten in tweede casus inderdaad breder en dieper met elkaar argumenteerden en dat ze veel meer argumentatieve sequenties echt gezamenlijk opbouwden. Dit zou kunnen wijzen op een positieve invloed van de vragenlijst, maar vanwege de opzet van de studie kan hier over geen definitief uitsluitsel worden gegeven. Ook was uit de resultaten af te leiden dat individuele epistemologische opvattingen nauwelijks invloed lijken te hebben op hoe leerlingen met elkaar discussiëren. Wel is het zo dat er een duidelijke relatie bleek te zijn tussen epistemologische opvattingen en de individuele post test scores. Dus, leerlingen met een complexe epistemologische opvatting discussiëren niet breder en dieper, maar hebben wel een bredere en diepere individuele argumentatie na de collaboratieve taak.

Conclusie en reflecties

Uit de studies blijkt dat studenten ondanks de ondersteuning van een CSCL omgeving nog moeite blijven houden met argumenteren om te leren. Diagrammen lijken de discussie enigszins te ondersteunen, maar dan vooral op het vlak van *hoe* een goede discussie eruit zou zien. De discussie vindt dan ook grotendeels *in* de diagrammen plaats en niet in de gesprekken met behulp van chat. De vragen die hierbij opkomen, zijn of de diagrammen die werden gebruikt in de studies wel geschikt zijn voor argumenteren om te leren of juist debatteren ondersteunen. Ook is de vraag hoe studenten dit soort tools gaan gebruiken wanneer ze een langere periode een aantal malen werken met diagrammen tijdens het discussiëren.

Uit de derde studie blijkt dat het onmiddellijk reageren op berichten erg belangrijk is voor het verdiepen van een discussie. Echter, wel bleek dat de uiteindelijke producten van leerlingen die asynchroon hadden gediscussieerd van betere kwaliteit waren wat betreft argumentatie. Dit roept de vraag op of het mogelijk is om verschillende typen CMC met elkaar te combineren in de taken rondom argumenteren om te leren.

De laatste studie liet zien dat het zinnig kan zijn om studenten bewust te laten worden van hun kijk op de taak en discussiëren. Het is de vraag in hoeverre ze dit kan helpen om breder en dieper met elkaar te argumenteren binnen de debatruimte. Daarnaast is het de vraag hoe studenten de gegeven taken opvatten. Zijn het voor hen echt discussietaken waarin het draait om het leren over een onderwerp of zien ze dit soort taken toch anders? Begrijpen leerlingen het verschil wel tussen discussies die draaien om argumenteren om te leren en discussies die draaien om het overtuigen van elkaar?

Ook laat de laatste studie zien dat individuele epistemologische opvattingen niet van invloed lijken te zijn tijdens samenwerken. Blijkbaar worden individuele opvattingen weggedrukt door wat er speelt aan interactieprocessen. Het is belangrijk uit te vinden waarom studenten het lijken te vermijden om het oneens met elkaar te zijn en meningsverschillen snel proberen op te lossen.

Deze dissertatie eindigt met de suggesties om in de onderwijspraktijk meer aandacht te besteden aan argumenteren om te leren en minder de nadruk te leggen op debatteren. Ook is het belangrijk dat argumenteren niet alleen geleerd wordt bij het vak Nederlands maar in allerlei plaatsen van het curriculum terug komt als middel om te kunnen leren over een onderwerp. Docenten zouden daarbij veel aandacht moeten besteden aan de sociale processen die spelen tijdens samenwerken om daarmee een veilig klimaat te creëren. Studenten krijgen zo de gelegenheid om met een open blik met elkaar te discussiëren over een onderwerp.

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Don't think me unkind, words are hard to find
They're only cheques I've left unsigned, from the banks of chaos in my mind
And when their eloquence escapes me, their logic ties me up and rapes me [*]

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[*] De do do do de da da da, The Police

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In the Lord put I my trust. †

Lisette

† Psalm 11: 1

Curriculum Vitae

Lisette Munneke (-de Vries) was born on the 12th of June 1976, in Swifterbant a part of the community of Dronten in the Netherlands. She completed her secondary education in 1995 at the Greijdanus-college in Zwolle, and started her graduation in Educational Sciences at the Utrecht University. She specialised in learning with new technologies and educational design. During her graduation she started teaching statistics and methodology of research. She graduated cum laude in May 2000. Since June 2000 she has been working as a Ph.D. candidate at the department of Educational Sciences at Utrecht University. Besides this work she taught several courses in learning with new technologies and statistics. Currently, she is working at the teacher education institute of mathematics at the Hogeschool Utrecht, where she is teaching educational sciences, statistics, several other courses, and is participating in applied research.

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