Knowledge construction through CSCL:
Student elaborations in synchronous, asynchronous, and three-dimensional learning environments

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Knowledge construction through CSCL:
Student elaborations in synchronous, asynchronous, and three-dimensional learning environments

Een wetenschappelijke proeve op het gebied
van de Sociale Wetenschappen

Proefschrift

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door

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Voorwoord

Toen mij eind jaren negentig van de vorige eeuw, ongeveer 20 jaar na mijn eerste onderwijsaanstelling aan de universiteit in Nijmegen, gevraagd werd mee te doen aan een internationaal onderzoeksproject met betrekking tot Computer-Supported Collaborative Learning (het CL-Net) was er, wat mij betreft, in de verste verte geen sprake van een proefschrift. Toen in 2000 het woord "promotie" viel, leidde dat tot een hele dag van stille overpeinzing. Ten eerste leken mij de gegevens die ik voor het CL net verzameld had niet voldoende om op te kunnen promoveren, ten tweede zat de onderzoekstijd er bijna op en dat zou betekenen dat er veel vrije tijd geïnvesteerd zou moeten worden.

Thuis gekomen, waren de reacties van mijn naaste omgeving nogal gevarieerd. Hein zei: "Het zou een stunt zijn"; Rik (toen 10) vroeg: "Wat moet je dan doen?" En toen ik hem zei dat ik dan een boek zou moeten schrijven reageerde hij: "Dat lukt je nooit." Maite (toen 6) was zwaar teleurgesteld dat het beroep "doctor" niet in haar beroepenkalender stond. Al met al een motiverende start!

Het proefschrift gaat over samenwerkend leren en is een product van samenwerking waarin veel geleerd is. Het was fijn om met een aantal deskundige mensen samen te werken. Hen met name ben ik veel dank verschuldigd. Allereerst promotor Robert-Jan Simons, die met zijn inspirerende stellingen de motto's gaf voor dit proefschrift. Zijn kennis en inbreng heb ik zeer gewaardeerd. Vervolgens co-promotor Simon Veenman, met wie ik al jarenlang op onderwijsgebied samenwerkte, maar van wie ik nu ook de gedrevenheid en het vakmanschap van het doen van onderzoek leerde kennen. Ook Frank de Jong, als tweede co-promotor dank ik voor zijn inzet bij de totstandkoming van dit proefschrift. Het samenwerken met hen heeft de kwaliteit van dit proefschrift verhoogd. Ik dank hen voor hun inzet en vriendschap.

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Dit proefschrift is zoals gezegd een product van samenwerking. Ik dank Hans Scheltinga en Anneriet van den Akker voor de hulp bij het coderen en analyseren van de interacties van de asynchrone communicatie. Ook Jeroen Janssen en Mirjam Winkelmolen, die eerst tijdens hun afstudeerfase en later in hun eerste onderzoeksbanen bij het NWO-"Active Worlds project" altijd bereid waren mee te denken, dank ik voor hun hulp en warme collegialiteit.

De onderzoeken die beschreven staan in dit proefschrift, waren nooit gerealiseerd zonder de medewerking van scholen en met name van de docenten van basisschool "De Luithorst" in Nijmegen, basisschool "De Tragellijn" in Lobith, het Raayland College in Venray, het Montessori Lyceum in Den Haag, de Openbare Scholengemeenschap de Bijlmer, de "Rijk Kramer" basisschool in Amsterdam en de scholen in Italië. Ik dank deze scholen en met name de docenten voor hun inzet tijdens mijn onderzoek en de bereidheid om hun leerlingen aan innovatieve werkvormen deel te laten nemen. Tot mijn grote genoegen zijn er op enkele van deze scholen samenwerkingsprojecten, verwant aan mijn onderzoek, voortgezet.

Naast de inhoudelijke kant van dit boek is ook het uiterlijk een resultaat van samenwerking. De ontwikkeling van een van manuscript als word-document tot een drukklaar PDF-file was een interessant proces, waarbij ik van verscheidene mensen hulp gehad heb. Dank daarvoor. De discussies over de omslag waren legio: het visualiseren van sycnchrone en asynchrone communicatie voor de omslag van "mijn boek" was weer een proces op zich. Voor dit "cover design" dank ik Hein en Arjan. Het resultaat van deze samenwerking mag gezien worden!

Nu, juli 2005, kunnen de CD-s van de Wolvetones en Ennya weer in de kast, de stapels boeken kunnen uit de serre verdwijnen en de huiskamertafel kan papiervrij gemaakt worden, het proefschrift is af. Het werken eraan is vrijwel altijd met plezier gebeurd, zij het dat het soms frustrerend was om naast het gewone werk de uren bij elkaar te sprokkelen om aan het proefschrift te werken. Hier past dan ook een woord van dank aan mijn vrienden en mensen in mijn thuissituatie die er mede voor gezorgd hebben dat ik mijn "uren aan de computer" kon maken, door taken in het huishouden over te nemen, op tijden de zorg voor de kinderen op zich te nemen, door belangstelling te tonen, of gewoon door er te zijn met hun vriendschap, zorg en liefde. Het is goed dat hier in dit boek uit te spreken.

Voor Hein
"The wind beneath my wings"

Chapter 1
General introduction

> *What constitutes a useful design for computer-supported collaborative learning, and what issues need to be addressed in designing CSCL environments? Practitioners of CSCL do not have definite answers to these questions. CSCL is too new and untested for anyone to be prescriptive and in any case, different designs will be needed in order to meet requirements of different tutors, learners, and institutions* (McConell, 2000, p.113).

1.1 Purpose of the study

One of the responsibilities of education is to prepare learners for participation in a networked information society where knowledge is perhaps the most critical resource for both social and economic development. Educational institutions are being challenged to discover and develop new instructional methods to meet the needs of society today. Ideas for such a new approach can be derived from society in general and from research on learning and instruction in particular. More specifically, a new learning approach should encompass: new learning outcomes, new types of learning processes, and new instructional models (Simons, Van der Linden, & Duffy, 2000).

The principles underlying constructivist theories of learning and the general assumption that learning involves the active construction of knowledge have strongly influenced recent thinking about new ways of learning. Learning is more and more seen to involve not only the memorization and recall of relevant study materials but also such activities as the search for, elaboration, and transfer of information in interaction with others. Constructivist theories suggest that learning occurs via dialogue with others rather than on an individual basis (Shuell, 2001). And it is therefore assumed that students should be encouraged to become active learners who engage in the knowledge construction process both inside and outside the classroom. That is, all daily life experiences can be part of the knowledge construction process in addition to direct teacher instruction and individual study. And the process of knowledge construction should therefore not be looked upon as an individual affair but rather as a process of interaction and negotiation with others in the learning environment including peers, teachers, and the available teaching materials (Van der Linden, Erkens, Schmidt, & Renshaw, 2000). So-called collaborative learning approaches fit rather well into a constructivist view of learning.

With the widespread emergence of various information and communication technologies (ICT), numerous new opportunities for learning in general and collaborative learning in particular have been created. Using the internet, students can explore issues in a much broader but also more detailed manner than ever before (cf. Simons et al., 2002a). The use of ICT facilitates new educational goals and possibilities related to new forms of communication (including distant communication), new ways of learning (collaborative knowledge construction) and new forms of intentional and self-directed learning (Simons et al., 2000a). The internet now allows both synchronous and asynchronous communication and thus provides numerous and varied opportunities for collaborative learning (Smeets & Mooij, 2001). According to Lehtinen, Hakkarainen, Lipponen, Rahikainen, and Muukkonen, (2000, p.3), in fact, "computers can play an important role in restructuring teaching learning processes to be better prepared for future challenges." Collaborative learning supported by computers is thus, according to these authors, one of the most promising ideas for the improvement of teaching and learning today.

Up until recently, research on computer support for education was primarily concerned with the individual learning process. Over the past few years, however, a shift has occurred towards greater attention to collaborative forms of learning involving ICT tools to facilitate the interaction between students and other students or students and teachers (Fabos, 1999). This type of collaborative learning is generally referred to as "Computer-supported collaborative learning" (i.e., CSCL). CSCL refers to instructional methods which encourage or require students to work together on learning tasks with the interaction between the students mediated by computer networks (Lehtinen et al., 2000). CSCL can thus be realized in different forms using - for example - synchronous communication (i.e., chat) formats, web-based asynchronous communication (i.e., discussion forum) formats, or a combination of the two.

The research on collaborative learning in general (i.e., with or without the support of computers) can be divided into two types of research: effect-oriented and process-oriented research. Effect-oriented research is basically concerned with the effects of collaborative learning relative to the effects of other pedagogic methods. Process-oriented research is more concerned with the collaborative process itself and pinpointing the effectiveness of collaborative learning (i.e., explanation). Within the process-oriented line of research, it is assumed that a collaborative learning situation stimulates the verbalization and explicit formulation of the concepts under discussion (Van der Linden et al., 2000). Furthermore, explicit verbalization is assumed to help students become more aware of the cognitive and metacognitive processes involved in the execution of a task. And students have been found to particularly learn from the provision of so-called "elaborated help" to others (Webb & Farivar, 1994). Elaborated help involves the provision of arguments, justification of viewpoints, and explanation. The provision of elaborated help stimulates the provider to use his or her own knowledge, discover any gaps in this knowledge, and draw connections to other knowledge elements (Van Boxtel, 2000).

Although there are several theoretical arguments suggesting that CSCL should foster the process of knowledge construction by having students work together via computer-mediated networks, few empirical studies have been undertaken to provide support for these arguments as yet. Furthermore, very little research has been conducted with respect to the use of CSCL in Dutch primary or high schools. Most of the research conducted along these lines in the Netherlands concerns higher forms of education such as teacher training programs or university teaching (Erkens, 1997; Lockhorst, 2004; Strijbos, 2004; Veerman 2000; Veldhuis-Diermanse, 2002). And the question that thus arises is whether or not CSCL can, in fact, facilitate the introduction of new ways of learning involving the joint construction of knowledge, as a promising solution to the demands of society.

Research by Bolhuis (2000) and De Kock (2004) has shown collaborative learning procedures - either with or without the support of computer networks - to not be common practice in Dutch secondary education despite the considerable amount of research demonstrating the positive effects of such procedures on the cognitive and social development of students (Cohen, 1994; Dillenbourg, 1999; Johnson & Johnson, 1999; Slavin, 1996). Teachers acknowledge the importance of collaboration among students but report problems with the incorporation of collaborative learning procedures into their curricula due to a lack of the pedagogic skills needed to organize the collaborative learning process or simply the unavailability of suitable study materials and instructional methods (Bolhuis, 2000; Dillemans, Lowyck, Van der Perre, Claeys, & Elen, 1998).

The focus of the present thesis is therefore on the implementation of CSCL in Dutch schools using different communication formats in order to determine if CSCL indeed elicits the process of knowledge construction in the form of the provision of elaborated verbalizations by students. The learning environments utilized in the three studies reported on in this thesis are based on a constructivist view of learning. Boekaerts and Simons (1995) define a learning environment as the sum of all conditions and measures taken to enhance the learning process. Viewed from such a perspective, teaching can be defined as the creation of a suitable learning environment. Lodewijks (1993) speaks of a “powerful environment.” And when such a learning environment is linked with ICT facilities, the power even augments. However, the “power” of such an environment for school learning has yet to be demonstrated. That is, the learning environment must first be shown to increase student activity, stimulate self-regulated learning, create opportunities for authentic learning, encourage collaboration, and help develop various thinking and learning skills before it can be construed as powerful.

The process of knowledge construction is defined within the context of the present thesis as the provision of elaborations in the form of posing comprehension questions that require explanations, the provision of answers with arguments or justifications, the presentation of new ideas accompanied by explanations, and the acceptance or rejection of the ideas of others accompanied by arguments for doing this. The general research question underlying the three empirical studies reported on here is: *Does CSCL elicit the process of knowledge construction in the form of elaborations?* The specific research questions addressed in the different studies concern the influence of the different communication formats used in the three educational settings: a setting involving a synchronous communication format, a setting involving an asynchronous communication format, and a setting involving a combination of both synchronous and asynchronous communication formats. The three studies otherwise share the following characteristics:

- all of the studies were conducted in Dutch primary or high schools;
- all of the studies were conducted in a collaborative learning setting within a normal classroom situation;
- all of the tasks were conducted as part of the normal curriculum;
- all of the teachers participated in the development of the collaborative tasks and in the conduct of the experiments within the classrooms; and
- in all of the studies collaboration was established using web-based communication formats.

All of the studies were conducted in authentic classroom settings involving the electronic facilities provided by the particular schools and not, thus, in an experimental setting.[3] The use of an authentic learning environment provides a context that reflects the manner in which various skills and knowledge can be used in real life. The use of an authentic learning environment also confronts students with those limitations that may be encountered in the real world and real life (Herrington & Olivier, 2000). In two of the settings, open learning tasks were used; in one setting, a structured mathematics task was used.

1.2 Organization of the thesis

This thesis comprises 7 chapters. Chapter 2 describes the theoretical background to CSCL and the concept of knowledge construction. A tradition that has contributed substantially to the development of CSCL is face-to-face (FTF) cooperative learning, which was an important element of the progressive pedagogies developed from the beginning of the twentieth century. Chapter 3 describes the development of a coding scheme to map the process of knowledge construction during the interactions of collaborating students. In current research on collaborative learning processes, peer interaction is increasingly being emphasized. This research shows specific types of interactions during collaborative learning to lead to learning gains under particular circumstances (Dillenbourg, 1999; Webb, 1992; Van der Linden, et al., 2000) The coding scheme was revised several times (Kleine Staarman, Krol, & Van der Meijden, 2005) and finally applied in the three studies reported on here.

The first study is described in Chapter 4 and was the result of involvement in a research program at the Radboud University of Nijmegen entitled “Implementation of Cooperative Learning in Primary Education” (Krol, 2005). In this study, the collaboration between children in two different collaborative settings was compared: children working together on a mathematics task in either a FTF setting in which they sit next to each other to perform the task or in a CSCL setting in which they communicate via synchronous chat. About 40 sixth

[3] An exception is the face-to-face collaboration condition in the first study.

graders from two primary schools in the Netherlands participated in the study. The main research questions were:

- *Does CSCL successfully elicit the process of knowledge construction in the form of the provision of elaborations within a synchronous learning environment?*
- *Do significant differences exist in the interactional behaviors of students working together in a FTF setting versus CSCL setting?*

The first research question was examined by analyzing the *synchronous chat interactions* logged by the computer during the conduct of the collaborative mathematics task. The second research question was examined by analyzing the transcripts of the interactions between the students collaborating in the FTF situation and the saved log files for the children collaborating at a distance using the chat program embedded in the Active Worlds computer program (see below).

The second study is described in Chapter 5 and was carried out within the context of a research project funded by the European Community and entitled "Computer-supported collaborative learning networks in primary and secondary education." The main objective of this project was to investigate the cognitive and pedagogic aspects of using computer-supported collaborative learning networks (CLNs). CLNs are learning environments in which educational technology is used to help create a community of learners who then proceed to construct knowledge together. The central question was just how effective knowledge construction can be supported using CLNs in European primary and secondary education. The research project was conducted by researchers from five different countries (i.e., Belgium, Finland, Greece, Italy, The Netherlands). Almost 600 students from primary, secondary, and vocational education and 25 teachers from a total of 20 schools participated in the project. The part of the research project reported on within the context of the present thesis concerns the implementation of CSCL in Dutch secondary schools. And the specific research question was:

- *Does CSCL elicit the process of knowledge construction in the form of the provision of elaborations within an asynchronous environment?*

This research question was examined by analyzing the *asynchronous interactions* in the form of written contributions to an online discussion forum. The Web Knowledge Forum (WKF), which is a computer network system that provides support for collaborative learning and inquiry, was used for this purpose. At the center of the software is a communal database, which can be filled with contributions from students and teachers. The students enter their own notes, and they can build on or react to each other's notes in order to find the answer to a question or solve a problem. The program encourages students to discuss a topic, bring forward new theories, ask questions, and establish common ground and a shared meaning with regard to a topic and thereby cooperatively construct knowledge (Hewitt & Scardamalia, 1998).

Chapter 6 reports on a study that can be considered a next step in the development of a powerful learning environment using new technical possibilities. The study involves the use of a three-dimensional (3D) virtual learning environment in which students can collaborate with each other both synchronously (via chat) and asynchronously via the WKF (see above). The learning environment is the 3D Active Worlds (AW) program (http://www.activeworld.com). A three dimensional constructive virtual world is a desktop application which has a three dimensional interface (for an extended description, see Chapter 6). The person who logs in takes the form of a little puppet that can gesture and walk or fly through the virtual environment. The constructive aspect implies that the users of the program can actually build their own objects within the 3D environment. Three Dutch and four Italian primary schools participated in the creation of "Euroland" and thus the conduct of the project, which was funded by the European Community to realize international collaboration at a distance. The collaboration within the 3D virtual world was quite concrete due to the possibility of constructing 3D objects within the virtual world and the fact that the students could work together at the same time. The specific research question addressed in the study reported on here was:

- *Does CSCL within a 3D virtual world involving both synchronous and asynchronous communication elicit the process of knowledge construction in the form of the provision of elaborations?*

The research question was examined by analyzing the *synchronous and asynchronous interactions* of the collaborating students. That is, the interactions of the students using the chat program embedded in the AW program and the WKF implemented as part of the AW program were analyzed.

Finally, in Chapter 7, the results of the three studies reported on in the preceding chapters will be combined to provide a broader perspective on CSCL and the use of different communication formats in this connection. First, the results of the three studies will be summarized in conjunction with each other. Second, a number of important theoretical and methodological issues will be considered such as the utility of the coding scheme applied and the potential of CSCL for restructuring teaching. Third, some possible limitations on the studies will be pointed out. Fourth, a number of implications for educational practice and recommendations for future research will be provided. And finally, the new questions generated by the results of this research will be presented for further reflection.

Chapter 2
Theoretical framework: Computer-supported collaborative learning

> *"The act of cooperation is something which is deeply embedded in western societies. It seems to be a fundamental aspect of our everyday lives that people cooperate, although we do make choices about when to cooperate and with whom"* (McConnell, 2000, p. 5)

2.1 Introduction

In the last decades, views on learning and instruction have changed fundamentally. Simons et al. (2000a) mention three important reasons for this change. First, greater attention is being devoted to the role of active and self-directed learning than before. Second, a much greater emphasis is being placed on active and collaborative learning than before. However, active learning is only possible when students have learned to monitor their learning and to communicate about their learning with others. Third, the new forms of learning have a stronger basis in the psychology of learning and instruction than previous forms of learning (Simons et al., 2000a).

In most contemporary theories of learning, which are generally referred to as constructivist learning theories, the learner is assumed to not merely remember and reproduce the material to be learned, but construct a mental representation of the material and the task to be performed, select relevant information, and interpret this information on the basis of his or her existing knowledge (Shuell, 2001). In constructivist theories of learning it is further assumed that learning typically occurs via dialogue with others, and not just individually.
As a result of this changing situation and the introduction of technology in education, the interest in peer learning, collaborative learning (CL) and computer-supported collaborative learning (CSCL) has greatly increased. The term "peer learning" is mostly used in a general sense, while the term "collaborative learning" refers to any of a number of instructional strategies or contexts in which students work in small groups to achieve a common goal (Lehtinen et al., 2000). Similarly, the term "computer-supported collaborative learning" refers to a learning situation in which student collaboration is mediated by computers.

The mechanisms underlying effective peer learning have been explained from different perspectives: social-behavioural approaches, cognitive-developmental approaches, and the cognitive elaboration approach. In the present thesis, the importance of cognitive elaboration approach will be stressed and further explored. Information and communication technology (ICT) is increasingly being used to support and promote collaborative learning. Learners can collaborate via computers and communicate both synchronously (at the same time, asynchronously (at different times), or use both communication formats to collaborate. The role of ICT in collaborative learning will be considered in detail in the present study, along with the advantages and disadvantages of the different forms of communication.

In the present chapter, recent perspectives on learning (section 2.2) and peer learning (section 2.3) will be discussed. In section 2.4, collaborative learning is defined in greater detail and the relevant CL research is reviewed. CSCL is described in section 2.5.1; computer-mediated collaboration versus face-to-face communication are then compared in section 2.5.2; synchronous communication versus asynchronous communication are compared in section 2.5.3; the combination of synchronous and asynchronous communication is considered in section 2.5.4; and the advantages and disadvantages of both CL and CSCL are discussed in section 2.5.5. Finally, the general research question motivating the present research will be introduced in section 2.6 along with a schematic outline of the theoretical framework underlying the present research.

2.2 Recent perspectives on learning

Most constructivist learning theories share three sets of beliefs (Shuell, 2001). First, learning is assumed to be an *active, self-regulated, constructive, cumulative,* and *goal-oriented* process. Learning is *active* because the learner carries out various cognitive operations on the information being learned, which results in the material being acquired in a meaningful manner. Learning is *self-regulated*, because the learner makes decisions about what to do next during the learning process (e.g., seek answers to questions, search for other sources of information); the learner monitors the learning process; and the learner may make adjustments at times during the learning process (Boekaerts & Simons, 1995). Self-regulated learning involves such metacognitive, motivational, and behavioral processes as goal setting, planning, selection of learning strategies, self-reinforcement, self-recording, and self-instruction. In other words, learning is undertaken proactively by students, rather than reactively as a result of teaching experiences (Zimmerman, 2002). Learning is also *constructive,* which means that knowledge is actively constructed by the learner who interprets new information on the basis of such factors as prior knowledge, interest, and motivation. Learning is *cumulative*, which means that new knowledge is built upon prior knowledge, skills, and experiences (Verschaffel, & De Corte, 1998). Learning is *goal-oriented*, which means that the provision of specific learning goals can facilitate the learning process. In the light of the constructive and self-regulated nature of learning, moreover, it is assumed that learning will be most successful if learners set their own learning goals (Shuell, 2001).

A second common assumption regarding learning today is that it is *situated* in a particular context in which it occurs and that it is *collaborative* (De Corte, 2001). According to situated theories, knowledge and learning are situated in a particular social context; distributed across various learners, artefacts, and tools (e.g., books and computers); and embedded in the norms and practices of the group in which the learner is participating. The focus of learning today is also more on practices the learner is participating in, than on the knowledge the learner acquires. Learning processes occur in continuous interaction with the social and cultural surrounding and not merely in the head of the individual learner (Verschaffel & De Corte, 1998). This situated perspective strongly stresses the importance of collaboration via such activities as the exchange of ideas, the comparison of solution strategies, and the discussion of arguments. Brown, Collins, and Duguid (1989) compare knowledge with a set of tools. People who actively use their tools rather than just acquire knowledge about them, build an increasingly rich understanding of the world. There is nevertheless an ongoing debate with regard to whether cognition is completely context dependent or partly context dependent, (see, for example the *Educational Researcher*, Anderson, Reder, & Simon, 1996, 1997; Anderson, Greeno, Reder, & Simon, 2000; Cobb & Bowers, 1999; Greeno, 1997). Where there are failures of transfer (Lave, 1988), there are also successes. While some performances benefit from training in a social context (Lave & Wenger, 1991), others do not (Salomon & Globerson, 1989).

A third general assumption with regard to learning today is that is a *social*, *cultural,* and *interpersonal* process. One of the most important differences between traditional and contemporary theories of learning is the role of participation. In traditional behavioral or cognitive theories, learning is typically defined in terms of changed behavior, knowledge, ability, mental processes, structures or understanding (Shuell, 2001). In contemporary theories, learning is defined as a constructive socially-culturally situated process. Knowledge is no longer viewed as a static element to be transmitted. Knowledge is, rather, distributed across individuals, tools, and knowledge therefore requires interaction (De Corte, 2001; Shuell, 2001).

The term "constructivism" is actually an umbrella term for a wide variety of views (Duffy & Cunningham, 1996). And according to Phillips (1995), the various forms of constructivism can be located along three basis continua. The first continuum concerns the construction of knowledge, with the construction of knowledge by the individual learner on the one side and the general construction of human knowledge on the other side. The second continuum concerns the process of knowledge construction and whether this process is influenced by the learner or imposed from the outside. The third continuum concerns the active construction of knowledge whether this can be described in terms of individual or social processes. The conceptualisation of learning as an individual process with emphasis on the acquisition of knowledge and cognitive skills lies at the one extreme while the socio-cultural conception of learning with an emphasis on collective participatory processes, active knowledge construction, context, interaction, and a situated perspective lies at the other extreme. Within the context of the present thesis, it is assumed that learning takes place in the individual mind and also within a social context. Salomon and Perkins (1998) have highlighted four views that appear to shape one's theoretical perspective on learning and development: (1) whether or not individual learning is viewed as embedded in social processes and individuals and groups are thus assumed to help the individual learn (or not); (2) whether or not knowledge is viewed as jointly constructed, the result of participation in a social process, and thus distributed; (3) whether or not social artifacts and such tools as books and computers are viewed as vehicles for the transport of knowledge and the scaffolding of learning (Blanton, Moorman, & Trathen, 1998); and (4) whether learning occurs within a learning group, where the collective group itself is assumed to function as a learning system (Salomon & Perkins, 1998).

A vivid discussion of the many faces of constructivism has been published in the *Educational Researcher* (Bereiter, 1994; Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Phillips, 1995, 1996; Smith, 1995; Von Glaserfeld, 1996). Of particular interest in this discussion were the influence of individual versus social factors, the mind versus the environment, and private versus public knowledge. And interest in the relations between the individual learner and the collective participatory process of active knowledge construction is growing. As constructivist theories suggest, learning often occurs via dialogue with others rather than individually, and interest in dyadic or group learning is therefore increasing (Duffy & Cunningham, 1996).

2.3 Perspectives on peer learning

Over the past ten years, interest in CL and CSCL has greatly increased. Most of the relevant research has involved the performance of specially designed collaborative tasks in relation to specific task related outcome measures. However, the emergence of constructivist views on learning has increased interest in group processes and peer learning. Given that learning is increasingly being considered a matter of social knowledge construction, *participation* in situations where learning is supported by other individuals has become a key concept as opposed the *acquisition* of knowledge (Lipponen et al., 2003). Acquisition and participation are two leading metaphors in research on learning. The acquisition metaphor is prominent in older writing, while the participation metaphor is prominent in more recent writing (Sfard, 1998). The acquisition metaphor construes learning as the development of concepts and the acquisition of knowledge; the human mind is a container to be filled. In contrast, the participation metaphor construes learning as part of the more general process of becoming a member of a particular community. Whereas the concept of acquisition implies a clear end point to the process of learning, the concept of participation implies that learning is an ongoing and potentially never ending process. In addition, learning activities should be never considered separate from the context in which they occur, according to the participation metaphor. And above all, the ability to communicate in the language of the surrounding community and act according to its norms, are critical features of the participation metaphor but not the acquisition metaphor (Sfard, 1998). In other words, the dichotomy between the acquisition metaphor and the participation metaphor should not be mistaken for the well-known distinction between individual and social learning, as the acquisition versus participation distinction, as described by Salomon and Perkins (1998), entails very different visions on mechanisms for learning.

The mechanisms underlying the effectiveness of social interaction for learning have been explained from different approaches on peer learning, namely *social-behavioral* approaches (motivational and social cohesion approaches), *cognitive-developmental* approaches (socio-cognitive and socio-cultural approaches), and - most recently - the *cognitive elaboration* approach (O' Donnell & O' Kelly, 1994). The different approaches with their relevant authors are depicted in Table 2.1.

Table 2.1
Overview of theoretical perspectives on peer learning and relevant authors

Theoretical perspectives on peer learning		
	Important authors	Positive outcomes expected based on:
Social-behavioral		
Motivation	Slavin, 1990, 1992	Peers are motivated to work with one another towards a group goal (reward)
Social cohesion	Johnson & Johnson, 1991	Peers develop a social bond with another and are mutual concerned
Cognitive-developmental		
Socio-cognitive	Piaget, 1926	Peers develop new cognitive structures by resolving cognitive conflicts
Socio-cultural	Vygotsky, 1978	Peers develop new cognitive structures by social interaction
Cognitive elaboration	Webb, 1991; Van Boxtel, 2000	Peers develop new cognitive structures as a result of elaboration activities

According to social-behavioral approaches, peer learning occurs when members of a group move towards a goal and the achievement of a goal by any one member of the group requires that other members also achieve the goal. Any individual movement towards the goal thus moves the entire group towards the goal. Within this general perspective on peer learning, two approaches with emphasis on motivation and social cohesion can be distinguished. According to the motivational approach, students are motivated to work with one another towards a collective group goal, which is usually a group reward (Slavin, 1990). According to the social cohesion approach, group members develop social bonds with each another and therefore act out of mutual concern; peers want to help each other and do not want to let others down (O'Donnel & O'Kelly, 1994). One of the cooperative learning techniques of Johnson and Johnson (1991), *Learning Together*, is based on the social cohesion approach. They identified five conditions for effective cooperative learning: (1) individual accountability, which means that both the individual and the group are aware of an individual's performance on a group task; (2) positive interdependence, which means that the members of the group need each other to succeed; (3) promotive interaction, which refers to the quality of interaction among the group members and such behaviors as helping one another, exchange of resources, provision of feedback and encouragement of one another; (4) social skills, which pertain to the ability of the group members to interact with each other; and (5) group processing, which refers to ongoing discussions of the group's progress, and the functioning of the group, and changes in group activities if necessary (Johnson & Johnson, 1994).

While the motivation and social cohesion approaches to peer learning emphasize the mechanisms that appear to promote social interdependence between peers, the different cognitive approaches to peer learning (e.g., cognitive-development approaches and cognitive elaboration approach) emphasize those mechanisms that appear to foster cognitive interdependence. In other words, peer learning is expected to produce positive achievement because individuals modify their own knowledge structures as a result of interaction with each other. Two separate cognitive approaches can be identified, namely cognitive-developmental approaches (e.g., the socio-cognitive and socio-cultural approaches) and the cognitive elaboration approach (O' Donnel & O' Kelly, 1994).

The socio-cognitive approach is based on the work of Piaget (1926) and considers cognitive conflict and the coordination of different points of view to be central to the processes of learning and development. The socio-cultural perspective is based on the work of Vygotsky (1978) considers the quality of observed talk and the mediation of meaning to be critical to the process of learning (Cole & Wertsch, 1996; Mercer, 1996). From a Piagetian perspective, cognitive structures develop via the resolution of cognitive conflicts generated during interactions. Piaget argues that the cognitive value of social interaction is the creation of socio-cognitive conflicts and thereby a state of disequilibrium (Hakkarainen, Järvelä, Lipponen & Lehtinen, 1998). That is, interactions between parties holding different views on intellectual or moral issues can lead to cognitive conflict and subsequent argument or debate can promote the development of new conceptual structures. Stated differently, interactions require children to consider another person's point of view and may thus prompt them to possibly alter their own ways of thinking to fit reality better. A child may perceive a conflict between what he or she understands and the explanation of demonstration of another, and new structures may thus be constructed to resolve conflict. Piaget further observed that discussions between peers appear to be more valuable than discussions between an adult and a child because the interactions with an adult are inherently unequal and asymmetrical, which disrupts the condition of reciprocity needed to achieve cognitive equilibrium (Tudge & Rogoff, 1989).

According to Vygotsky and the socio-cultural approach to learning and development, interaction with a more skilled partner fosters conceptual development via the internalization of such culturally- historically formed tools of mediation as language (Cole & Wertsch, 1996). A central concept in the work of Vygotsky is the "zone of proximal development", defined as: "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). In other words, interaction with peers who have different levels of understanding or cognitive and metacognitive practices enables the achievement of new competencies within a child's own zone of proximal development. The key element to successful peer learning from a Vygotskian perspective is that a more capable person (e.g., an adult or more capable peer) assist and direct the learner in the accomplishment of a task that the learner would not be able to accomplish alone (O' Donnel & O' Kelly, 1994). Interactions with more skilled partners are considered critical because they supply children with the intellectual tools of their society. For Vygotsky, thus, ideal partners are not equal and their inequality should reside in understanding as opposed to power.

Piaget and Vygotsky both emphasized the role of the social context in the construction of knowledge. They also maintained that peer interactions provide a rich and necessary context for students to revise their current cognitive systems. That is, reflection on peer reactions and perspectives provides a basis for students to revise their cognitive systems and such revisions can, in turn, lead to the establishment of new meanings (Cole & Wertsch, 1996; De Lisi & Goldbeck, 1999; Hogan & Tudge, 1999). Leseman, Rollenberg, and Gebhardt (2000) have more recently used the concept of co-construction to further integrate the Piagetian and Vygotskian lines of thinking. Co-construction is defined as as the active participation of individual children in a collaborative activity marked by semantically coherent relations between each student's contribution to the joint activity. Knowledge construction is assumed to occur in interaction with others be largely based on stimuli provided by others. Prior knowledge is activated, doubts and questions are shared; answers are jointly sought; information is exchanged; and, in such a matter, new knowledge is created. Social relationships and communities of individuals with different competencies are also established at the same time.

A third approach of inquiry concerned with collaborative learning and peer interaction has recently emerged, namely the cognitive elaboration approach, which emphasizes the cognitive processing performed by interacting individuals and attempts to determine the circumstances in which social interaction promotes the learning of academic content. According to the cognitive elaboration approach, interaction with others leads to the active processing of information by the individual and can lead - in turn - to the modification of cognitive structures. Elaboration refers to the detailed explanations that occur when peers provide examples of a topic, provide multiple representations, explain a concept, or supply specific argumentation. An important notion within the cognitive elaboration approach to peer learning is verbalization, as this can lead to elaborate cognitive processing and thereby reflection, awareness, (re)organization, differentiation, fine-tuning, and the expansion of knowledge (Van Boxtel, 2000). Based on the generative model of learning (Kourilsky & Wittrock, 1992), it is also assumed that new information must be meaningful related to previously acquired knowledge for the retention of the new information. Learners must generate or elaborate connections between incoming information and representations in memory. And one strategy for encouraging students to do exactly this is to have them explain things to others (Fuchs, Fuchs, Hamlett, & Karns, 1998).

Webb (1989, 1991) has shown the role of verbalization within the cognitive elaboration approach to indeed be critical. One important finding along these lines is that the achievement of children is associated with the quality of the responses they provide when asked for help. The provision of elaborated responses is associated with high achievement, while the provision of just the correct answer (without elaboration) is not. According to Webb (1991), it is likely that the provision of elaborated answers allows students rehearse and reorganize their understanding of things. Studies by both Webb and Farivar (1994, 1999) and King (1994, 1999) have provided considerable empirical support for the assumption that so-called elaborative talk contributes to the use of more elaborate conceptions in subsequent situations. The provision of elaborated help prompts the explainer to clarify and reorganize existing material, fill any gaps, and thereby better understand the relevant material better.

The benefits of elaboration have also been found to occur across a variety of contexts: e.g., while giving help to another student, while justifying one's own views or strategies, and during the resolution of disagreements or discrepancies (King, 1994; Webb & Farivar, 1994). The process of elaboration involves explicit comparison of different perspectives or conceptions, the development of shared meaning, and the co-construction of new knowledge and/or the collaborative resolution of conflicting points of view. More concretely, when students discuss a topic or try to solve a problem together, they verbalize their thoughts and such verbalization can elicit elaborative cognitive processes (Van Boxtel, 2000).

2.4 Collaborative learning

Collaborative or cooperative learning is an instructional method that is in line with the concepts on learning as a constructive, cumulative, situated, self-regulated and social process (Shuell, 2001). The term collaborative learning refers to a large number of instructional strategies that involve students working in small groups. During collaborative learning, students work together to achieve common goals that are not only important to themselves but also to the other members of the group. The different members of the group also know that they can reach their learning goals only when the other members of the learning group also reach them (Johnson & Johnson, 1994). In the literature on collaboration, authors often make a distinction between collaborative versus cooperative learning (see McWhaw, Smackenberg, Sclater, & Abrami, 2003). Collaboration involves the mutual engagement of participants in a coordinated effort to solve problems together, while cooperation typically involves a division of labor across participants and each person is therefore responsible for only a part of the problem-solving process (Roschelle & Teasley, 1995; Dillenbourg, Baker, Blaye, & O' Malley, 1996). The above distinction is largely untenable, however, as both collaboration and cooperation often involve shared work (e.g., Cohen, 1994; Johnson & Johnson, 1994; Kagan, 1994). It is, however, more important to stress the similarities than the differences between collaboration and cooperation (Kirschner, 2001). In both cases, according to Kirschner: the learner is active; the teacher is usually a facilitator; teaching and learning are shared experiences; students participate in small group activities; students must take responsibility for their learning; students are stimulated to reflect upon their assumptions and thought processes; and both team and other social skills are developed via the achievement of consensus.

In the present thesis, both the terms collaborative learning and cooperative learning will be used to refer to learning environments in which small groups of students work together to achieve a common goal. It is nevertheless recognized that the different members of the group may choose to take responsibility for different subtasks and therefore work cooperatively or tackle all parts of the problem together and therefore work collaboratively (also see Underwood & Underwood, 1999). It is also recognized that in the collaborative learning situation in particular, students are responsible for not only their own learning but also for helping others to learn and for their contribution to the group task (Abrami et al., 1995).

Numerous studies have shown collaborative learning to enhance student achievement (Cohen, 1994; Dillenbourg, 1999; Johnson & Johnson, 1994; Slavin, 1996). Both field and laboratory studies on the achievement effects of collaborative learning have been conducted for every major subject and all grade levels. In their review of the impact of competitive, individualistic, and cooperative learning efforts on achievement, Johnson and Johnson (1989) examined a substantial amount of studies conducted over the last 90 years. Their conclusions show cooperative methods to lead to higher achievement than competitive or individualistic methods when measured using a variety of indices. When students exposed to "pure" (McConnell, 2000) cooperative learning methods, they are found to: (1) produce significantly higher achievement; (2) use more metacognitive skills and produce higher-level elaborations; (3) provide more solutions and new ideas; and (4) show higher levels of learning transfer, also to individual learning situations as well. When students have worked in a cooperative environment, their learning is transferred to situations where they work individually.

Cooperative learning has been shown to not only enhance learning outcomes but also social and motivational outcomes. According to Slavin (1990) cooperative learning: (1) can promote inter group relations; (2) can help breakdown barriers to friendship and interaction with less able students; (3) can increase self-esteem as students are likely to work in situations where they are liked by their peers, which in itself positively affects achievement; (4) can create group norms that support high achievement; (5) can increase "time on task" as students are motivated to actually spend more time on the learning task; (6) can improve the class climate as students tend to enjoy cooperative learning activities; and (7) can teach students to behave more socially; listen to others and cooperate.

In sum, there is a widespread consensus among researchers on the positive effects of both collaborative and cooperative learning on student achievement (Slavin, 1996). There exist, however, still many questions to be answered, disagreement on just why such learning methods promote achievement, and little or no understanding of the conditions required for effective collaborative and cooperative learning (Slavin, 1997; Webb & Palincsar, 1996).

2.5 Computer-supported collaborative learning.

With the introduction of computers into schools, and the development information and communication technology (ICT), new forms of computer-mediated communication (CMC) have become possible. CMC systems provide both synchronous and asynchronous formats for collaboration (see section 2.5.1 below). CMC can be considered as a general form of communication mediated by computers (e.g., e-mail, videoconferencing, chatting). A CMC technology specially designed to promote collaboration for small group work is *computer-supported collaborative learning* (CSCL), which structures the learning environment to facilitate social interaction between group members (Kreijns, Kirschner, & Jochems, 2003).

2.5.1 Computer-supported collaborative learning in general

As the term suggest, CSCL refers to an instructional method that requires or encourages students to work together on problem-solving or learning tasks and where the collaboration is mediated by networked computers (Lehtinen et al., 2000). In CSCL, ideas and problems are entered into a communal database, read, discussed, and elaborated upon from different perspectives in order to co-construct new knowledge. The focus of CSCL is on the use of computer technology to enhance peer interaction and thereby learning (i.e., the distribution of knowledge and expertise among group members) (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003). In its ideal form, CSCL involves the mutual engagement of learners in a coordinated effort to solve problems and acquire knowledge.

The use of computers for communication has been found to enhance student achievement in a number of studies. Fabos and Young (1999) found CMC to improve writing skills presumably because a meaningful and supportive writing context is provided and both formal and informal written communication are stimulated. In their review, Fabos and Young (1999) found eight studies in which informal e-mail writing encouraged students to write more fluidly and twelve studies in which CMC increased the number of messages written and the length of the written messages.

In a meta-analysis, Lou, Abrami, and d'Apollonia (2001) quantitatively synthesized the empirical findings from 122 studies of the effects individual learning and small group learning in conjunction with CMC media, that allowed groups of teachers and students to communicate, share information, learn and collaborate across distance (e.g., e-mail, computer conferences, CSCL systems, and the Internet). On average, small group learning via CMC produced significantly more positive achievements effects than individual learning on both student's individual achievement and group task performance. Not only cognitive learning outcomes improved significantly, but also affective outcomes. Student attitudes towards group work and student attitudes towards classmates improved significantly after working in small groups with CMC. In addition, Fabos and Young (1999) report an increased student motivation while learning via CMC.

In the review by Lou et al. (2001) and Fabos and Young (1999), the different educational goals for which the computers were put to use were not distinguished. Although it is hard to draw specific conclusions about the effectiveness of CSCL on the basis of these general CMC studies, there is a reasonable amount of published data showing CSCL to elicit positive learning effects (Lehtinen et al., 1999). CSCL is reported to facilitate task-oriented and reflective activity (Cohen & Scardamalia, 1998; Hakkarainen, Lipponen, Järvelä and Niemivirta, 1999), complex reasoning and argumentation (Veerman, 2000; Veldhuis-Diermanse, 2002), and the learning of complex scientific concepts (Roschelle, 1992). It is also argued that CSCL supports such collaborative knowledge construction as engagement in deeper levels of explanation and the posting of higher-order questions that then elicit higher-order answers (Lipponen, 2000; Scardamalia, Bereiter, & Lamon, 1994). Furthermore, CSCL is argued to increase both metacognitive understanding (Cohen & Scardamalia, 1998) and student motivation (Talamo & Niemivirta, 2000).

In sum, the results of several empirical experiments suggest that CSCL promotes higher-order social interaction and thereby better learning in the form of deeper understanding. However, numerous questions remain with regard to the wider applicability of CSCL in regular classrooms and the added value of computers and networks when compared to collaborative learning without such technology (Bernard et al., 2004; Lehtinen et al., 1999).

2.5.2 Computer-mediated communication versus face-to-face communication

Face-to-face (FTF) communication involves both verbal and nonverbal exchanges and thus provides a rich array of information to understand and interpret. Communication via computers lacks the nonverbal mode while much of the information obtained via FTF interaction is in the form of body language, sound (i.e., intonation and phonology), and other physical codes. In CMC, the absence of such nonverbal information has been found to lead to frequent misinterpretation (Neuage, 2002). The absence of nonverbal cues, reduces the expression of socio-emotional material and thereby decreases the information available about the other, which may hamper affective interaction. One of the theories that has been used in communication research and educational psychology to explain the social context of telecommunications-based interactions is that of social presence. Short, Williams, and Christie (1976) define "social presence" as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships” (p.65). With respect to mediated communication, this means the extend to which a person is perceived as a real person. Short et al. (1976) characterize social presence as a quality of the medium itself, hypothesize that communication media vary in their degree of social presence, and argue that such variations may be an important determinant of manners in which individuals interact. CMC participants may explicitly increase overt social-emotional expressions - such as greetings - and paralinguistic cues in order to compensate for missing communication channels (Gunawardena, 1995). And according to Walther (1992), CMC users indeed develop an ability to express missing nonverbal cues in a written form. One way of expressing emotion via a text-based medium is the use of “relational icons” or “emoticons” (i.e., different faces that can be entered into a piece of text using a combination of punctuation marks (☺).

The introduction of CSCL environments has raised the question of whether the communication in a CSCL environment resembles the communication groups in a FTF collaborative learning environment without the technology. Some authors have argued that communication in CSCL groups may be more task oriented due precisely to the lack of social presence (Jonassen & Kwon, 2001; Light & Light, 1999). Other authors have argued that the absence of various nonverbal and social context cues in the CSCL situation may hamper efficient communication (Bordia, 1997; Straus, 1996).

A study by Straus and McGrath (1994) showed large differences in productivity in favor of FTF groups. Jonassen and Kwon (2001) examined patterns of communication in CMC and FTF groups while solving well-structured versus ill-structured problems and found the messages in the CSCL groups to be of a lower quality but more task related than the messages in the FTF groups; the participants in the CSCL groups reflected more on ideas and perspectives related to the problem at hand than the participants in the FTF groups. A more extended comparison of groups of students collaborating in CMC versus FTF environments is undertaken in Chapter 5 of this thesis.

2.5.3 Synchronous versus asynchronous communication

Several CMC systems have been developed during the past decade. The systems differ in many respects: the manner in which the interaction is structured, availability of cognitive tools, interface for the system, organization and structure of the communication tools, use of a local area network or wide area network, availability of help functions, use of graphics, and use of hypertext (Veldhuis-Diermanse, 2002). It is obvious that the nature of each medium of communication will influence the extent and quality of the interactions among the users of the medium (Moore, 1993). One of the important characteristics of CSCL systems is whether the system allows for synchronous or asynchronous interaction and communication. Internet-based CSCL systems provide both synchronous and asynchronous environments for interactions. Antillanca and Fuller (1999) classified collaborative systems with regard to the temporal relationships. They speak of *same time* versus *different (any) time* systems. A system that is *same time* allows synchronous interaction and communication, such as chatting or videoconferencing; the timing of the interaction is similar to that of a FTF conversation of discussion. Asynchronous communication in the form of discussion forums and mailing lists allows interaction to occur between learners but at different times. Learners need not be present to receive information and may thus communicate whenever they want to.

Several currently used examples of synchronous communication are: Chat rooms, MUDs (multiple-user dungeons), MOOs (multiple object orientations), videoconferencing, Internet Rely Chat, and other chat and virtual reality programs. Synchronous communications rarely follow a sequential pattern. Participants in a chat discussion react one after another with jumps back to earlier contributions, thus. When there are many people chatting at the same time, the conversation may become chaotic. Conversations in a chat room are rarely planned, very informal, often experimental, and frequently used for entertainment and escape (Rheingold, 1993). According to Veerman and Veldhuis-Diermanse (2001), synchronous communication via a chat program tends to be fleeting with short contributions and numerous turns. There is little time for reflection, and the pressure to react quickly is rather high due to the sense of absence brought about by slow reactions. Chat rooms differ from other Internet communication formats in that only a few lines of text can be observed at a time with the next lines following rapidly and thereby acting to de-focus from what preceded. Print media, in contrast, allow one to read or review sections and thereby check one’s understanding. Chat text is not static like printed text but flows across a relatively small screen space and disappears at a virtually uncontrollable speed (Neuage, 2002). A question posted in a chat conversation may often go unanswered simply because the information vanishes so quickly from the screen (Veerman & Veldhuis-Diermanse, 2001).

As already mentioned, asynchronous communication is communication taking place at different times and over a period of time. A message is composed and sent to be read by the recipient(s) at a later time. Several currently used examples of asynchronous communication are: e-mail, electronic mailing lists, newsgroups, messaging programs, and discussion forums (Neuage, 2002). The participants need not to be online at the same time. Questions, answers, and new contributions are added to a communal database, which provides a permanent record of all contributions. In contrast to the synchronous communication format, the asynchronous communication format provides time for reflection and the pauses needed for demanding intellectual activity (Hewitt & Scardamalia, 1998). In an asynchronous discussion forum, contributions or “notes” remain present at all times, which means that students can return to earlier notes, reply to earlier notes, and revise their own notes if necessary. The automatically stored information in the communal database can be derived by the students and allows them to elaborate on earlier given information. Using networked computers, a number of students can contribute to the database or can comment the contributions of others. The communal database objectifies the participant’s knowledge construction (Scardamalia & Bereiter, 1992).

Most of the research on CSCL has examined the asynchronous CMC networks as these are the most common of instructional technologies in education. Few studies have been conducted on synchronous CSCL systems or have compared synchronous versus asynchronous CSCL systems. Nevertheless, Neuage (2002) studied the characteristics of chat talk and found the talk to be limited to short phrases and numerous turnovers. Turns with more than a few words written by the same speaker were rare. Sampling of a dozen chat rooms and hundreds of entrances revealed an average of seven words per turn. And within that sampling, more than 80% of the words were no more than five letters.

Veerman and Veldhuis- Diermanse (2001) have described the results of four studies in which university students worked collaboratively on complex tasks within a CSCL environment. The students collaborated via synchronous communication in two of the studies and asynchronous communication in the other two studies. Comparisons showed the following for the synchronous environment in particular: the frequency of short messages was very high; the contributions were not very well evaluated; the frequency of comprehension questions was very low; and the frequency of elaborated information was very low (Veerman & Veldhuis- Diermanse (2001). The authors conclude that for academic learning where the focus is on the elaboration of ideas and explicitation of insights, asynchronous environments should to be preferred (Veldhuis-Diermanse, 2002).

Bonk, Hansen, Grabner-Hagen, Lazar, and Mirabelli (1998) compared the interactions of 32 educational psychology students discussing four problematic scenarios using a synchronous electronic conferencing tool to the interactions of 33 students discussing the same problematic scenarios using an asynchronous conferencing system. The dialogue coding indicated vast differences in the processing of the scenarios and interaction. The students working in the synchronous environment interacted more frequently than the students working in the asynchronous environment but their contributions were mainly personal opinions and short content-related remarks, while the contributions of the students in the asynchronous environment were much more responsive to their peers and more elaborated. The study of Bonk et al. (1998), thus, shows asynchronous communication to foster more elaborated and lengthy interactions than synchronous communication.

2.5.4 Synchronous and asynchronous communication formats combined

Educational environments simultaneously employing different communication formats are generally assumed to support collaborative knowledge construction (Ligorio, 2001). That is, the availability of different learning environments, media, and different communication formats is assumed to meet the needs of the learner (Collis & Moonen, 2001). And a combination of synchronous and asynchronous media is assumed to provide the benefits of both formats (Mason, 1999). However, only a very few studies have examined how the different communication formats interact with each other (Ligorio, 2001). When classroom activities were combined with online activities, and the so-called “blended learning approach” was applied, the results are beneficial (Dut-Doner & Powers, 2000; Kleine Staarman, 2003; Dietz-Uhler & Bishop-Clark, 2001). In other studies synchronous online communication was found to promote a sense of community, while asynchronous activities stimulated reflection (Haythornthwaite, Kazmer, & Robins, 2000; Ligorio, 2001; Schwier & Balbar 2002). In other words, the combination of different learning environments with different communication formats stimulates knowledge construction. (For an extensive description of the relevant studies and the blended learning approach, see Chapter 6).

2.5.5 Advantages and disadvantages of collaborative learning and computer-supported collaborative learning

There is growing evidence that collaborative learning methods promote the construction of knowledge, the establishment of deeper understanding and the development of cognitive and social skills engaging students in the learning process (Marjanovic, 1999). However, not all students appear to benefit from collaborative learning methods, with or without the support of computers. Salomon and Globerson (1989) found some group members to simply sit back and let the other members of the group do all the work or a “free rider” effect. The free-rider effect sometimes turns into a “sucker effect” when the group members who are doing all the work start to contribute less to group work to avoid being a sucker (Webb & Palincsar, 1996). Finally, certain group members may dominate the group at the expense of those members with “stage fright” or those members with a different social or cultural background (Marjanovic, 1999). Meloth and Deering (1999) also found aggressiveness and hostility to lead to unconstructive arguments, passivity, acquiescence, and premature agreement on answers. Another debilitating process that may arise in group setting is failure to seek help when it is needed. Sometimes students may simply not be aware of the fact that they need help and, even if they are, be hesitant to seek such help for fear of being judged incompetent or unwanted member of the team (Nelson-Le Gall, Gumerman, & Scott-Jones, 1983; Webb & Mastergeorge, 2003).

To overcome the aforementioned problems associated with collaborative learning in classroom, one might consider the introduction of CSCL (Simons, Van der Meijden, & Vosniadou, 2000b). CSCL provides tools to monitor the collaboration process, and makes the patterns of communication clearly visible. Who is communicating with whom? Who is active? Who is passive? Who is taking the initiatives? Who is reacting? What kind of input are different students providing? What is the quality and depth of the ongoing discourse? Another advantage of using a CSCL environment is greater inclusion and participation on the part of students. A CSCL environment generally provides students with more opportunities to speak than a traditional classroom environment in which the teacher accounts for 75% to 80% of the dialogue (Pilkinton & Walker, 2003). Greater participation in a CSCL environment is fostered by less restricted turn taking, on the one hand, and the possibility of several participants composing responses at the same time, on the other hand. However, CSCL participants may also need to develop new skills to manage multiple parallel threads of discourse, maintain focus, and attain coherence (Pilkinton & Walker, 2003).

Although the empirical research on CSCL has shown improved learning results at both the individual and collective levels (Lehtinen et al., 1999; Lipponen et al., 2003), certain disadvantages have also been revealed. In general, students do not participate very intensively in a CSCL environment. The number of contributions is low on average (Guzdial, 1997; Guzdial & Turns, 2000; Hara, Bonk, & Angeli, 2000; Hsi, 1997; Lipponen et al., 2003). In addition to the low level of participation, most of the discussion threads are very short and thus contain only a few contributions (Guzdial, 1997, Guzdial & Turns, 2000; Lipponen et al., 2003). CSCL discussions have also been found to be rather superficial and divergent. Another potential drawback is that CSCL students may become overloaded. When participation is frequent, overload is less likely. But when participation is less frequent and a period of absence intervenes, it is often the case that large amounts of information have accumulated and overload can then occur. The group member may simply feel overwhelmed by the number of messages to be read and choose to ignore the material to read and digest it, which is very time-consuming. Alternatively, the group member may skim the material in an attempt to gain a glimpse of what has happened during his or her absence. Even when students participate frequently, the amount of information to be processed can still piles up. And the information overload can take one of two forms: first, there may simply be too many messages for the user, from too many people; second, the messages may not be organized sufficiently to see their relations to previous messages (McConnell, 2000).

To overcome the aforementioned disadvantages, Guzdial and Turns (2000) have proposed a set of features that they consider essential for an asynchronous discussion forum to benefit learning: discussion management features, facilitation features, and anchoring features. So-called discussion management features help the students follow the discussion. A threaded discussion forum, for example, tracks the relations between notes (e.g., which notes are responses to which other notes) and depicts these relations in the discussion interface. A threaded discussion forum thus helps students see the relations between notes, easily find notes of interest, and maintain a sense of the overall discussion (in contrast to other programs which only show new contributions and track by default what has been read before, like newsgroups. Discussions with notes that can only be read once make it difficult to reconstruct the flow of a discussion at a later date. So-called facilitation features help students with the formulation of their contributions. The classification of notes or need to indicate the nature of the note in combination with such prompts as "My opinion is…"or I don't understand…" can be very useful for the composition of a note. Given that a blanc screen can be rather intimidating for a student, a prompt can help the student get started with the writing of a contribution. So-called anchoring features can motivate the student to participate in the discussion forum. The role of an anchor is to set the context for a problem and provide a focus for the relevant discussion.

Chou (2001) has similarly summarized those features that appear to benefit learning in a synchronous learning environment: (1) the environment should be easy to access and easy for students to find their way around in; (2) the environment should provide private rooms for students, such as a virtual office where students can meet and discuss group related matters, without bumping into the teacher or other fellow students when they do not want to be interrupted); (3) the environment should provide affective affirmation, which can com from the system, from peers, and from teachers; and (4) the environment should include support tools for knowledge construction, such as a whiteboard and storage of information for later retrieval. Clou 's (2001) conc lusion is that the current synchronous systems are limited in their ability to facilitate collaboration and stimulate critical thinking. In contrast, several of the asynchronous systems such as CAMILE or Knowledge Forum have found to meet the criteria of Guzdial and Turns (2000).

2.6 Outline of the theoretical framework and general research question

CSCL environments constitute a powerful constructivist learning tool, and create multiple opportunities for peer interaction. CSCL appears to facilitate interaction both within and beyond the classroom as students write down their thoughts, negotiate resolutions, agree or disagree with the ideas of others, encourage other members of the group to achieve a common goal, and - in such a manner - construct new knowledge in collaboration with others. In the present thesis, the focus is on collaborative learning, and the construction of knowledge within a CSCL environment where the collaboration can be realized via synchronous communication, asynchronous communication, or a combination of the two. Departing from the cognitive elaboration approach, knowledge construction is operationalized as the provision of elaborations such as the posing of comprehension questions, requests of explanations, provision of answers with extended arguments or justification, presentation of new ideas with explanations, and the acceptance or rejection with arguments of ideas coming from others. In Figure 2.1, theoretical framework underlying the studies in this thesis is presented schematically. Departing from a constructionist view that learning is a self-regulated, constructive, and collaborative process of knowledge construction, the focus is on elaboration as important feature of the process of knowledge construction. The learning environment applied in the three studies in the present thesis, shows that the studies differ in the manner collaboration is organized: synchronous communication with (studies 1 and 3) and without (study 1) the support of computers, asynchronous communication (studies 2 and 3) and synchronous communication in combination with a synchronous communication (study 3). In the present thesis, the process of knowledge construction through CSCL is examined. The general research question motivating the three studies reported in the present thesis, is:

Does CSCL elicit the process of knowledge construction in terms of elaboration? In the next chapter, the methods used to analyze the data collected in three separate studies will be presented.

THEORETICAL FRAMEWORK

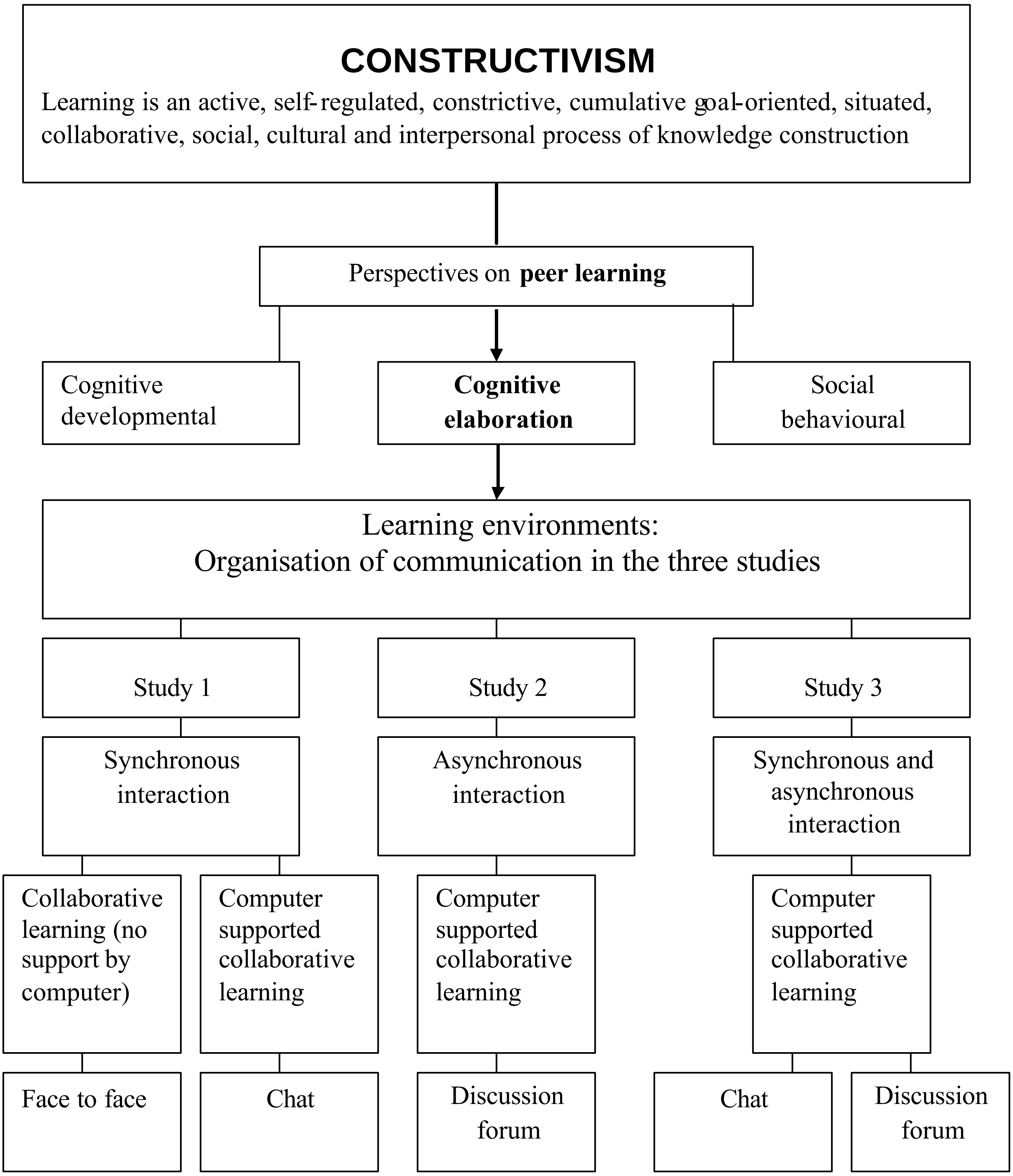

Figure 2.1
Visualization of the theoretical framework underlying the three studies in this thesis.

Chapter 3:
Analysis of peer interactions in a computer-supported collaborative learning environment: towards a coding scheme

> *"The techniques we used were not adequate to capture the complexity and fluidity of live learning talk. ....We tried out different formulations on the data none of which was adequate in itself but of which we ultimately put different elements together to develop a new framework"* (Barnes & Todd, 1977, p.139).

3.1 Introduction

Over the last two decades, learning in small groups has been intensively studied and the nature of interactions has become a central issue for research on learning in social settings. Several analytic approaches have been developed to examine the ways in which knowledge is socially constructed in classrooms and other educational settings, including CSCL environments. The theoretical framework presented in Chapter 2 makes it clear that in order to map interaction in small group learning, both the individual learner and learning as a participatory process of active knowledge construction must be taken into account. However, the focus of the relevant research to date has been on the quality of collaborative products and individual learning outcomes with little attention to collaborative processes and outcomes in relation to each other (Dillenbourg, 1999). One exception to the above is the work of Strijbos, Martens, and Jochems (2004) who adopt a probabilistic view of the learning and interaction processes within a CSCL environment. It is assumed, namely, that a CSCL environment does not guarantee learning benefits for all participants, but supports student participation and interaction, which is likely to lead to skill acquisition. In the present thesis, hardly any attention is paid to learning outcomes as the focus of the present research is on the nature of the interaction processes that occur (or do not occur) within a CSCL environment.

CSCL tools can provide an enormous amount of information with regard to the psycho-social dynamics of students working together, the learning strategies adopted, and the acquisition of knowledge and skills. Much of this information, moreover, is not available via any other learning situation (Henri, 1992). As Henri has observed, however, a participant's contribution within a CSCL context must be considered both singly and in relation to the contributions of others. In the present thesis, the first step towards the development of the coding scheme for this purpose was therefore to review those CSCL studies in which the content of peer interactions has been analyzed with regard to the construction of knowledge. Subsequently we tried to gain insight into the process of knowledge construction, by analyzing the patterns of interaction of collaborating students.

In the present chapter, we will first discuss (section 3.2.) three alternative conceptualizations of interactions (i.e., participation, social structure, content), and present an overview of those interactions that have been found to be particularly beneficial for learning (section 3.3). we will then discuss a number of specific methods used by previous researchers to analyze CSCL peer interactions (section 3.4). This will be done with regard to participation and the social structure of the interactions (section 3.4.1) and the content of the interactions (section 3.4.2). Next, we will describe the development of the coding scheme used in the three studies presented in this thesis (section 3.5), and the processes of segmentation and coding. And finally, the different steps taken to analyze the knowledge construction process within the context of the present thesis will be outlined (section 3.8).

3.2 Conceptualization of interaction

Gunawardena, Lowe, and Anderson (1997, p. 407) defined interaction as "the process through which negotiation of meaning and co-creation of knowledge occurs." In their opinion, interaction is the total of all interconnected and mutually-responsive messages. Gunawardena et al. (1997) further describe the co-construction of knowledge as analogous to the production of a patchwork quilt: starting with small pieces of cloth, which stand for the contributions of individual participants, an overall pattern is created. Similarly, interaction is the process used to put pieces of information together and co-constructed knowledge.

Interactions can, nevertheless, be conceptualized in many different ways. According to Strijbos et al. (2004), three basic conceptualizations of interaction can be distinguished: (1) as communication networks, (2) as temporal communication structures, or (3) as communicative statements. The conceptualization of interaction as communication networks means that the interaction is understood in terms of the relations between the members of a group. The relations can be characterized in terms of "density" and "centrality", which provides information on the positions of the members of a group: which members stand central and which members are relatively isolated (see section 3.4.1). Alternatively, interaction can be conceptualized in terms of temporal communication structures, which means that the temporal relations between successive periods of interaction are examined for one-way communication, two-way or reactive communication, and interactive or reciprocal communication. One-way communication refers to an interaction dominated by a single student. Reactive communication refers to interaction episodes, with none of the participants building on the information contributed by other participants (i.e., a reaction is given and nothing more). Reciprocal communication refers to interaction episodes with participants clearly building on the information contributed by other participants. Finally, interaction can be conceptualized in terms of communicative statements or acts. In the present thesis, interaction is not seen as merely temporal and the focus is therefore on communicative statements or acts. Such statements or acts provide information on the content of the contributions made by the participants in a CSCL environment and therefore have been frequently analyzed for such purposes (see section 3.4.2).

3.3 Peer interactions beneficial for learning

In the present thesis and as described in Chapter 2, a cognitive elaboration approach to the process of knowledge construction was adopted. Obviously, not every communicative statement or act during a collaborative learning task enhances the process of knowledge construction, and research has shown the construction of knowledge during collaborative learning to be largely determined by the quality of the interactions between the students working together (Kneser & Ploetzner, 2001; Mercer, 1995; Webb & Farivar, 1999; Webb, Troper & Fall, 1995). Stated more strongly, only certain interactions under specific conditions during a collaborative learning task can lead to learning gains. One of the most important interactions for deep processing of information within collaborative learning is the asking and answering of questions (Damon & Phelps, 1998). Since the eighties, Webb has studied the effects of giving and receiving help during collaborative learning activities on the performance of students. Interestingly, those students who help other students within a collaborative learning group appear to learn the most. However, this is only the case when the explanations they provide contain some form of elaboration: the student providing the help clearly explains his or her answer. That is, the student giving help is actively involved with the learning material: explaining and clarifying concepts, evaluating and conceptually reorganizing material, detecting and reconciling inconsistencies, and drawing connections between concepts. And such cognitive activity and elaboration may explain the positive relation between the giving of help and student performance.

In addition to the giving of help, Webb also studied the receipt of help and found the effectiveness of the help to depend upon the following conditions: (1) the help must be relevant for the recipient (i.e., the target student); (2) the level of elaboration must correspond to the level of help needed; (3) the help must be given in close temporal proximity to the target student's error or question; (4) the student in need of help must understand the explanation; (5) the student in need of help must be given an opportunity to use the explanation; and (6) the student in need of help actually must make use of an opportunity to use the newly acquired explanation (Webb, 1992).

When King (1990, 1994), studied the types of questions that students ask, a clear correlation between the types of questions posed and the answers provided was found. Higher-order questions in particular were found to elicit explanations with concomitant justifications. By asking the right questions, thus, students can start a high-quality dialogue. And triggering an elaborated explanation can positively influence the performances of both the student providing the help and the student requesting the help (King, 1999). King (1994) distinguished three types of questions: (1) factual questions or questions intended to elicit simple restatements of factual material, (2) comprehension questions or questions intended to elicit descriptions or paraphrasing in own words; and (3) integration questions or questions intended to elicit elaborated explanations. When posed by the student in need of help, adequately answered integration questions can positively affect performance (Webb et al., 1995). Integration questions include among others: open-ended questions, deep-reasoning questions connected with causes, consequences, and/or expectations; and goal-oriented questions (King, 1990; King , Staffieri, & Adelsgais, 1998).

Scardamalia and Bereiter (1991) have also stressed the importance of question asking in classrooms. In regular education, teachers ask questions and thereby determine the objectives of learning activities and what should be remembered by students. The typical school question-answer discourse provides no means for children to develop the competencies underlying the posing of good questions. Scardamalia and Bereiter distinguished four levels of questions along a so-called Knowledge Advance Scale and found students to indeed ask greater higher order questions in an open learning environment. The different levels of questions asking were: (1) asking for facts; (2) asking for facts and reasons; (3) asking for reasons and explanations; and (4) asking for relations and solutions.

Veerman, Andriessen, and Kanselaar (2002) have also emphasized on the importance of asking questions for collaborative learning and examined the relations between question asking and argumentation during university collaborative learning tasks. Students did not ask higher order questions when an instructor was present. When asked to competitively discuss a proposition or in the absence of an instructor, however, the students proved capable of posing higher order questions. These higher order questions did not lead to greater argumentation although a significant correlation was found when students discussed a self-generated proposition between the posing of higher order questions and argumentation, on the one hand, and inference questions and argumentation, on the other hand.

In sum, the results of several studies have shown particular types of interactions between students working together under certain circumstances to clearly produce learning gains. The asking of higher order questions (e.g., questions concerned with an explanation, a justification, a relation, or a cause) can elicit elaborated answers, which have been shown to be important for the process of knowledge construction. In the following review of the literature, those specific methods used to analyze the particular interactions occurring in a CSCL environment will be considered.

3.4 Analyses of interactions in computer-supported collaborative learning environments

In 1977, Barnes and Todd made an important contribution to research concerned with peer interactions during collaborative learning. While meaning is typically considered fixed and located in a single utterance in most linguistic analyses, Barnes and Todd showed meaning to be open to change, dependent upon the context, and often spread across an exchange of utterances. In other words, meaning is not owned by a single participant in a discussion but something that develops and changes; it is constructed and reconstructed across a series of contributions by different participants. Participants bring different bodies of knowledge to a discussion, and bodies of knowledge are not static but affected by what is going on in a discussion and a participant's evaluation of what is going on. Not only the content of a particular utterance should be taken into account, thus, but also the context of previous utterances and any reactions to the particular utterance (Barnes & Todd, 1977).

In the domain of research on CSCL, it is widely accepted that meaning is constructed in interaction with others. However, there is very little agreement on the pedagogical characteristics of CSCL interactions, just how learning occurs under such circumstances, or which elements give rise to learning (Henri, 1992; Lipponen et al., 2003). Very different methods have also been adopted to analyze peer interactions within CSCL environments. In the review that follows, some of these methods will be described. There is no attempt to be comprehensive, as the literature is extensive and the focus of the review is therefore on a set of concepts central to the analysis of interactions in CSCL environments, with no attention to the findings of the studies described in the review.

3.4.1. Research on participation and social structure of interactions in a computer-supported collaborative learning environment

We agree with Lipponen, Rahikainen, Hakkarainen, and Palonen (2002) that learning via discussion stems from active participation in a discussion, which may also take the form of writing notes or some other contribution. In research on CSCL, student participation is sometimes defined as the number of written contributions (Guzdial & Turns, 2000: Hakkarainen, Järvelä, Lipponen, & Lehtinen, 1998; Lipponen et al., 2002, 2003) and sometimes defined as the number of written contributions plus the reading (passive participation) of contributions by peers (Lipponen, 2002; Veldhuis-Diermanse, 2002). Among the questions addressed in this type of research are the following. How many messages do students contribute on average? Do all students participate? Is participation broad? And is a small minority responsible for the majority of the contributions?

In addition to the level of participation for the individual learner, the social structure of the peer interactions in a CSCL environment has also been a topic of investigation. Among the research questions addressed in this type of research are the following. Do students really collaborate or do they actually work individually? Who writes to whom? One method used to examine the social structure of the CSCL interactions is to analyze the replies (i.e., build-on notes) and answers given to questions posted on a discussion forum (Guzdial & Turns, 2000; Scardamalia & Bereiter, 1994). Another method used to study the social structure of CSCL interactions is so-called social network analysis (SNA) (Wortham, 1999; Lipponen et al., 2003). SNA transforms all contributions into a graphic scheme and thereby depicts the level of group cohesion. With SNA, it is possible to determine the relations between the different CSCL participants and thereby answer such questions as: Who has a central role in the discussion? Is the interaction more or less evenly distributed across many participants (density) or centered around certain participants (centrality)? (Lakkala, Muukonen, Ilomaki, Niemivirta, & Hakkarainen, 2001; Lipponen, 2003). Neither the level of participation nor the social structure of the peer interactions, however, provide insight into the content of the learning processes associated with CSCL environments.

3.4.2 Content-analyses of interactions in computer-supported collaborative learning environments

To gain insight into the learning and communication of students working in a CSCL environment, it is not enough to know the level of participation or with whom they communicate, it is also important to know about the types of information that they contribute to a database or chat. Analyses of the content of students' contributions can provide answers to the following types of questions. How do students approach the task? Do students provide elaborated information? Do students elaborate on information coming from others? And does CSCL elicit the process of knowledge construction? In Chapter 2, the knowledge construction process was operationalized as the provision of elaborations such as the posing of comprehension questions requiring explanations, the supply of answers with arguments or justification, the presentation of new ideas accompanied by explanation, and the acceptance or rejection of ideas coming from others accompanied by arguments.

With regard to the analysis of the content of CSCL interactions, the analytic framework of Henri (1992) is most frequently cited. Her work has been replicated, criticized, and adapted by other researchers (Gunawardena et al., 1997; Hara et al., 2000; Lockhorst, 2004; Newman, Webb, & Cochrane, 1995; Veldhuis-Diermanse, 2002, Pena-Shaff, Martin, & Gay, 2001, Pena-Shaff & Nicholls, 2004). The analytic framework of Henri (1992) is based on a cognitive approach with two types of strategies assumed to underpin the learning process: cognitive and metacognitive strategies. The framework includes five dimensions for analysis: participative, social, interactive, cognitive, and metacognitive dimensions. The *participation* dimension comprises two categories of quantitative data: data concerned with the totality of messages and data concerned with participation in the learning activity. The *social* dimension consists of any statement not related to the formal content of the subject matter. The frequency of such statements can indicate the level of focus on the group, the level of social cohesiveness established within the group, or the extend to which affective support plays a greater or lesser role in the learning process. The *interactive* dimension consists of three categories: (1) explicit interaction with direct responses to and comments on statements from others; (2) implicit interaction with indirect responses and comments but no mention of the connection to other statements; and (3) independent statements. Henri argues that "although users and researchers are in full agreement that computer-mediated communication is essentially an interactive process, nowhere does the literature provide a full theoretical or operational definition of what we are to understand as interactive process." (Henri, 1992, p.127). The *cognitive* dimension concerns numerous cognitive skills that support a significant learning process, understanding, reasoning, the development of critical skills, and problem solving (e.g., elementary clarification, in-depth clarification, inference, judgment, application of strategies to reach a solution). According to Henri, it is not sufficient to identify the presence of certain cognitive skills; rather the level of information processing should also be taken into account. Learners learn more if they critically evaluate information, organize it conceptually, and compare it to previous information. Along these lines, Henri initially distinguished surface processing from in-depth processing and, later, surface learning from deep learning. Surface learning includes skimming, memorizing, and regurgitating for tests whereas deep learning requires a critical understanding of the relevant material. According to Henri, the *metacognitive* dimension is difficult to observe within traditional teaching/learning situations. Metacognitive processes are rarely manifested or intentionally mentioned and mostly investigated using "thinking aloud protocols". In CSCL environments, examination of the transmitted messages constitutes a valuable source of information on metacognitive activities. CSCL messages cannot be expected to reveal the entire metacognitive process, but they can at least give us insight into the metacognitive characteristics of the learning process and the metacognitive activities and skills of the learners.

Newman et al. (1995) undertook content analyses to measure the amount and type of critical thinking that occurs in CSCL groups. The cognitive and metacognitive dimensions of Henri's model were used to examine the promotion of deep learning by CSCL. Newman et al. (1995) were also interested in the quality of CL and CSCL activities and therefore developed a list of indicators of critical thinking versus uncritical thinking: relevant versus irrelevant statements, important points versus unimportant points, new ideas versus repetition of what has been said, bringing in outside knowledge or experiences versus rejection of such, justification of arguments versus judgment without further explanation. Their method of analysis did not include the coding of all the statements. Only the most obvious indicators were coded and counted; all other statements were not included in the analyses.

In a study of the negotiation of meaning and co-construction of knowledge via computer conferencing, Gunawardena et al. (1997) also selected the model of Henri (1992) as the most promising starting point for an interaction analysis. The authors wanted to determine whether knowledge was actually co-constructed within the group via exchanges among the participants and whether individual participants modified their personal understandings or create completely new knowledge constructions as a result of the interactions within such a group. One important aspect of the Henri model that the authors chose not to examine was the social content of the conference messages. Gunawardena et al. (1997) neither paid attention to the participation dimension of Henri's model proposed, because they felt that participation should be studied separately from message content. Thus, from Henri's model three dimensions of the model were taken: interactive, cognitive and metacognitive. Gunawardena et al. adopted a more constructivist view of learning than Henri who was more teacher-centered and interested in individual student performance as opposed to learning. According to Gunawardena et al., the distinction between surface and deep processing did not really get at the learning process that occurs during the negotiation of meaning and collaborative construction of knowledge. Both Newman et al. (1995) and Gunawardena et al. (1997) found it difficult to distinguish cognitive from metacognitive messages. And with regard to the interactive dimensions of Henri's model and her suggestion that messages can be either "monologic" or "interactive", Gunawardena et al. argued that on the basis of their data virtually all messages can be linked to other messages and to the theme of a discussion, as participants build upon previous messages. In line with Salomon and Perkins (1998), Gunawardena et al. also stressed the importance of taking the individual and social learning that occur in any shared learning situation into consideration. That is, knowledge can be created at the social group level, but the individual participant also creates his or her own personal understanding. On the basis of their data, Gunawardena et al. outlined five phases of knowledge construction associated with computer conferencing or debate: (1) the sharing and comparing of information; (2) the discovery and exploration of dissonance or inconsistency among ideas; (3) the negotiation of meaning and co-construction of knowledge; (4) testing and modification; and (5) final statement of agreement and/or the application of newly constructed meanings. Gunawardena et al. included metacognitive statements in their fifth phase because, in their opinion, metacognitive activities are closely related to cognitive activities and metacognitive activities do not always occur. Where there is little conflict among the ideas held by the participants in a group, there is little need for negotiation; participants simply accept each others' statements or examples as consistent with what they and the group members already know.

Hara et al. (2000) used the five dimensions of Henri with some adaptations in their content analyses of online computer conferencing in an educational psychology course. With regard to the metacognitive dimensions they analyzed only skills exhibited within the dialogue such as planning, regulation, and evaluation. With regard to the interactive dimension, the analyses were based on a visual representation of the contributed messages.

The instrument of analysis developed by Veldhuis-Diermanse (2002) to examine how university students construct knowledge during CSCL interactions and the levels of information-processing involved, was also inspired by the work of Henri (1992). However, the Structure of the Observed Learning Outcome (SOLO) taxonomy from Biggs and Collis (1982), was also used to distinguish five stages of understanding: (1) the pre-structural stage when activities are off-task; (2) the unistructural stage when activities are focused on only one aspect of a task; (3) the multistructural stage when several aspects of a task are mastered, but not connected with each other; (4) the relational stage, when several aspects of the task are acquired and connected to each other; and (5) the extended abstract stage when students reflect on ideas and integrate new knowledge into existing structures. According to Veldhuis-Diermanse (2002), both the coding scheme based on Henri's (1992) work and the SOLO taxonomy were successfully applied to analyze the CSCL interactions.

Also drawing on the work of Henri (1992), Pena-Shaff and colleagues (2001, 2004) analyzed student participation, interaction, and knowledge construction in a synchronous computer bulletin-board system. Online messages were coded as interactive or not (i.e., part of a monologue) and also for the type of learning activities taking place using a coding scheme with the following 13 categories: reflective analysis, subjective analysis, task related, assertion, personal experiences, topic evaluation, off-task sentences (i.e., monologue categories), question, reply, support, consensus building, clarification/elaboration, and social interaction (i.e., interactive categories). The categories of clarification and elaboration, consensus building, assertion, reflective analysis, and questions were found to be most related to the process of knowledge construction.

Also Lockhorst decided that the analytical framework of Henri (1992) suited best in her instrument to analyze the online communication of student teachers and teacher educators. She developed a multi-perspective method which included five perspectives. These perspectives refer to the participation of all respondents, the nature of the content, the interaction between the participants, the level of information exchange of the participants, and the students' regulative communication. The social dimensions was embedded in the nature of the content. A description of the methods of analysis, the dimensions taken from Henri's model, and the aspects of knowledge construction examined in the previous studies, is depicted in Table 3.1.

In other content analyses, Hakkarainen (1998) examined the contributions of students working in a CSCL environment for the type of comment, the object of the comment, and the degree of explication provided. This form of analysis is mainly used in Finnish (Muukkonen, Hakkarainen, & Lakkala, 1999) and Dutch research (Veldhuis-Diermanse, & Lutgens, 2002; De Laat, 2002), where the learning task is structured according to the Progressive Inquiry (PI) model which is based on the work of Scardamalia and Bereiter (1992) and further developed by Hakkarainen (1998) and Hakkarainen and Muukonen (1999). The PI model consists of several steps for students to follow to complete a task, including the formulation of a research question, the search for relevant information, and the evaluation of the answers to the research questions. Although the PI model has been applied in several studies, the associated method of analysis is not very widespread, due to its ties to the PI model (Veldhuis-Diermanse, 2002). The PI model proved useful for one of the studies in the present thesis, but the method of analysis developed by Hakkarainen (1998) and Hakkarainen and Muukonen (1999) was not adopted, due to its inapplicability in the other two studies.

Table 3.1
Overview of verbal analysis methods, units of analysis and aspects to asses knowledge construction (based on Henri, 1992)

Author	Verbal analysis method	Unit of analysis	Aspects of knowledge construction examined
Henri, 1992	5 dimensions *participative dimension*: number of messages *social dimension*: off-task or not related to subject matter *interactive dimension*: chain of connected messages or independent statements *cognitive dimension*: elementary clarification, in-depth classification, inference, judgment, use of strategies *metacognitive dimension*: evaluation, planning, regulation, self-awareness	message unit of meaning message unit of meaning unit of meaning	Surface processing or in-depth processing of information (e.g., linking of facts, provision of explanations, justifications, and examples)
Newman, Webb, & Cochrane, 1995	2 dimensions of Henri: *cognitive* and *metacognitive*	unit of meaning	Critical thinking as indicated by elementary clarification, in-depth classification, inference, judgment, application of strategies
Gunawardena, Lowe, & Anderson, 1997	4 dimensions of Henri: *participative, interactive, cognitive, metacognitive* interactive dimension analyzed separately	unit of meaning message	5 phases of knowledge construction 1: sharing/comparing information 2: discovery of dissonance and inconsistency 3: negotiation of meaning/co-construction of knowledge 4: testing and mo dification 5: application of newly constructed meanings
Hara, Bonk, & Angeli, 2000	5 dimensions of Henri with some adaptations: *metacognitive* included only skills exhibited within the dialogue, such as planning, regulation, and evaluation interactive analyzed using visual representation of messages	unit of meaning message	Surface processing or in-depth processing of information (e.g., linking of facts, provision of explanations, justifications and examples)

Veldhuis-Diermanse, 2002	4 dimensions of Henri: *participative, interactive, cognitive, metacognitive* Henri's *social dimension* renamed as *affective* dimension participative and interactive dimensions analyzed separately	unit of meaning message unit of meaning	SOLO taxonomy with associated 5 stages 1: pre-structural stage (off-task activities) 2: uni-structural stage (activities focused on one aspect of a task) 3: multi-structural stage (activities focused on several aspects of a task) 4: relational stage (several aspects of the task are connected) 5: extended abstract stage (reflection upon and integration of new ideas)
Pena-Shaff, Martin, & Gay, 2001 Pena-Shaff & Nicholls, 2004	3 dimensions related to Henri: *participative*, *monologue,* or *interactive* messages monologue categories: reflective analysis, subjective analysis, task-related, assertion, personal experiences, topic evaluation, and off-task sentences. Interactive categories: question, reply, support, consensus building, clarification/elaboration, and social interaction	message unit of meaning	Knowledge construction indicated by the identified categories: clarification/elaboration, consensus building, assertion, reflective analysis, and questions
Lockhorst (2004)	3 dimensions related to Henri: *participative*, *interactive* and *metacognitive*	unit of meaning	Knowledge construction: 5 types of from surface learning to deep learning
Van der Meijden (this thesis)	3 dimensions of Henri: *cognitive*, *metacognitive*, and *social* (renamed as *affective* dimension)	message unit of meaning	Process of knowledge construction as indicated by 1: level of participation (and interaction, study 2) 2: use of high-level elaborations (asking questions and giving answers or information with explanations or justifications) versus low-level elaborations (asking factual questions, giving answers of information without further explanations of justifications)

Kumpulainen and Mutanen (1999, 2000) analyzed the verbal functions, cognitive processes, and social processes of peer interactions in different collaborative learning settings Examples of verbal functions are: arguing, asking questions, evaluating, dictating, and reading aloud. Examples of cognitive processes are: expressions concerning procedures, explorative expressions, and irrelevant expressions (non-task-related remarks). And examples of social processes were provided by asking such questions as: Who is the leader? To whom the members of the group listen? Kumpulainen and Mutanen (1999, p.455) defined peer interaction as follows: "Peer interaction is treated as a dynamic process in which language and other semiotic tools are used as instruments of communication and learning. Interaction is seen as a complex social phenomenon which is composed of non-verbal and social properties in addition to its verbal characteristics."

Finally, Veerman (2000) studied the role of argumentation in university CSCL environments and distinguished three levels of activity: (1) focusing where students have to initiate and maintain a shared focus on the task, (i.e., understanding the meaning of the relevant concepts, application of concepts); (2) critical argumentation or the use of such moves as checks (i.e., when students do not fully understand the information and ask for more information), challenges (i.e., when students doubt information and ask for justification), and counters (i.e., students express disbelief or disagreement); and (3) the production of constructive activities such as: additions (i.e., the supply of new information not connected to previous information), explanations (i.e., the explanation of earlier stated information), evaluations (i.e., the provision of personal judgments on earlier stated information), summaries (i.e., the restructuring of information and drawing of conclusions), and transformations (i.e., the gaining of new insights). Veerman (2000) took also the production of constructive activities to be indicators of knowledge construction.

3.5 Development of a coding scheme

In order to analyze the verbal interaction data collected to answer the research question underlying the present research, we studied several methods of analyses of CSCL data and opted for analyses of student participation, interaction patterns, and the content of the students' contributions.

There were, however, several reasons for not choosing one of the analytic methods described above and therefore we developed our own scheme. First, we operationalized knowledge construction as the provision of elaborations, while none available models or analytic methods paid attention to - for example - requests for elaborated help and the provision of such. Second, we were interested in the cognitive activities of students working in a CSCL environment while the preceding models and analytic methods provide little information on the types of learning activities performed by students in primary and secondary education working in a CSCL environment. Third, we needed an instrument that was applicable in both synchronous and asynchronous collaborative learning settings. And finally, we needed an instrument that was applicable across different tasks.

Our decision was therefore to develop a new coding scheme that combines elements of the previous schemes, including the idea of studying the dynamics of peer group interaction (Kumpulainen & Mutanen,1999), in subsequent steps (Veldhuis-Diermanse (2002). The study by Veerman (2000) proved important for the development of this coding scheme because it showed the importance of argumentation, evaluation, and summarization. Three dimensions from the model of Henri (1992) thus formed the main categories for the coding scheme: the cognitive, metacognitive, and social (affective) dimension. The participative and interaction dimensions were applied as a first step in the analysis of the level of knowledge construction, followed by an analysis of the content of the CSCL interactions and, more specifically, the provision of high-level and low-level elaborations as a second step (see section 3.7.3).

The cognitive dimension refers to the thinking activities that students use to process learning content and attain learning goals. The types of learning content can be, for example: facts, concepts, formulas, reasoning, arguments, definitions, and conclusions. The metacognitive or regulative dimension refers to statements intended to redirect one's efforts during the conduct of a task and statements to help organize matters. The social/affective dimension refers to any emotional remark concerning the collaboration and contributions of those involved in a cooperative task. Given that the success of working together depends on not only cognitive but also affective factors, affective elements were included in the coding scheme as well as cognitive and regulative elements. Those interactions that did not reflect one of these dimensions were coded as "non-task-related remarks." And the coding of the learning activities in the coding scheme was limited to those activities visible in the CSCL data. An activity such as "memorizing", for example was not visible in the CSCL data and therefore not coded.

3.5.1 The cognitive dimension

The cognitive dimension contained a total of 13 interaction codes divided across three main subcategories: asking questions, answering questions, and the provision of information. The subcategory "asking questions" emphasizes the importance of asking questions and giving help as demonstrated by Webb (1991), King (1999), and Meloth and Deering (1994).

Table 3.2
Overview of the cognitive subcategory "asking questions"

CHV1	The student asks about a fact or just asks what the answer is. The question does not provoke any explanation. • *When did people start genetic engineering?* • *What do the letters YMCA stand for?* • *Is there a student-board in your school?*

CHV2	The student asks for an explanation/elaboration. • *Why is genetic engineering a threat to the environment?* • *What Dutch political parties would you call racist, or anti-racist? What is their political program with regard to refugees in The Netherlands?* • *How is the administration of Europe organized? Which organization is the most powerful?* • *How is school organized? Who is in charge, and what influence do students have?*
CHVER	The student asks a question to find out whether others agree with his or her remark, conclusion, or answer. • *I would not like to eat manipulated food, would you?* • *Do you also think the Socialist Party has less severe rules for immigration?*

An overview of the codes for the subcategory "asking questions" is presented in Table 3.2. The code CHV1 stands for asking factual questions; CHV2 stands for asking comprehension questions requesting elaboration; and CHVER stands for asking a verification question, to determine whether others agree or not.

In the second cognitive subcategory "answering questions" and in keeping with Webb (1991), a student can answer either with or without further elaboration. A student can simply answer "yes/no" or provide the solution to a problem without further explanation, which is coded CHG1. Alternatively, the student can provide a more or less extended explanation which is coded CHG2. In Table 3.3, an overview of the codes for the subcategory "giving answers" is presented.

Table 3.3
Overview of the cognitive subcategory: "giving answers"

CHG1	The student answers the question but does not provide further explanation or elaboration. • *When did people start genetic engineering? People started genetic engineering in the seventies.* • *YMCA stands for Young Men's Christian Association.*
CHG2	The student answers by explaining how the problem can be solved and explains why the problem must be solved in such a manner(i.e., uses such keywords as "because" or "that's why"). Sometimes a counter-question may be asked to prompt or let the other think. • *Why is genetic engineering a threat to the environment? Genetic engineering is a threat to the environment because the consequences genetic of engineering for the environment in future are not clear at this moment.* • *We examined the position of three Dutch political parties with regard to the policy of refugees in the Netherlands, the Labour Party (PvdA), the Democratic party (D66), and the Socialist Party (Groen Links). They all agree that the refugee policy should improve and that the immigration rules should be much more severe (PvdA) but that anyone who is really in need should be accepted as a refugee.*

The third cognitive subcategory "giving information" pertains to the general input of information and acceptance or rejection of information provided by others. The presentation of new ideas without elaboration is coded as CI1, and the presentation of new ideas with elaboration is coded as CI2. References to previously discussed ideas are coded as CIT, while explicit evaluation of the content or summaries of previously discussed ideas are coded as CIE. Four categories of acceptance or rejection are further distinguished: acceptance without further elaboration, coded as ACCEPT- ; acceptance with further elaboration is coded as

Table 3.4
Overview of the cognitive subcategory "giving information"

CI1	The student formulates an idea or thought, but does not give an explanation • *Furthermore, we interviewed the school director; there is no racism in our school.* • *There are some 40 local anti-racist organizations in The Netherlands, located in almost every (bigger) town.* • *There have been four mayor accidents with nuclear power:* *1957 Windscale/Sellafield (England),* *1958 Kyshtym (Russia),* *1979 Harrisburg (USA),* *1986 Tsjernobyl (Russia).*
CI2	The student formulates an idea or thought and then explains or elaborates on it. • *Radiation is a natural phenomenon and not as scary as people generally think it is. It is not more dangerous than daily life risks like traffic and has some advantages, for example, like its use in medicine.* • *I think that we must add two x kilograms to the left layer, I think two. Because this is one and four. Eight divided by four. Because it is four times as long.*
CIT	The student refers to previously formulated information • *In Note # 103, they mention some elements of biotechnology.* • *As we already said in the previous note…* • *Do you remember the dinosaur? He was heavier than the little girl, so the balance went down on his side.*
CIE	The student evaluates the content, summarizes, or concludes. • *To conclude: The Dutch queen does not have much power. The government (queen, prime minister, and ministers) rule the country, controlled by the parliament, First, and Second Chamber* • *Summary: there is a central administration in our school, which consists of three people. The students have a student board, this is an advisory board without the right to decide*
ACCEPT-	The student accepts the contribution of another participant without further comment/addition. • *Yes, okay.* • *Yes.*
ACCEPT+	The student accepts the contribution of another participant and adds a comment or elaboration. • *Yes, six. Yes, because here it is still going down, cause this is the same length.*
NACCEPT-	The student does not accept the contribution of another participant and does not provide any further explanation for not accepting. • *No, I cannot put the fulcrum here.*
NACCEPT+	The student does not accept the contribution of another participant and provides an explanation for not accepting. • *No, I don't think here, because the right layer of the balance beam will go down.*

ACCEPT+, rejection without further elaboration is coded as NACCEPT-, and rejection with further elaboration is coded as NACCEPT+. An overview of the codes for the third cognitive subcategory is presented in Table 3.4.

The cognitive dimension of the coding system we developed covers the three types of talk distinguished by Mercer and Wegerif (1999): *disputational talk* or not accepting what has been said by a peer but without further explanation; *cumulative talk*, or following the arguments of a peer without any further critical remarks or provision of new information; and *exploratory talk*, or following the arguments of a peer with the addition of further information or explanation.

3.5.2 The regulative dimension

Although research has demonstrated the importance of metacognitive regulation strategies for individual student learning (Artzt & Armour-Thomas, 1997; De Jong, 1992; Schraw & Moshman, 1995), research on the metacognitive regulation of CSCL is still scarce. In general, metacognition refers to the awareness of goals, the ability to plan the learning process, and the capacity to monitor a learning process and adjust the process as necessary (Schraw & Moshman, 1995, Boekaerts & Simons, 1995).

Table 3.5
Overview of the regulative subcategories, affective category, and rest subcategories

RV	The students plan the execution of the task, distribute the tasks, monitor the conduct of the task, keep track of the time, or comment on the group process. • *Not so precise, otherwise we will never finish on time.*
RINS	One participant instructs another participant • *Just make the drawing.* • *Just a straight line here and then two little puppets on top here.*
A	The student makes a positive, neutral, or negative remark about another participant or about the task. • *Yes, well, that is not so hard.* • *Duh, this is really difficult.*
GREE	To indicate the presence or absence of a person in the communal database or the chat room. • *Hello…* • *bbs (be back soon).*
AND	Non-task-related comments and or interactions/remarks that do not fall into any other coding categories or subcategories, and non task-related remarks. • *Hey, I got a Game Boy for my birthday.* • *The test this morning was a disaster!*

More specifically, metacognition concerns metacognitive knowledge (i.e., what one knows about how to use a series of cognitive strategies) (Torrano Montalvo & Gonzalez Torres,

2004) and metacognitive regulation (i.e., activities that help control one's learning or thinking). Metacognitive regulation strategies that are typically assumed to be of particular importance for learning are - for instance - planning i.e., the selection of appropriate strategies and adequate allocation of resources, monitoring i.e., keeping track of comprehension and task performance, and evaluation i.e., appraisal of the products and processes of one's learning.

There are several reasons to assume that metacognitive regulation is of equal importance for CSCL. First, CSCL requires students to work together without much teacher guidance and thereby places a heavier burden on student regulation strategies than more traditional forms of education. Second, CSCL tasks are usually complex, ill-structured and often open-ended (i.e., there is no "right" or "wrong" answer). Such regulation strategies as monitoring, planning, and evaluation are therefore called for (Artzt & Armour-Thomas, 1997). Third, in a CSCL setting nonverbal and social context cues are absent, which creates a need for more active and explicit regulation of learning processes. Fourth, the effectiveness of collaborative learning, is clearly increased when each team member of the team monitors his or her own learning process and the learning process of other team members as well (Larson et al., 1985). The metacognitive regulative dimension contains two subcategories, as can be seen from Table 3.5. The first pertains to the conduct of the task, namely the planning, monitoring, and evaluation of the task and is coded as RV. The second pertains to the instruction of another participant and is coded as RINS.

3.5.3 The affective dimension

Although the focus in the present thesis is on cognitive learning activities, we agree with Vermunt (1992) and Veldhuis-Diermanse (2002) that affective learning activities play an important role in the learning process because positive or negative feelings with regard to the task at hand can influence the learning process (Vermunt, 1992). Students can express positive feelings about what they have done or what others have done. They can also express negative feelings about the task at hand when they find it too hard or they cannot find the right information on the internet, for example. Positive, negative, and neutral affect expressions are coded in a similar manner, as can be seen from Table 3.5, namely as A for "affective".

3.5.4 Rest categories

As can again be seen in Table 3.5, greetings, used to indicate entrance or departure from the communal database or chat room are coded GREET. And in contrast to Henri (1992), we added a special subcategory for "non-task-related remarks" and remarks that do not fall into any other category or subcategory. Such non-task-related or otherwise irrelevant remarks are coded AND. The coding scheme thus contains a total of 18 possible codes.

3.6 Testing of the coding scheme

The original coding scheme was tested and adapted several times (Kleine Staarman, Krol, & Van der Meijden, 2005). Within the cognitive category, for example, it became clear that interactions do not always consist of just questions and answers or help in response to such questions; information was also often provided without someone first asking a question; and this observation led to the addition of the coding possibilities of sub-categories "giving information with/without elaboration." Within the regulative category, it became clear that students sometimes tell each other what to do in CSCL environments. Instructions on how to use the computer program could be provided, for example, and the subcategory "instruction of the other student" was therefore added to the coding scheme.

Table 3.6
Main categories and subcategories of the coding scheme

Cognitive: asking questions	
CHV1	Asking questions that do not require an explanation (facts or simple questions)
CHV2	Asking questions that require an explanation (comprehension or elaboration)
CHVER	Verification or asking for agreement
Cognitive: giving answers	
CHG1	Answering without explanation
CHG2	Answering with explanation (using arguments or by asking a counter-question)
Cognitive: giving information	
CI1	Giving information (an idea or thought) without elaboration
CI2	Giving information (an idea or thought) with elaboration
CIT	Referring to earlier remark/information
CIE	Evaluating the content (summarizing/concluding)
ACCEPT-	Accepting contribution of another participant without elaboration
ACCEPT+	Accepting contribution of another participant with elaboration
NACCEPT-	Not accepting contribution of another participant without elaboration
NACCEPT+	Not accepting contribution of another participant with elaboration
Affective	
A	Positive, neutral, or negative emotional reaction to another participant or with regard to the task
Regulative	
RV	Planning, monitoring, and evaluation of the task or group process
RINS	Instructing: one participant instructs another participant
Rest	
AND	Non-task-related remarks, unfinished sentences, or interactions that do not fall into any other category
GREE	Greetings to indicate the presence or absence of a person

Finally, the coding scheme was tested in different collaborative settings (Kleine Staarman et al., 2005) where students were working synchronously in a face-to-face learning environment or in dyads in a CSCL environment.

To summarize: A coding scheme for the analysis of CSCL interactions was developed in several stages. First some specific CSCL interactions that appear to be particularly beneficial for learning were examined. Second, the methods used to analyze interactions in CSCL environments in previous research was examined and found to focus on participation, social structure, and the content of the interactions. Finally, a coding scheme was developed and tested for use in the three studies reported on in this thesis. In Table 3.6, the different categories and subcategories constituting the coding scheme are listed with the associated codes.

3.7 Analysis of peer interactions in a computer-supported collaborative learning environment

According to Chi (1997), the coding of verbal interaction data which may include the transcripts of audio or video recordings of small groups of students working together or their contributions in CSCL environments can proceed in three functional steps. The first step is reduction or sampling of the transcripts. Once the data has been collected and transcribed as needed, it may not be possible to code all the data. Reduction must then be undertaken, and this can be done by random sampling or according to particular criteria i.e., language used by participants (see Chapter 6). Once the corpus of transcripts to be coded has been determined, the unit of analysis must be determined. In a second step, thus, the relevant units for coding and analysis are identified. This process is called segmentation. This can be done using non-content features (i.e., words, sentences, turn-taking) or content-related features (i.e., ideas, argument chains, topics of discussion). Keeping the relevant theoretical notions and questions to be addressed in mind (Chi, 1997), the selected coding scheme can now be applied to the data. The actual assignment of a specific code to each and every unit thus constitutes the third step in the coding of verbal interaction data.

3.7.1 Segmentation and determination of the unit of analysis

In two of the studies, no reduction or sampling took place; all of the collected data were thus analyzed. In the study concerned with both synchronous and asynchronous communication, the initial 80 hours of chat data were reduced (see Chapter 6). After reduction, segments of the transcript data were identified. In other words a so-called process of “unitizing” was undertaken (Rourke, Anderson, Garrison, & Archer, 2001). Such non-content features as words or sentences (i.e., syntactic units) can be used to segment data, but a disadvantage of adopting such a fine unit of analysis is that it generates an enormous amount of data for coding and analysis purposes. An alternative unit of analysis with many advantages over the syntactic unit is the message or note. Unlike other units of analysis, multiple raters tend to agree on what constitute a message or a note as unit of analysis. In addition, a manageable set of contributions is established using such a message (Rourke et al., 2001). In CSCL however, the nature of the message as unit can vary greatly: some messages of notes may contain several paragraphs and deal with multiple topics (i.e., a note in a discussion forum), while others contain very little information (i.e. a sentence in a chat). This brings us to the most commonly used unit in content analyses in CSCL environments; namely the unit of meaning (Henri, 1992). A significant disadvantage of adopting the unit of meaning as the relevant unit for coding and analysis purposes is that this greatly delays the process of segmentation. That is, segmentation on the basis of content (i.e., meaning), is more time-consuming than segmentation on the basis of non-content, because the transcripts must be examined for their meaning in order to determine the units of analysis.

The reviews by Rourke et al. (2001) and Strijbos and Martens (2003), who reviewed the proceedings of the CSCL 2001 and 2002 Conferences, show: that (1) the unit of analysis takes many forms, including "message/note," "meaningful event," "argument," or "proposition"; (2) that arguments for choosing a specific unit of analysis are not extensively presented or discussed; (3) that the procedure used to segment communication transcripts is only occasionally mentioned and rarely discussed or described at length; and (4) that studies based on units of analysis smaller than the message/note only report coding reliability and not the reliability of the segmentation process itself (Rourke et al., 2001). In addition, Strijbos and Martens (2003) observed that when segmentation reliability is reported, it tends to be very low. In reviewing the Strijbos and Martens study however, it has to be notified that the authors examined only conference papers and did not examine how segmentation reliability is reported in articles based on these papers published in international journals.

Within the context of the present research, it was decided that the "meaningful unit" based on the work of Henri (1992), best fits our research aims. The steps of "determining the relevant units" and "assigning codes" were thus combined in the present research. In our opinion, it made no sense to separate segmentation from coding because segmentation depended on meaning (Henri, 1992; Gunawardena et al., 1997).

Following Henri (1992) and Gunawardena et al. (1997), we thus divided the messages/notes into significant "units of meaning." Although the length of a unit of meaning could vary from a single word ("No") to an extended paragraph, each unit of meaning was assigned only a single code. The unit of meaning was also adopted as the unit of analysis because the knowledge construction that occurs during group interactions can be viewed as largely interdependent; that is, the questions and responses of one participant are, to a great extent, elicited or stimulated by the questions, statements, and responses of the other participant (King, 1994).

3.7.2 The coding of the transcripts

Prior to the coding of the transcripts of the videotapes, audiotapes, and chat log files in study 1, the contributions to the discussion forum in study 2, and chat log files and contributions in the discussion forum in study 3, each time two coders/researchers went through a training program of about 40 hours. The training program involved the formulation of rules for coding, learning to apply the computer program Multiple Episode Protocol Analysis (MEPA) as developed by Erkens (2001), and the coding of a number of transcripts to determine inter-coder reliability. Each transcript was then coded in its entirety by one of the trained researchers. For each study, the interrater agreement and Cohen's (1960) Kappa for the coding of the transcripts were then calculated.

3.7.3 Analysis of the process of knowledge construction

In the previous chapter knowledge construction was operationalized as the provision of elaborations, in the form of asking comprehension questions requiring explanations, the provision of answers with arguments or justification, the presentation of new ideas with explanations, and the acceptance or rejection of ideas coming from others with arguments for doing this. Two levels of elaboration were distinguished to characterize the contributions of the students to the verbal interactions: high-level elaboration and low-level elaboration. This classification is indirectly based on the work of Webb, Nemer, Chizhik, and Sugrue (1998). *High-level elaboration* is reflected in five of the subcategories from the cognitive dimension in our study, namely: comprehension questions asking for elaboration, answers with elaboration, presentation of new ideas with further elaboration, acceptance with further elaboration, and rejection with further elaboration. *Low-level elaboration* is reflected in the other eight subcategories from the cognitive dimension: factual questions, verification questions, answers only, presentation of new ideas without further elaboration, references to previously discussed ideas, summarization, acceptance without further elaboration, and rejection without further elaboration. In Table 3.7, the five codes that were used to assess the knowledge construction process are summarized.

Table 3.7
Five cognitive codes indicating high-level elaboration

High level elaboration	
CHV2	Asking questions that require an explanation (comprehension or elaboration)
CHG2	Answering with explanation (using arguments or by asking a counter-question)
CI2	Giving information (an idea or thought) with elaboration
ACCEPT+	Accepting contribution of another participant with elaboration
NACCEPT+	Not accepting contribution of another participant with elaboration

In the present thesis, different approaches to describe and analyze the level of participation, interactional behavior, and the process of knowledge construction will be used to answer the general research question: *Does CSCL elicit the process of knowledge construction in terms of elaborations?* The quantitative data include the total number of messages (asynchronous communication) and the total number of turns (synchronous communication).

7.8 Three steps to analyze the interactions in this thesis

Three steps were followed in the analyses of the CSCL data, as depicted in Figure 3.1.

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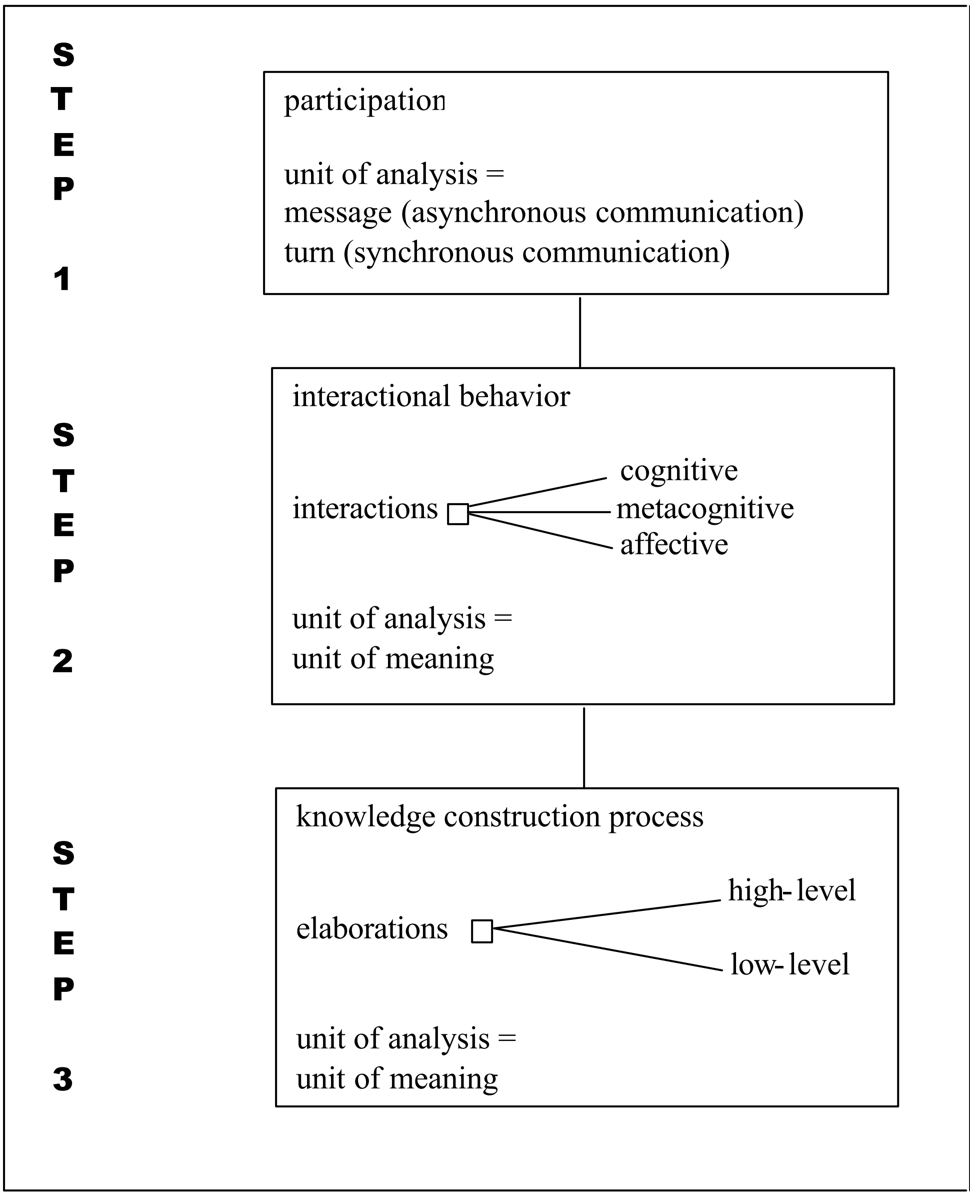

Figure 3.1
Three steps for in the analyses of CSCL interactions.

The first step was to quantitatively analyze the degree of participation (unit of analysis: message/turn) in a CSCL environment[2]. The second was to analyze the interactional behaviors of the participants in different CSCL situations in terms of the cognitive, affective, and regulative characteristics of their contributions (unit of analysis: unit of meaning). The third step was to assess the quality of the knowledge construction process and thus the extend to which high- versus low-level elaborations were found to occur (unit of analysis: unit of meaning).

Three CSCL settings, involving three different communication formats were utilized in the present thesis: a CSCL setting with synchronous communication, a CSCL setting with asynchronous communication, and a CSCL setting with a combination of synchronous and asynchronous communication. In the study described in the following chapter (Chapter 4), the collaboration between children working in two different collaborative settings is compared: primary school students working together on a mathematics task in a FTF situation (i.e., sitting next to each other to collaboratively perform a task) versus primary school students collaborating in a CSCL setting (i.e., communicating with each other by means of synchronous chat. The FTF data were collected as a part of the research project "Implementation of cooperative learning in primary education" at the Radboud University Nijmegen. In the second study the knowledge construction process of high-school students working in a asynchronous CSCL environment is examined. This study is part of a research project called "Computer supported collaborative learning networks in primary and secondary education", which has been funded by the European Community. In the third study described in Chapter 6, the interactions and knowledge construction process of primary and high-school students collaborating and communicating in a three-dimensional virtual world are analyzed. The research project on which this study is based is called "Euroland" and was also funded by the European Community. Three Dutch and four Italian schools participated in the collaboration at a distance.

[2] In the synchronous CSCL environments, participation was not analysed

Chapter 4
Student elaborations in a synchronous (computer-supported) collaborative learning environment[3]

4.1 Introduction

Computer-mediated communication (CMC) is increasingly being used in schools as an environment for collaborative learning (Gunawardena et al., 1997). CMC has been promoted as a means to improve communication and collaboration between students. CMC has also been promoted as a means to facilitate the sharing of knowledge and understanding among students who are not working together in a face-to-face (FTF) situation (Lipponen, 1999). An important question is how CMC affects interaction patterns in a collaborative learning group while solving a collaborative task when compared to FTF communication. In this study, interactions within FTF collaborative learning groups are compared to interactions within CMC collaborative learning groups.

Numerous studies show collaborative learning to enhance not only student achievement but also their social development (Cohen, 1994; Dillenbourg, 1999; Johnson & Johnson, 1994; Slavin, 1996). Both field and laboratory studies on the achievement effects of collaborative learning have been conducted for every major subject and all grade levels. The result is widespread consensus among researchers on the positive effects of collaborative learning on student achievement (Slavin, 1996). In recent years, the question of just how collaborative learning enhances peer interactions and group work has resulted in a new area of research referred to as computer-supported collaborative learning (CSCL).

Perspectives on learning in cooperative or collaborative groups have been strongly influenced by sociocognitive theory based on the work of Piaget (1926) and sociocultural theory based on the work of Vygotsky (1978). One line of research influenced by the work of both Piaget and Vygotsky is the cognitive elaboration approach (see Chapter 2). According to the cognitive elaboration approach, interaction with others leads to the active processing of information by the individual, which can then - in turn - modify the individual's cognitive structures. Elaboration is viewed as a strong concept and refers to the detailed explanations that occur when peers provide examples of a topic, use multiple representations, explain a concept, or supply specific argumentation. An important notion within this context verbalization, which can lead to elaborate cognitive processing and thereby reflection, awareness, (re)organization, differentiation, fine-tuning, and the expansion of knowledge (Van Boxtel, 2000). The present study borrows from the Piagetian and Vygotskian

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[3] This chapter is based on: Van der Meijden H., & Veenman, S. (2005). Face-to-face versus computer-mediated communication in a primary school setting. *Computers in Human Behavior 21*(5), 831-859.

perspectives on development and the importance of social interaction for learning. That is, the importance of the active reconciliation of different perspectives and the importance of studying learning as a social or collaborative process, are emphasized. The present study also borrows from the cognitive elaboration perspective the assumption that students working in small groups can learn more from the provision of high-level elaborated help to others than from the receipt of low-level elaborated help.

Despite the increasingly large literature on cooperative or collaborative learning, few studies have explicitly compared collaborative learning in FTF versus CMC situations at school. Although computers appear to play an increasingly important role in children's learning at school, little is known about the effects of computer-mediated versus FTF collaboration in primary school settings. At this moment, the small working groups formed at school rely primarily on FTF interaction as the medium for collaboration. The present study addresses the question of whether differences exist in the interactions of student pairs working collaboratively FTF versus collaboratively in a computer-mediated situation.

4.2 Review of relevant studies on computer-mediated versus face-to-face communication

The introduction of CMC to support collaborative problem solving and decision making has raised the question of whether the communication patterns, task effectiveness, and work satisfaction under such circumstances resemble the patterns of communication, task effectiveness, and work satisfaction under FTF circumstances. Some authors have argued that the performance in CMC groups is superior to the performance of FTF groups due to the lack of a social presence in the CMC groups and thereby a less personal and socio-emotional form of interaction and a more task-oriented form of communication than in the FTF groups (Jonassen & Kwon, 2001; Light & Light, 1999). In contrast, other authors have argued that the task discussions in CMC groups almost always take longer to complete than in FTF groups; that the absence of various nonverbal and social context cues to communication in the CMC situation may hamper the efficiency of task performance; and that the absence of a social context and nonverbal cues to communication may even create a significant degree of anonymity and thereby a higher incidence of rude or offensive behavior in the CMC as opposed to FTF situations (Bordia, 1997; Straus, 1996).

General communication effects

Bordia (1997) synthesized the results of 18 experimental studies examining the communication effects of working in CMC versus FTF groups and found strong evidence for the following propositions: (1) CMC groups take longer than FTF groups to complete the assigned task; however, this difference may simply be due to typing, which takes more time than speaking; (2) CMC groups produce fewer remarks within a given time period than FTF groups; (3) CMC groups perform better than FTF groups on idea-generation tasks; (4) there is greater equality of participation in CMC groups; (5) when time is limited, CMC groups perform better than FTF groups on tasks involving less, and worse than FTF groups on tasks requiring greater social-emotional interaction; given sufficient time, however, the observed differences between the groups disappear ; (6) there appears to be relatively less normative social pressure in the CMC groups; and (7) perceptions (i.e., understanding) of the collaborative partner and the task are poorer in the CMC groups than in the FTF groups. Less strong research evidence was found for the following propositions: (1) there is a higher incidence of uninhibited behavior in the CMC groups than in the FTF groups; (2) CMC induces a state of deindividuation, which in turn leads to uninhibited behavior; and (3) CMC groups exhibit less choice shift (i.e., differences between individual pre-group discussion choices and final group decision) and also attitude change than FTF groups.

Task characteristics

As the review study by Bordia (1997) indicates, the outcomes and collaboration processes found to characterize CMC versus FTF groups are mediated by the characteristics of the task. From this perspective, Hollingshead, McGrath, and O'Conner (1993) also examined the influence of different tasks on the interactions in CMC versus FTF groups. More specifically, they examined the influence of four cooperative tasks with different levels of interdependence: generate tasks, intellective tasks, decision-making tasks, and negotiation tasks. *Generate tasks* do not require consensus or very much interdependence between group members because the task objective is simply to generate as many solutions as possible. *Intellective tasks* require the group members to find a demonstrably correct answer and thus involve some degree of interdependence. *Decision-making tasks* complicate the process of attaining consensus because no single demonstrably correct solution exists; the level of interdependence is relatively high as the group members must reconcile their different perspectives, attitudes, opinions, and information in order to reach consensus. *Negotiation tasks* involve the highest level of interdependence as the group members must reconcile not only their different perspectives, attitudes, opinions, and information, but also any conflict of interest. With each successive level of interdependence, the group's need for a rich amount of information increases and the task of reaching consensus becomes more difficult.

Generate tasks require a minimum of interdependence as the transmission of specific ideas is sufficient for effective task performance; the evaluative and emotional connotations associated with the message and the source do not play a role and may even be a hindrance at times. At the other extreme, negotiation tasks require maximum interdependence in order to resolve any conflicts of interest and any discrepancies in the facts, values, attitudes, emotions, and expectations that the different group members bring to the task. Hollingshead et al., (1993) found FTF groups to perform significantly better than CMC groups on both intellective and negotiation tasks, while no significant differences were found between the two groups on the generate or decision-making tasks.

In a study by Straus and McGrath (1994), three types of collaborative tasks with increasing levels of interdependence were distinguished: idea-generation tasks, intellective tasks, and judgment tasks. The first two tasks resembled those in the study by Hollingshead et al., (1993) while the judgment tasks were akin to the decision-making and negotiation tasks considered by Hollingshead and colleagues. The findings from the Straus and McGrath study showed few differences in the quality of the work produced by the CMC versus FTF groups, but large differences in productivity favoring the FTF groups. While there were no significant differences in the effectiveness of the CMC versus FTF groups on the idea-generation task or the intellective task, substantial differences were found on the judgment task in favor of the FTF groups. With regard to the quality of the work that the two groups completed, no average differences were found.

Jonassen and Kwon (2001) examined the patterns of communication in CMC and FTF groups while trying to solve well-structured versus ill-structured problems. The well-structured problems were low in complexity and high in clarity and predictability while the ill-structured problems were high in complexity and low in predictability. Jonassen and Kwon found the quality of the messages in the CMC groups to be lower but more task related than in the FTF groups because the participants in the CMC groups reflected more on ideas and perspectives related to the problem at hand. Given that the CMC messages were stored and could be retrieved whenever group the members wanted them, the participants in this group were found to reflect more on their comments. The participants' perceptions and patterns of communication did not differ for the well-structured versus ill-structured problems.

Satisfaction

Satisfaction concerns the participants' perceptions of being able to achieve success and feelings about the outcomes achieved (Keller, 1983). Several studies have explored student satisfaction under CMC versus FTF conditions. For example, Fjermestad and Hiltz (1999), Johnson, Aragon, Shaik, and Palma-Rivas (2000), Ocker and Yaverbaum (2001), Olaniran, Savage, and Sorenson (1996), Straus (1996), and Light and Light (1999) found students to be more satisfied with a FTF collaboration process than with a computer-mediated collaboration process. Several reasons for the relatively more negative perceptions of the students in the CMC conditions are then mentioned by the authors: asynchronity, coordination difficulties as the group members must, for example, agree on how frequently to communicate; relative anonymity of computer-mediated collaboration resulting in less effort on the part of some members; lack of non-verbal clues and "social presence" resulting in a sense of depersonalization; dislike of the text-based nature of computer-mediated collaboration due to the increased time needed to type and read messages; and mismatch in expectations regarding online interactions as based on years of experience in FTF school settings. In contrast, studies by Jonassen and Kwon (2001) and Cohen and Scardamalia (1998) show students to be more satisfied with the computer-mediated collaboration process than with the face-to-face-collaboration process because the former provided greater flexibility and responsiveness to their learning requirements and expectations. In addition, computer-mediated collaboration promoted greater reflection (i.e., monitoring and coordination of ideas to create a more integrated framework), the debate of issues, the clarification of concepts, the asking of questions as part of a collaborative community, and the deliberation that is part of critical thinking (Austin, 1997; Cohen & Scardamalia, 1998). These inconclusive findings suggest that greater insight is needed into the elements that students like and dislike about CMC versus FTF settings in order to increase their satisfaction.

Summary

The findings from the aforementioned studies show group performance to sometimes depend on the type of task being performed. Tasks calling for high levels of interdependence and/or a richness of information appear to require FTF interaction while tasks calling for low levels of interdependence and/or less information richness are better suited for CMC groups. When the participants in CMC groups are accustomed to using the computer, typing, and given sufficient time to complete the task, they may perform equally well as the participants in FTF groups. The results of studies exploring student satisfaction under CMC versus FTF conditions are inconclusive; some studies found students to be more satisfied in FTF groups while other studies found students to be more satisfied in CMC groups.

Limitations

A major limitation on the generalizability of the findings from the aforementioned studies is the use of mostly college students or managers as subjects. The characteristics and cognitive skills of primary school students differ from those of college students and working adults (Bordia, 1997). It is therefore not clear whether the results found in the studies reviewed here also apply to primary school students - that is, the subjects for our study. The subjects in the aforementioned studies were also all volunteers. For the present study, the teachers from the participating schools volunteered, but not the students. That is, the class as a whole was recommended by the teacher for participation in the present study although the students had the right to refuse to participate. Finally, most of the studies reviewed above were conducted in a laboratory setting. Little is known about how collaborative CMC versus FTF groups - composed of primary school students working on school learning tasks - may influence task performance of small group interaction. In the present study, the effects of using collaborative CMC groups versus FTF groups on the task performance and interactions of primary school students while working together in small groups will therefore be examined.

4.3 Research Questions

In the present study, the following research questions will be addressed.

1) Do the students in FTF groups provide and receive more or fewer elaborations when working on a collaborative task than the students in CMC groups?
2) Do the students in FTF groups perform better or worse on a collaborative task than the students in CMC groups?
3) How do the students in FTF groups perceive working on a collaborative task relative to the students in CMC groups?

4.4 Method

4.4.1 Research setting

This study was carried out within the context of a research program within the Radboud University Nijmegen, namely "Implementation of cooperative learning in primary education" (Krol, 2005). In this study, the collaboration between children in two different collaborative settings is compared: children working together on a mathematics task in a FTF situation where they sit next to each other while performing the task, versus children in a CSCL setting, where they communicate by means of synchronous chat.

4.4.2 Participants

Subjects were 84 sixth grade students aged 11-12 years from nine primary schools located in the east and south of The Netherlands. All of the subjects' parents or their school directors had consented to their child's participation. Prior to the study, the schools and students had little or no experience with working in collaborative groups. The schools and classes involved were comparable with regard to location, school size, and school enrollment. Two conditions were created: a FTF condition (referred to as the FTF group) and a CMC condition (referred to as the CMC group). Seven schools were involved in the FTF condition and two schools in the CMC condition.

The teachers were asked to divide the students in their classes into three levels of mathematics ability: low, medium, and high. Based on the students' ability levels, two types of dyads were formed. For the first type, a low-ability student was randomly paired with a medium-ability student; for the second type, a medium-ability student was randomly paired with a high-ability student. The formation of the different types of dyads was based on the assumption that the ability levels of the students should be different in order to generate help and help-seeking behaviors but not too different in order to allow the students to work within their "zones of proximal development" (Vygotsky, 1978). Research from a Vygotskian framework suggests the importance of pairing students with more expert peers (O'Malley, 1995). Studies by Azmitia (1988) and Verba and Winnykamen (1992) show that pairs with unequal abilities or unequal domain expertise improved more than pairs with equal ability or domain expertise and that their interactions were characterised by more tutoring or guidance.

Within each of the seven FTF sixth grade classrooms, two students were randomly selected from the three ability levels (i.e., 6 students per classroom) and randomly paired into 21 high-medium or medium-low dyads. Within the two CMC sixth grade classrooms, all of the students were randomly paired into 22 dyads. In general, each dyad in the FTF group was composed of one girl and one boy. The 21 pairings made for the FTF group were subsequently checked by the teachers to exclude dyads of students who could not get along with each other. Based on this check, three FTF dyads were omitted and replaced by three newly formed dyads. The 22 pairings made for the CMC group did not need to be checked because the members did not know with whom they were collaborating. The distribution of the dyads according to group and ability level is shown in Table 1. The data from one dyad in the FTF group is missing due to inaudible recording, which makes for a total of 20 FTF dyads.

Table 4.1
Distribution of the 42 dyads constituting the FTF and CMC groups according to ability level

Ability level	FTF group	CMC group	Total
Level 1: low-medium pairing	11	10	21
Level 2: medium-high pairing	9	12	21
Total number of dyads	20	22	42

Analyses of variance were used to confirm the differences between the performance scores of the students sorted by the teachers according to three levels of mathematics ability. For this analysis, the national achievement (CITO) test scores for mathematics attained in the spring of the same school year were used as the dependent variables. As expected, the ability levels for mathematics indeed proved statistically significant: F (2,81) = 169,12, p = <. 01). The mean scores, which could range from 1 (= *highest*) to 5 (= *lowest*), were as follows: high-ability (M = 1.14, SD = .36, n = 21), medium-ability (M = 2.40, SD = .59, n = 42), and low-ability (M = 4.24, SD = .63, n = 21). The pairing procedure thus resulted in dyads of students with clearly different ability levels.

4.4.3 Collaborative task and procedure

All of the dyads were asked to solve a mathematics task. In the FTF group, the students worked in dyads FTF to solve the mathematics task. In the CMC group, the students worked in dyads on the same task but their collaboration was mediated by computer use. All of the sessions took place in the morning. At the start of each session, the researcher provided a brief description of the task, described how the answers should be recorded, and explicitly stated that the students should collaborate on the task that had to be solved within 30 minutes. In the

FTF group, the researcher brought two students from a classroom into a room where the materials were already set up. In the CMC group, one of the two researchers took 10 or, alternatively, 12 students out of the classroom and assigned them to one of two computer rooms, which were both monitored. The members of the CMC dyads worked synchronously on the mathematics task in a virtual chat room provided by the Active Worlds program, a three-dimensional learning environment developed by Active Worlds Inc. (1997). In this learning environment, students chat synchronously (http://www.activeworlds.com/). For the students in the CMC group, how to work with the chat program was also explained and the CMC group practiced for 15 minutes how to chat before the start of the collaborative task.

The mathematics task, which required formal reasoning and discussion, was developed to be challenging for sixth graders and did not include topics discussed previously in the classroom. During the development phase, a sample of three dyads consisting of seventh and eight graders from schools not involved in the study provided feedback on the adequacy of the materials. On the basis of this pilot work, the wording of the mathematics task was slightly modified.

In order to promote logical reasoning, a balance beam task was used. Students had to predict which side of the beam would go up or down when various configurations of weights and distances were set up. Such a task has been successfully used in earlier experiments by Siegler (1976), Phelps and Damon (1989), and Tudge (1992). In contrast to the work by these authors, our study did not involve a real balance beam with removable pegs on each side of the fulcrum or a capacity to really tip to the left, the right, or remain balanced. Our study involved of a paper-and-pencil task with drawings of a balance beam involving different configurations of weights and distances from the fulcrum (cf. Ros, 1994).

Students were given a 15-page booklet with 15 problems to solve (Appendix A). The first five problems pictured a scale with weights on it, and the students had to indicate whether the scale was balanced or - if not - which side would go up or down. The first five problems were the simplest involving basic weight and distance problems that have been found to be fairly easy for most sixth graders: placing greater or less weight on a balance beam with equal or different distances from the fulcrum in order to achieve balance (Phelps & Damon, 1989). For the first five problems, the booklet provided feedback on the solution to the problem, and the students could then compare their solution with the one in the booklet. The first five problems were intended to highlight the importance of different weights and different distances from the fulcrum and thereby familiarize the students with how to work with a balance beam. After completion of these problems, the students were asked to collaboratively solve 10 more problems with the weights and distances from the fulcrum varied in a more complicated manner. The solutions for the last 10 problems required more formal reasoning because the students had to consider both the amount of weight and the distance of the weights to the fulcrum (Phelps & Damon, 1989). Each dyad in the FTF group received one booklet and one worksheet with the problems to be solved. After discussion of a problem, one of the students wrote the proposed solution down. In the CMC condition, each of the students received a booklet and one of them typed the shared solution in the chat box after discussion of the problem with the other student in the dyad. Sometimes both students typed in the solution.

4.4.4 Data collection and preparation

All of the sessions in the FTF group were video recorded and later transcribed. In the CMC group, all of the chats were saved for later analysis. After completion of the task, all of the students were administered a brief questionnaire in order to assess their individual perceptions of the manner in which they had worked together with the other student in the dyad.

The total performance score for the mathematics task was the sum of the points awarded for each correct answer to the balance beam problems. Correct answers to the 15 problems were assigned one point to produce a possible maximum of 15 points.

The coding scheme

The theoretical framework used in the present study rests on the assumption that learning can be described in terms of both individual cognitive activities and social processes (Salomon & Perkins, 1998; Shuell, 1996). The analytic framework involving cognitive, affective, and regulative) dimensions is described in Chapter 3. The cognitive dimension refers to the thinking activities that students use to process the learning content and attain their learning goals. The types of learning content are, for example: facts, concepts, formulas, reasoning, arguments, definitions, and conclusions. The affective dimension refers to any emotional remarks concerning the collaboration and contributions of those involved in a cooperative task. Given that the success of working together may depend on not only cognitive but also affective factors, the coding scheme thus included affective elements as well. The regulative dimension refers to statements intended to redirect one's efforts during the conduct of a task and statements to help organize matters. Those verbal interactions that did not reflect one of these dimensions were coded as "non-task related remarks." The emphasis in the present study is primarily on the cognitive dimension.

The *cognitive dimension* contained 13 verbal interaction categories distributed as follows: three categories pertaining to the posing of questions (i.e., factual questions, comprehension questions asking for elaboration, and questions asking for verification); two categories pertaining to the provision of help (i.e., answers only and answers with elaboration); two categories pertaining to the input of new ideas (i.e., presentation of new ideas without elaboration and presentation of new ideas with elaboration); two categories pertaining to previously discussed ideas (i.e., references to previously discussed ideas and summarization); and four categories pertaining to the acceptance or rejection of ideas (i.e., acceptance without further elaboration, acceptance with further elaboration, rejection without further elaboration, and rejection with further elaboration). The *affective dimension* contained one category pertaining to the process of collaboration (i.e., emotional reactions). The *regulative dimension* contained two categories pertaining to the conduct of the task (i.e., the planning of the task and instruction of the other student).

Yet another category was added to the coding scheme for the analysis of the interactions of the dyads in the CMC group, namely greetings (i.e., indications of entrance into or departure from the communal database). The coding scheme thus contained a total of 17 verbal interaction categories for the FTF condition and 18 verbal interaction categories for the CMC condition (including the category with "non-task related remarks").

Unit of analysis

In order to code the verbal interactions of the dyads, the verbal interaction was first divided into conversational turns defined as a change of speaker. Note that a single turn can sometimes contain more than one utterance, which was the basic unit of analysis. In the FTF condition, one utterance was distinguished from another by a "perceptible pause", comma, or period in the transcript and a singular communicative function (Van Boxtel, Van der Linden, & Kanselaar, 2000b). Although the length of an utterance could vary from a single word ("No") to an extended monologue, each utterance was assigned to only one of the categories within the present coding scheme. In the CMC condition, a conversational turn was defined by the use of the "enter button" to indicate the end of an individual's contribution; a single utterance was distinguished in the same manner as in the FTF condition (i.e., a comma or period).

The scores for a given student were the number of utterances falling into the different categories within the coding scheme. The unit of analysis for all subsequent analyses of the students' contributions was the dyad. This unit of analysis was adopted because the process of knowledge construction that occurs during dyadic interactions can be viewed as largely interdependent: that is, the questions and responses of one partner are, to a great extent, elicited or stimulated by the questions, statements, and responses of the other partner (King, 1994).

Coding of the interactions

Prior to the coding of the transcripts of the videotapes and the chats, two researchers went through a training program of about 40 hours. The training program involved the formulation of rules for coding, learning to apply the computer program Multiple Episode Protocol Analysis (MEPA) as developed by Erkens (2001) to code transcribed verbal interactions, and the coding of three transcripts from a sample of three dyads from schools not involved in the study. The transcripts for the 42 dyadic interactions were randomly assigned to the two researchers for coding. Each transcript was coded in its entirety by one of the two trained researchers. The interrater agreement for the coding of the transcripts was calculated on the basis of nine transcripts randomly selected from two subject groups (23% of all transcripts). The percentage agreement was found to be 94%, and the Cohen's (1960) Kappa was .93.

Measurement of student evaluations
To gain insight into students' perceptions of working together, a short Likert-scale questionnaire was administered directly after completion of the mathematics task (Appendix B). Seven items concerned with the manner in which the students reached a shared solution and helped each other, were rated along a five-point scale (1 = *highly disagree*; 5 = *highly agree*). The Cronbach's reliability coefficient for this questionnaire was found to be .83.

Measurement of computer skills
In the CMC group, yet another brief questionnaire was administered to the students to gain insight into their computer skills (Appendix C). This questionnaire consisted of six questions concerning the frequency of daily computer use at home and at school, the programs used by the student, and typing ability. The responses were assigned a score between 1 and 3 depending on the content of the answers provided by the students. When a student earned 12 or more points for the six questions considered together, he or she was assigned to the high-level computer skills group; when a student earned less than 12 points, he or she was assigned to the low-level computer skills group. Dyads with a score of 24 or higher out of a possible total of 36 were assigned to a high-level computer skills group. Dyads with a score of less than 24 points were assigned to the low-level computer skills group.

4.5 Data Analysis

Two levels of elaboration were distinguished to characterize the contributions of the students to the verbal interactions: high-level elaboration and low-level elaboration. This classification is indirectly based on the work of Webb, Nemer, Chizhik, and Sugrue (1998). *High-level elaboration* encompassed five categories from the cognitive dimension in our study, namely: comprehension questions asking for elaboration, answers with elaboration, presentation of new ideas with further elaboration, acceptance with further elaboration, and rejection with further elaboration. *Low-level elaboration* encompassed eight categories from the cognitive dimension: factual questions, verification questions, answers only, presentation of new ideas without further elaboration, references to previously discussed ideas, summarization, acceptance without further elaboration, and rejection without further elaboration. In order to illustrate the use of high- and low level elaborations and the use of regulative statements between the FTF and CMC groups, four extracts from the transcripts were selected.

For each dyad, which was again the unit of analysis, the frequencies of high- and low-level participation were calculated by summing the individual code frequencies. The percentages of high-and low-level participation could then be calculated for each dyad by dividing the number of high- and low-level utterances, respectively, by the total number of utterances. The total number of utterances was calculated by summing up the individual code frequencies for the 17 categories of the code scheme for the FTF groups and the 18 categories of the code scheme for the CMC group (including the "non-task related remarks").

For the performance scores, the unit of analysis was again the dyad as the mathematics problems were solved jointly with the solution written down on a single worksheet in the FTF condition and typed in the chat box in the CMC condition. For the student perception data for both groups and the computer skills data for the CMC group, the unit of analysis was the individual student as each student individually completed the questionnaires. In addition, the individual student was the unit of analysis for the correlations between the frequency of high and low level elaborations and the performance scores of the students.

The differences between the FTF and CMC groups were examined using *t* tests for independent samples. A significance level of 5% was used in all of the statistical tests (two-tailed). Effect sizes (*ES*s) were calculated by dividing the difference in the mean scores for the FTF versus CMC groups by the pooled standard deviations for the scores of the FTF and CMC groups (Cohen, 1988).

4.6 Results

4.6.1 Quantitative analyses of the verbal interactions

In order to give insight into the interactional behaviors of the students collaborating within a FTF versus a synchronous CSCL situation, a summary of the frequencies and percentages for the different categories of interaction is presented in Table 4.2. The first research question was whether the dyads in the CMC condition provided and received more or fewer elaborations while working on the cooperative mathematics task than the dyads in the FTF condition. In Table 4.3, an overview of the mean percentages for the high-and low-levels of elaboration as well as for the affective and regulative categories of verbal interactions are presented. Note that the percentages do not add up to 100 because some of the utterances (e.g., non-task related remarks or reading aloud) do not fall into one of the coding categories. In addition, the total number of utterances is presented.

The data displayed in Table 4.3 show significant differences in the verbal interactions of the dyads in the FTF and CMC groups. While working on the mathematics task, the FTF dyads exchanged significantly more high-level and low-level elaborations than the CMC dyads ($p < .01$). The relatively high effect sizes were all in favour of the FTF dyads. In addition, statistically significant differences between the FTF dyads and the CMC dyads were found for the occurrence of affective and regulative utterances in favour of the CMC dyads ($p < .01$). The majority of the utterances were nevertheless coded within the category of

Table 4.2
Frequencies and percentages for different categories of interaction in the FTF versus CMC setting

	FTF Number of statements (*N* = 2886)				CMC Number of statements (*N* = 3402)			
	M	*SD*	*S*	%	*M*	*SD*	*S*	%
1. *Cognitive contributions*								
Comprehension questions	.95	1.19	19	0.6	.91	1.48	20	0.6
Answers with elaboration	5.25	3.75	105	3.6	3.5	4.82	77	2.3
New ideas with further elaboration	4.95	4.89	99	3.4	2.86	2.71	63	1.8
Acceptance with further elaboration	4.25	4.39	85	2.9	.55	.91	12	0.4
Rejection with further elaboration	3.4	3.32	68	2.3	168	2.01	37	1.1
Factual questions	5.95	3.52	119	4.1	10.82	5.44	238	7.0
Verification questions	7.30	5.06	146	5.0	7.55	6.19	166	4.9
Answers only	18.5	7.12	370	12.8	23.00	5.70	506	14.8
New ideas without further elaboration	8.85	8.72	177	6.1	4.73	3.56	104	3.1
References to previously discussed ideas	3.65	2.28	73	2.5	.55	1.01	12	0.3
Summarization	8.50	6.24	170	5.8	4.23	3.58	93	2.7
Acceptance without further elaboration	26.65	10.39	533	18.5	16.55	6.99	364	10.7
Rejection without further elaboration	3.95	2.78	79	2.7	4.27	3.89	94	2.7
2. *Affective contributions*	4.05	3.68	81	2.8	9.45	5.70	208	6.1
3. *Regulative contributions*:								
Planning of the task	11.15	6.33	223	7.7	43.00	17.64	946	27.8
Instruction of other student	3.75	3.99	75	2.5	2.73	2.78	60	1.8
4. *Greetings*	0	0	0	0	5.82	3.75	128	3.8
5. *Non-task-related remarks*	12.65	8.15	253	8.8	12.45	9.99	274	8.1
Level of elaboration								
High-level elaborations:	18.80	10.65	376	13	9.50	7.75	209	6.1
Low-level elaborations:	83.35	29.04	1667	58	71.68	18.55	1577	46.0

Note: % FTF do not add up to 100% "reading aloud" was not counted cognitive utterances. Most of the cognitive utterances were found to be low-level elaborations (59%) with high-level elaborations occurring much less frequently (13%).

Table 4.3
Mean percentage of high- and low-level elaborations, affective utterances, regulative utterances and the total number of utterances for the FTF and CMC groups (t-test results)

Interaction categories	FTF group (N=20)		CMC group (N=22)			
	M	*SD*	*M*	*SD*	*t*	*ES*
Cognitive utterances						
High-level elaboration	12.53	3.96	5.87	4.14	5.32*	1.64
Low-level elaboration	59.05	10.92	47.00	7.82	4.14*	1.28
Affective utterances	2.65	2.53	6.39	4.26	-3.42*	-1.06
Regulative utterances	10.03	4.36	29.12	6.07	-11.60*	-3.58
Total number of utterances	144.30	52.09	154.64	43.26	-0.70	-0.22

* $p < .01$

Additional analyses revealed significant differences with regard to the use of high-level elaborations within the two ability groups for both the FTF and CMC dyads: Level 1 (low-medium pairing) versus Level 2 (medium-high pairing). The FTF Level 1 dyads (M = 19.77; SD = 4.55; n = 11) used significantly more high-level elaborations than the CMC Level 1 dyads (M = 8.93, SD = 5.11, n = 10) (t = 5.14, p < .01, ES = 2.25). Also, the FTF Level 2 dyads (M = 22.02, SD = 5.46, n = 9) used significantly more high-level elaborations than the CMC Level 2 dyads (M = 8.80, SD = 5.83, n = 12) (t = 5.28, p < .01, ES = 2.33).

4.6.2 Qualitative analyses of the verbal interactions.

To facilitate the interpretation and thereby the meaningfulness of the quantitative data, four illustrative transcripts of the interactions for the FTF and CMC dyads are presented below. These transcripts deal with the solution of problems 11 through 13. Transcripts 1 and 2 illustrate the use of high-level elaborations by a FTF dyad relative to a CMC dyad (both level 2: high-medium pairings).

Transcript 1
Interaction of a FTF dyad working on problems 11 through 13

FTF dyad: high-medium level
Student 1: Tim [a] / = pause shorter than 3 seconds
Student 2: Anne // = pause longer than 3 seconds

Problem 11
1 1: (reading aloud) Draw the right side of the seesaw.
2. Put four kilograms on the right side of the seesaw in such a way
3. that the seesaw is in balance.

4. 2: Huh? With four kilo? // Should we draw the bar, or something like that?
5. 1: I think so. Yes. Where do we put the four kilograms?
6. 2: Oh, where do we put the four kilograms. I think here, // because here is two, two
7. less, because that is heavier. / Here, yes, don't you think so?
8. 1: Yes, I think so too.
9. 2: Yes, and near the points here. Well, four. Like this!

Problem 12
10. 1: (reading aloud) How many kilograms have to be added to the end of the right side of
11. the seesaw to achieve balance?
12. 2: How many, how many do you think? Two, six. // I don't understand,
13. how many kilograms on the end of the right side of the seesaw.
14. 1: I think three.
15. 2: To achieve balance? That's nine kilograms on this side and, no this is more.
16. 1: Well, I think zero.
17. 2: Well, but… / it could be three kilograms, because it is at the end of the bar.
18. Well I think three kilograms.

Problem 13
19. 1: (reading aloud) Where do you put the point of support for the seesaw?
20. Draw the point of support beneath the seesaw.
21. 2: I think here, because…./ No, no, no, wait….
22. 1: I think here.
23. 2: On this side, because three kilos is half, half of the half you could say.
24. Here in this line. //

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[a]To preserve the anonymity of the students, their names have been changed.

Transcript 2
Interaction of a CMC dyad working on problems 11 through 13

CMC dyad: high- medium level
Student 1: Tom
Student 2: Carmen

Problem 11
1. 1: Okay, let's do 11.
2. 2: Problem 11 is on spot B, do you agree?
3. 1: Yes, it is spot, B, so we agree. Next problem.

Problem 12
4. 2: Problem 12 is 0 kilograms.
5. 2: Do we agree?
6. 2: Let's do the next problem.
7. 2: Problem 13 is on spot D.
8. 1: Hey, we are still doing problem 12!
9. 2: 12 is 0 kilograms.
10. 1: Problem 12 is 3 kilograms, because otherwise there is not enough contra-weight.
11. 1: Do we agree?
12. 2: Dammed, you are right.
13. 2: We do agree!
14. 1: Yes? Let's do the next problem.

15. 2: Okay.

Problem 13
16. 2: Problem 13 is spot D.
17. 2: Do we agree?
18. 1: Yes that's correct.
19. 1: Let's go for the next one!

The most striking difference between the two transcripts is the difference in the use of high-level elaborations. Tim (student 1) from the FTF dyad initiates the discussion by simply reading the relevant parts of the text aloud on several occasions (lines 1, 10, and 19). He also provides unelaborated answers (lines 14, 16, and 22) while Anne (student 2) provides elaborated answers. She thinks aloud, explains things, and clearly reasons as exemplified by her use of the word "because" (lines 7, 17, and 23). Anne also tries to involve Tim by prompting him to answer or asking for confirmation (lines 4, 7, and 12). In the CMC dyad, most of the effort comes from the high-level student, Carmen (student 2), who initiates the problem solving process but provides unelaborated answers and directly types the solution (lines 2, 4, 7, 9, and 16). After doing this, she then asks Tom (student 1) if he agrees with her solution (lines 2, 5, and 17). Tom is not so fast. He agrees with Carmen when he thinks the given solution is right, and disagrees when he does not think Carmen's solution is right but then with an elaborated answer (although the only one in this example; line 10).

Another remarkable finding is the difference in the length of the utterances for the FTF versus the CMC dyads. The members of the CMC dyad use short sentences ending with a "return" to indicate a turnover. Compared to the CMC dyad, the FTF dyad can be seen to engage in a much longer discussion before agreement is reached and the answer is written down.

As already mentioned, most of the FTF and CMC dyads used mainly cognitive statements while working on the mathematics task. Regulative statements were less frequent (see Table 4.3) but nevertheless important for successful completion of the task. The CMC dyads used significantly more regulative statements to complete the task than the FTF dyads. Transcripts 3 and 4 illustrate the use of regulative statements by a FTF dyad compared to a CMC dyad (level 2: high-medium pairing). These transcripts deal with the solution of the problems 11 through 13/14.

Transcript 3
Regulative statements used by a FTF dyad working on problems 11 through 14.

FTF dyad 12: high- medium level
Student 1: Tanja — / = pause shorter than 3 seconds
Student 2: Niels — // = pause longer than 3 seconds

Problem 11

1. 1: It must be on the spot here. Than it must be spot two.
2. 2. Yes//

Problem 12

3. 1: (reading aloud) Draw the right side of a seesaw.
4. Well, it is not three that does not fit with the six kilograms. // I think three or so.
5. 2: I don’t think that it will balance that way.
6. 1: No.
7. 2: Here, exactly in the middle, here are three kilograms and there are six.
8. 1: But actually, if you think this is not there, look, this is the long side.
9. 2: Oh, like that.
10. 1: But it still is longer… / equal // I think two. // There are six kilograms standing. //
11. Two is possible… / but // What do you think? /
12. 2: I don’t know. // I think six.
13. 1: It is a little bit odd, six kilograms. / Yes, it is, but it is not at the end of the lever. //
14. Normally it would be three, and now it is six. //
15. Shall we skip this problem and go on to the next one, and then come back to this one 16. later? /

17 2: OK. //

Problem 13

18. 1: What do you think about this? Here six, then four, and then two kilograms.
19. 2: Yes. //

Problem 14

20. 1: Eight.
21. 2: I think so. //
22. 1. I think two. Because this is one and four. Eight divided by four. //
23. Because it is four times as long… //

Problem 12 (again)

24. 1. Now, back to problem 12. //
25. 2: Anyway I think it is three. //
26. 1. Yes, but in that case there should be six kilograms on there.
27. And then that side is heavier. // In my opinion, it is zero kilograms. //
28. Because three is half of six / is two. That one is a little bit longer. //
29. Do you think that three kilograms should be here to get it to balance?
30. 2: Yes I think so too. //
31. 1: This one is going more to the other side. If that one just was right in the middle. //
32. Yes okay, three kilograms. // Well, we’re finished now.
33. 2: OK. //

Transcript 4
Regulative statements of a CMC dyad working on problems 11 through 13

CMC dyad: high- medium level
Student 1: John
Student 2: Maria

Problem 11

1. 1: Oh I thought we were doing problem 11, but we are doing 10, aren't we?
2. 1: Aren't we?
3. 2: No, right now we're doing 11.
4. 1: Yes, sorry, I was looking at the wrong page.
5. 1: ¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿¿
6. 2: I think at spot D, don't you?
7. 2: Hello.
8. 1: Yes, I think so too, or at spot C.
9. 2: In that case both sides are equal, don't you think?
10. 1: Yes.
11. 2: No, not at C, then one of the bars is shorter.
12. 1:Yes, you are right, I think at D too.
13. 2: Okay. Next problem.

Problem 12

14. 2: Hello.
15. 1: Okaaay.
16. 1: What do you think?
17. 2: Boy, you sure took your time!
18. 2: What do you think?
19. 1: We are doing 12, aren't we?
20. 2: Yes.
21. 1: What do you think?
22. 2: Well, I don't know.
23. 1: I don't understand, it is a very strange question....
24. 1: I don't know either…
25. 2: Yes, it is a strange question, let's look at the question again, okay?
26. 1: Okay.
27. 2: I think 3kg.
28. 1: Did you read the problem?
29. 2: Next question.
30. 1: Okaaay.

Problem 13

31. 2: Then it is 6 kg together.
32. 2: Next problem, problem 13.
33. 1: I think at spot C.
34. 2: I think so too, that's not too difficult.
35. 1: Do you?
36. 2: Next problem.
37. 1: Yes, next problem.

In the FTF transcript (transcript 3), Tanja and Niels are trying to find the answer to problem 12. After a while Tanja (student 1) decides that it may be better to move on to the next problems (line 15), and Niels agrees (line 16). After they have written down their answer for the next two problems, problems 13 and 14, they return to problem 12 (line 23). This FTF dyad thus uses several important (metacognitive) regulative strategies, including monitoring and planning. They recognize that finding the solution to problem 12 may take too much time and they may want to see if the solutions to the next problems can help them find the solution to problem 12. And the use of these strategies indeed helps them to successfully complete the entire task within the assigned amount of time.

The CMC transcript (transcript 4) depicts a different type of regulative activity. John (student 1) asks which problem they are working on (lines 1 and 19), which prompts Maria to indicate the transition to the next problem (lines 13, 29, 32, and 36). The fact that they cannot see each other makes such questions as “Did you read the problem?” (line 28) necessary. These types of regulative activities can be characterized as attunement to the task. Also remarkable are several expressions of impatience. Given that the students cannot see each other, they do not know what the other student is doing and appear to become annoyed by the waiting involved (lines 7, 14, and 17).

4.6.3 Results on performance scores, computer skills, and student perceptions

Performance scores

The second research question was whether any performance differences occurred for the FTF versus CMC dyads. The performance scores showed the FTF dyads to attain higher performance scores ($M = 9.85$, $SD = 1.5$) than the CMC dyads ($M = 8.27$; $SD = 2.5$). The difference is statistically significant ($t = 2.43$, $p < .05$), and the effect size ($ES = 0.75$) is in favor of the FTF dyads.

Additional analyses showed a significant difference in task completion for the two groups. All of the FTF dyads finished the 15 problems within the allowed 30 minutes. In contrast, the CMC dyads solved an average of 12.7 out of the15 problems ($SD = 2.66$). This difference proved statistically significant ($t = 4.01$, $p < .01$). Of the 22 CMC dyads, only 10 dyads completed the task within the allocated amount of time.

Other analyses revealed a significant correlation for the combined FTF and CMC groups between the frequency (expressed as percentages) of high-level elaborations provided by the dyads and their performance scores ($r = .32$, $n = 42$, $p < .05$). The correlation for the combined FTF and CMC groups between the frequency of low-level elaborations and performance scores was non significant ($r = .24$, $n = 42$, $p > .05$). Presumably due to the small number of dyads, no significant correlations between the frequency of high-level elaborations provided by the dyads and their performance scores were found for the FTF and CMC groups when analyzed separately (FTF dyads: $r = .10$, $n = 20$, $p > .05$; CMC dyads: $r = .22$, $n = 22$, $p < .05$). However, a significant positive correlation was found for the CMC dyads between the frequency of low-level elaborations and performance ($r = .51$, $n = 22$, $p > .05$) and, conversely, a negative but non significant correlation for the FTF dyads between the frequency of low-level elaborations and performance ($r = -.41$, $n = 20$, $p =. >.05$).

Computer skills

In order to examine whether the performance scores of the CMC dyads were mediated by the computer and typing skills of the students, the CMC dyads were classified into two groups depending on their answers on the Computer Skill Questionnaire: A high-level computer skills group and a low-level computer skills group. Comparisons of the high- and low-level groups then revealed no statistical differences in the use of high- and low-level elaborations. For the high-level computer skills dyads, 7.42% of their utterances could be classified as high-level elaboration (*SD* = 5.3) for the low-level computer skills dyads, 8.23% of their utterances were high-level elaborations (*SD* = 5.4) ($t = 0.31$, $p > .05$; *ES* = -0.15). For low-levels elaborations, the figures were 46.07% (*SD* = 6.3) and 41.44% (*SD* = 6.8); respectively ($t = -1.40$, $p > .05$, *ES* = 0.69). Significant differences were found between the high-level computer skills dyads and the low-level computer skills dyads with regard to their performance scores. The high-level computer skills dyads (*M* = 9.83, *SD* = 2.3, $n = 6$) produced significantly higher performance scores than the low-level computer skills dyads (*M* = 7.00, *SD* = 1.6, $n = 13$) ($t = -3.09$, $p < .01$; *ES* = 1.52). Finally, differences were found between the high-level computer skills dyads and the low-level computer skills dyads with regard to the number of mathematics problems solved within the allotted 30 minutes. The high-level computer skills dyads solved 13.3 of the 15 problems (*SD* = 2.9) on average while the low-level computer skills dyads solved 12 problems on average (*SD* = 2.7). However, this difference did not prove statistically significant.

Student Perceptions

The last research question addressed any differences in the perceptions of the FTF versus CMC students with regard to working together. The FTF students scored significantly higher on the total Quality of Collaboration scale than the CMC students ($t = 5.52$, $p < .01$; *ES* = 0.25). The mean score for the FTF students on this 5-point scale ranging from 1 = *highly disagree* to 5 = *highly agree* was 4.5 (*SD* = 0.4; $n = 40$) and that for the CMC students was 3.8 (*SD* = 0.7, $n = 39$)

4.7 Discussion

The present study addresses the question of whether differences exist in the interactions of pairs of students working collaboratively in a FTF learning situation versus computer-mediated learning situation. In addition, students' perceptions of the quality of the collaboration were explored.

The first research question was whether the dyads in the FTF situation provided and received more or fewer elaborations than the dyads in the CMC situation when working on a cooperative mathematics task. About 70% of the utterances produced by the FTF dyads and about 53% of the utterances produced by the CMC dyads while working together on the mathematics task could be classified as cognitive statements (i.e., a combination of high- and low-level elaborations). The FTF dyads provided significantly more high-level elaborations than the CMC dyads while when solving the mathematics problems, but also significantly more low-level elaborations. This was the case for both the Level 1 ability groups (medium-low pairing) and Level 2 ability groups (high-medium pairing). The difference in the provision of elaborations by the FTF versus CMC dyads can be explained by the use of the computer during the collaborative problem solving process. As Wegerif and Mercer (1997) have observed, the computer medium influences the type of talk during an interaction and extensive discussion is generally more common in FTF interactions. Wegerif and Mercer further suggest that students working in a CMC situation may devote considerable time to the relatively superficial aspects of what they write or type (i.e., format, spelling, punctuation) rather than the actual content. In addition, Veerman and Veldhuis-Diermanse (2001) argue that synchronous communication via a chat program tends to be fleeting with short contributions and numerous turns. There is little time for reflection, and the pressure to react quickly is rather high due to the feeling of absence in cases of slow reaction ("Boy, you sure took your time!").

In both interaction conditions, the frequency of high-level elaborations was low. In the FTF condition, 13% of the cognitive utterances could be classified as high-level elaborations. In the CMC condition, 6% of the cognitive utterances could be classified as high-level elaborations. These findings are in line with other studies showing academic discussions among peers to typically not include many elaborations (Fuchs et al., 1994, 1999; Webb, 1989; Webb & Farivar, 1994). In other words, students do not appear to develop effective interactional styles as a natural consequence of participating in cooperative learning activities. Rather, students require careful guidance in order to interact effectively during collaborative work. Without such guidance, their explanations often appear ambiguous or confused and they tend to provide very few opportunities for constructive application of different explanations. Research shows that explicit training can elicit to student interactions with greater reliance on elaborated help giving (Webb & Farivar, 1994; 1999; Fuchs et al., 1996; Fuchs et al., 1999). In order to improve the quality of the interactions of students working collaboratively in FTF or CMC situations, explicit instruction on how to interact most effectively and productively should be provided along with the practice of collaborative learning activities. As demonstrated by Webb et al. (1995) and Webb and Farivar (1999), moreover, the construction of extended explanations or elaborations appears to be a strong predictor of achievement.

The dyads in the CMC condition provided about three times as many regulative utterances as the dyads in the FTF condition: 29% versus 10%, respectively. In the FTF condition, the students worked next to each other and shared a single working sheet. It was easy to indicate which mathematics problem they were working on. There was also a minimal need for explicit verbal expressions under such circumstances. FTF communication is considered the richest medium for the conveyance of meaning using verbal, paraverbal (e.g., intonation, voice), and non-verbal signals (Barile & Durso, 2002). The anonymous CMC condition does away with such nonverbal cues as facial expression, direction of gaze, posture, dress, and physical distance (Short et al., 1976). Students are probably aware of this reduction of cues and may compensate for this by using more regulative utterances. In other words, the head nods, other indications of agreement or disagreement, and pointing characteristic of FTF interaction situations may be replaced by such typed phrases as “Yes, I agree.”, “Which problem are we working on?”, or “We’re doing problem 12, right?” (cf. Short et al., 1976). A recent study by Barile and Durso (2002) has also shown the number of coordination statements in a collaborative writing task to be higher for CMC groups than for FTF groups.

The dyads in the CMC condition in the present study provided about twice as many affective utterances as the dyads in the FTF condition: 6% versus 3%, respectively. Although emotional cues in the form of such textual “pictures” as emoticons are appearing in CMC communication, they are still quite new and lack the full range of expression found in FTF interaction situations (Barile & Durso, 2002). Along these lines, a study by Hara et al. (2000) has shown about 27% of the elements of online discussion to consist of expressions of feeling, self-introductions, jokes, compliments, greetings, and closures.

The second research question was whether any performance differences occurred for the dyads working in the FTF versus CMC situations. The FTF were indeed found to produce higher performance scores than the CMC dyads, which is in keeping with the results of studies by Hollingshead et al., (1993) and Straus and McGrath (1994) who found FTF groups to solve intellective tasks significantly better than CMC groups. FTF groups appear to transmit the information needed to meet demands of a particular task more successfully than CMC groups. In CMC groups, additional cues are needed to reduce the possible equivocality of information, arguments, and evaluations.

Additional analyses also revealed significant differences in task completion for the FTF versus CMC groups. Only 10 of the 22 CMC dyads completed the entire task while all of the FTF dyads completed the task within the time given. Additional evidence for this finding is also provided in the literature showing students in CMC groups to need more time to complete an assigned task than students in FTF groups (Bordia, 1997; Straus, 1996). Some authors argue that discussions in CMC groups almost always take longer to complete than in FTF groups due to the absence of important nonverbal and social context cues, which clearly hampers communication efficiency (Straus, 1996). Other authors argue that CMC groups take longer to complete the assigned task simply because the students in such groups must type their answers, which takes inherently more time than speaking (Bordia, 1997). Our findings show that computer and typing skills to play a clear role in the explanation of the observed in task performance. Although no statistically differences between the dyads with high-level computer skills and the dyads with low level computer skills were found for the level of elaborations, the dyads with high level computer skills produced significantly higher performance sores than dyads with low level computer skills. This last difference cannot be fully explained by the typing skills of the dyad with high-level computer skills as these dyads solved 13 of the 15 mathematics problems within the allocated time, while the dyads with low-level computer skills solved 12 of the 15 problem within the allocated time, which was a non significant difference. Closer inspection of the CMC transcripts suggests that the difference in the performance scores of the students with high-level computer skills versus low-level computer skills may be due to the fact that the students with low-level computer skills must attend to two sets of skills, namely those skills needed to solve the mathematics problems and those skills needed to type and use the computer. In contrast, students with high-level computer skills can more or less focus all of their attention on the problem solving process and the content of the problems constituting the current task.

The present results also suggest a connection between elaborated help-giving and performance on the balance beam problems. A significant correlation was found for the combined FTF and CMC groups between the frequency of high-level elaborations provided by the dyads and their performance scores. In addition, a non significant trend towards a negative correlation between the frequency of low-level elaborations and the performance scores for the FTF dyads was found. These results are in line with previous research showing a positive link between the construction of high-level explanations and mathematics achievement and a negative or no correlation between the construction of low-level explanations and mathematics achievement (Webb, 1989; Webb & Farivar, 1994, 1999). That is, students who construct explanations to clarify processes for their peers appear to learn more than students who simply tell their peers the answer.

An unexpected finding in the present study was a significant positive correlation for the CMC dyads between the frequency of low-level elaborations and their performance scores. Closer inspection of the transcripts showed many of the low-level elaborations from the CMC dyads to have a regulative function, which again shows many of the CMC dyads to encounter problems with the coordination of the problem solving process.

The last research question addressed the possibility of differences in the perceptions of the FTF versus CMC students with regard to the experience of working together. The total Quality of Collaboration scale scores were found to be significantly higher for the FTF students when compared to the CMC students. In fact, the FTF students scored significantly higher on all of the items than the CMC students. The FTF students were thus more satisfied with the collaboration and the manner in which the members of the dyad helped and supported each other. This finding is in keeping with other research also showing students to be more satisfied with FTF collaboration than with computer-mediated collaboration (Fjermestad & Hiltz, 1999; Johnson et al., 2000, Ocker & Yaverbaum, 2001; Straus, 1996; Light & Light, 1999).

In closing, some possible limitations on the present study should be mentioned. First, the removal of students from their classrooms in the FTF situation somewhat limits the ecological validity of the present study. The possibility of creating an artificial context within which pairs of students worked together cannot be ruled out. It is possible that within a more natural classroom context students may have performed differently. Second, the relatively small sample sizes limited the power of the statistical analyses. Sufficiently large sample sizes should therefore be used in future studies to examine the representativeness of the present findings. Third, the effects of working collaboratively were only examined with respect to a mathematics lesson and, more specifically, the calculation of weight and distance problems in a balance beam task. When exploring the effects of FTF versus CMC conditions on the interactive behavior of primary school students in the future, additional topics and perhaps a wider range of grade levels should thus be considered. Fourth, the data on the levels of elaboration for the primary school students were collected on only a single occasion, which somewhat limits the generalizability of the present findings. In future studies, interactional data should be collected on multiple occasions to provide greater insight into the long-term effects of collaborative FTF versus CMC conditions on the interactive behavior of primary school students. Fifth, the mathematics problems used in this study have obvious answers and well-structured solutions, which means that they can be characterized as intellective tasks (Straus & McGrath, 1994). There is little room for extensive controversy with the exception of arguments regarding what constitutes the right procedure or answer (Cohen, 1994). In addition, tasks that have obvious answers can easily be explained or demonstrated by a particularly competent group member. Having a competent student in the group increases the dyad’s chances of successfully solving the relevant problems. Tasks that have ill-structured solutions (e.g., judgment tasks) may often require more intensive interaction, which means that any factors that affect the amount and richness of the interaction may affect task performance. Tasks with ill-structured solutions require more intensive group interaction than tasks with well-structured solutions because no student has all of the knowledge necessary to solve the task. Given this inherent source of group interdependence, ill-structured tasks may: naturally motivate students to participate and cooperate, elicit elaborate discussions, and sometimes produce cognitive conflict and thereby a need for resolution (Fuchs et al., 2000). Future studies should therefore explore the role of different task arrangements and instructions on the promotion and restraint of elaborated interaction. A sixth possible limitation on the present study is that the students were not explicitly trained on the provision of elaborated explanations or effective computer skills for use in CMC learning situations. As stated before, students require careful guidance in order to interact effectively during collaborative group work. Finally, the effects of collaborative FTF and CMC conditions on student learning in general were not examined, which means that no conclusions can be drawn with regard to just how much students learn from working in FTF versus CMC situations. In the present study, the achievement or performance effects were limited to the solution of a balance beam task. Additional small- group interaction and achievement data are needed to explore the long-term effects of working collaboratively under FTF versus CMC circumstances.

In addition to the aforementioned general study limitations, the present results suggest that a number of specific problems related to the use of computer-mediated work groups should be considered. It is also important to keep in mind that the characteristics of the group (e.g., ability levels, motivational goals), attributes of the group members (e.g., personal learning goals, experience with computers), requirements of the task (e.g., ill-structured versus well-structured problems), and features of the classroom context (e.g., open versus indifferent towards collaborative group work) may modify the effects of the communication medium on collaborative task performance. When coupled with explicit efforts to instruct and guide students on how to interact effectively and productively in collaborative learning situations, the outlook for the use of CMC for group problem solving and learning efforts may be more promising than indicated by the results of the present study.

Chapter 5
Student elaborations in an asynchronous computer-supported learning environment[4]

5.1 Introduction

The use of computers in schools has created new questions for learning and instruction. Educators have begun to see the computer as a device to support collaborative modes of learning and their interest in the potential of small group or peer learning has grown. In a meta-analysis, Lou et al. (2001) synthesized the empirical research from 122 studies of the effects of small group learning versus individual learning when students learn via computer-mediated communication (CMC). CMC was defined as the use of e-mail, computer conferences, computer-supported collaborative learning (CSCL), and the Internet, which all allow groups of teachers and students to communicate and share information electronically and to thus learn and collaborate across a distance. The results of the meta-analysis showed small group learning to have a significantly more positive effect than individual learning on individual student achievement (*ES* = +15), group task performance (*ES* = +0.31), and such affective outcomes as student attitudes towards group work (*ES* = +0.52) and student attitudes towards classmates (*ES* = +0.29). In addition, different working conditions and different patterns of interaction in work groups appear to lead to different learning outcomes, and a closer analysis of the dynamics underlying productive interactions is thus called for.

Much of what students learn appears to depend on just how they interact during small group work or peer learning. More specifically, research has shown the construction of elaborations to play an important role in small group learning (Fuchs et al., 1998; King, 1999; Webb & Farivar, 1994, 1999; Webb & Mastergeorge, 2003). Elaboration refers to the detailed explanation that occurs when peers provide examples, explain a concept, or supply specific argumentation and justification. Students who provide elaborations, which clarify processes to help classmates arrive at their own solutions, have been found to learn more than students who simply tell classmates the solution to a problem. In other words, the construction of elaborations appears to constitute a critical mediator of successful collaborative learning activities in the context of small group learning. In addition, the provision of extended elaborations can be expected to promote the social construction of knowledge because the provision of such explanations not only compels students to externalize and verbalize their thoughts but also make their ideas explicit and accessible to both themselves and others.

[4] This chapter is based on: Van der Meijden H., & Veenman, S. (in press). Gender group composition, group size, student ability, and the provision of student elaborations within a computer-supported collaborative learning environment *Computers in Human Behavior*

Theoretical support for the role of elaborations in collaborative learning is provided by sociocognitive theory based on Piaget (1926) and sociocultural theory based on Vygotsky (1978). Both theories have emphasized the role of the social context in the construction of knowledge and emphasized that peer interactions provide a rich and necessary context for the revision of developing cognitive systems and creation of new meanings or knowledge (Cole & Wertsch, 1996; De Lisi & Goldbeck, 1999; Hogan & Tudge, 1999).

With the introduction of computers into schools, new forms of communication emerged. A CMC technology specially designed to structure small group work is CSCL. With CSCL, the learning environment is structured in such a manner that it facilitates social interaction between group members (Kreijns et al., 2003). The focus of CSCL is on how computer technology can be used to enhance peer interaction and learning in groups (Lipponen et al., 2003). More concretely, different ideas and problems may be written down in a communal database, read, discussed, and elaborated upon during CSCL in order to reconstruct and co-construct new knowledge.

An implicit promise associated with CSCL has been that it will increase student participation in the classroom and also enhance the equity of participation across students with different characteristics, cultural and ethnic backgrounds, and learning orientations. Several recent studies, however, have revealed marked inequities as a result of CMC exchanges (e.g., Herring, 1993, 2000) and shown active and broad participation and high quality interactions to not follow automatically from CMC or CSCL. In many situations, attempts of using CSCL have been found to produce low levels of student participation and unsustained and divergent discussions (Guzdial, 1997; Guzdial & Turns, 2000; Lipponen et al., 2002, 2003).

According to Guzdial and Turns (2000), discussions between students in a CSCL environment should have the following characteristics to be effective: (1) be sustained (i.e., contain numerous contributions and extensive dialogue rather than short and divergent communication episodes), (2) have broad participation (i.e., a large number of students should actively be engaged in the making of contributions); and (3) be focused on class topics (i.e., the most direct indicator of student learning is talking about class topics). These three stepping stones towards effective CSCL constitute what Guzdial and Turns (2000) call sustained on-topic discussion. Expanding on Guzdial and Turn's arguments regarding effective discussions within the context of computer-mediated discussion forums, Lipponen et al. (2003) have also suggested that the discussions should be reflective in nature. In order to discuss reflectively, students must not only provide information related to the contributions of others but also question the arguments put forth by others or ask for clarification at times. In fact, asking for clarification is regarded as essential for students to build and advance their collective knowledge and understanding. Within the context of the present study, we consider asking for and providing clarifications to be similar to asking for and providing elaborations. The use of elaborations constitutes what Lipponen (2000) calls "explanation-oriented discourse" or the mode of discussion that students and teachers should promote because it leads to knowledge construction and progressive discourse.

An important working condition for CMC and CSCL to promote collaborative group processes and positive learning outcomes is the manner in which the groups are structured. Research has shown the composition of groups with regard to gender, size, and student ability to shape the behavior and experiences of the members of collaborative groups (Webb & Palincsar, 1996; Wilkinson & Fung, 2002). Most studies on the effects of gender group composition, however, have been focused on CMC learning environments while most studies on the effects of group size have been focused on primarily cooperative or collaborative learning in FTF classroom learning situations. Very little attention has been paid to gender group differences, group size, or student ability in research on CSCL (Volman & Van Eck, 2001).

In the present study, the relations of gender group composition, group size, and student ability to the provision of elaborations during CSCL will be examined. The term CSCL refers to network-based learning environments in which small groups of students work together to achieve a common goal. Collaborative learning refers to a learning environment in which students are helped to actively construct their knowledge while working collaboratively with classmates in small groups.

5.2 Review of relevant studies on gender group composition, group size, student ability, and school subject

We will first discuss the research on the effects of gender group composition in CMC situations. After that, we will discuss some relevant studies of the effects of group size, student ability, and "gendered" school subjects in relation to effective group processes and learning outcomes. The overview presented below is by no means comprehensive as such a review is beyond the scope of a single journal article. The overview is intended to refine the set of concepts relevant for the present study.

Gender Group Composition

Recent studies have focused on an important aspect of CMC for small group learning, namely the composition of the groups with regard to gender (Savicki, Kelley, & Lingenfelter, 1996a,b; Savicki, Kelley, & Oesterreich, 1998, 1999). More specifically, the pattern of associations found to occur between group activity and gender composition indicates that gender must be taken into account in attempts to understand the productivity and satisfaction of group members.

Studies dealing with gender group composition (female-only groups, male-only groups, mixed-gender groups) show group composition to be related to such group processes as participation, choice of language, group well-being (e.g., satisfaction and group development), and performance. Analysis of CMC conversations in two studies by Savicki et al. (1996a,b) show female-only groups to use more self-disclosure, statements of personal opinion, "I" statements, and coalition language than male-only or mixed groups. Female-only groups were also the least to argue. This so-called High Communication Style also significantly related to satisfaction with the online group process and to higher levels of group development and productivity. The participants in mixed groups with a higher proportion of men than women used more fact-oriented language and more calls for attention while the participants in mixed groups with a higher proportion of women than men used more self-disclosure and made more attempts at tension prevention and reduction. In a subsequent study, Savicki et al. (1998) instructed single-gender and mixed-gender groups on the elements of the previously observed High Communication Style. The male-only groups showed significantly lower participation than the other groups while the female-only groups scored higher for group development than the other groups.

Underwood, McCaffrey, and Underwood (1990) examined the performance of three types of pairings on a computer-based language task performed by upper primary school students. Single-gender pairs improved with respect to students working alone while mixed-gender pairs did not. Students working in mixed pairs tended not to work by negotiation to achieve joint problem solving, but co-operated by instruction. That is, one student took over the keyboard and the other provided instructions. In a subsequent study, Underwood, Jindal, and Underwood (1994) again found mixed-gender pairs to be at a disadvantage with respect to single-gender pairs working on a computer-based language task. While girls tended to collaborate whether instructed to or not, the mixed pairs showed little evidence of collaborative working in general and the pairs of boys only showed the greatest gains when organized into collaborative relations. In a more recent study, however, Underwood, Underwood, and Wood (2000) found no such task performance differences between mixed-gender pairings and single-gender pairings in primary school classrooms although the mixed-gender pairs showed relatively lower levels of verbal interaction and less keyboard collaboration. Fitzpatrick and Hardman (2000) also found no task-performance differences between same- and mixed-gender pairs in the primary classroom although their findings showed mixed-gender pairs to be more assertive and less transitive (i.e., collaborative) than same-gender pairs on both a language-based computer task and a non-computer task. In contrast to the studies by Underwood et al. (1990, 1994, 2000), Hughes and Greenhough (1989) found mixed pairs to outperform girl-girls pairings when working on a LOGO programming task, which suggests that the nature of the task can influence the manner in which students collaborate with each other.

Gender group differences in relation to the learning of upper primary school students working with computers were also found in a study by Light, Littleton, Bale, Joiner, and Messer (2000). In the first part of this study, students worked on a computer-based treasure hunt task in either same-gender or mixed-gender dyads; each student had his or her own computer; and no verbal interaction was allowed. The boys generally outperformed the girls with the gender differences significantly more polarized in the mixed-gender dyads. In the second part of the study, co-action dyads with the students working alongside one another but on separate computers and without any overt interaction (as in the first part of the study) were compared to interaction dyads with the students working alongside one another on a single computer and no restrictions on the interaction. The polarization of observed gender differences in the mixed dyads was again found for the co-action dyads but not for the interaction dyads. The authors suggest that gender-stereotyped expectations (i.e., that boys will be better with computers than girls) may be done away within the interaction condition as the students can quickly discover one another's competencies and thus defuse any gender-stereotyped expectations.

In their meta-analysis of small group learning versus individual learning, Lou et al. (2001) found different effect sizes for different group compositions. When the groups were formed using ability and other criteria, the effect size proved large (*ES* = +1.15) and significant. When the groups were homogeneous in terms of gender, the effect sizes was moderately large (*ES* = +0.51) and also significant. When heterogeneous ability groups and heterogeneous gender groups were formed, however, the effect sizes did not differ significantly from zero. Furthermore, working in groups generally proved to be superior to working alone.

In sum, the preceding studies show that the makeup of a collaborative group may have profound implications for the behavior of the group members. Depending on the composition of the group, gender may serve as a "diffuse status characteristic" that influences interaction and learning in collaborative small groups (Light et al., 2000; Underwood et al., 1990, 1994; Webb, 1984; Webb & Palincsar, 1996; Wilkinson & Fung, 2002).

Group Size

As group size increases, group performance effectiveness depends, on the one hand on the groups use of increased resources and opinions and on the handling of increased coordination and group management processes on the other (Strijbos et al., 2004). In only a few studies has workgroup size been experimentally manipulated and examined with regard to the productivity of student interactions in school settings. Fuchs et al., 2000) compared dyadic and four-member groups and observed that four-member group compositions elicited more cognitive conflicts (disagreement and negotiation) than dyads, and appeared suited for average and high-achieving students. A non-significant trend was observed favoring dyads with respect to participation equality, especially in favor of low-achieving students. A meta-analysis by Lou et al. (2001) showed individual student learning within a CMC setting to be significantly more positive for students working in pairs (*ES* = +0.18) when compared to students working in groups of three to five. Group size was significantly related to learning outcomes (see also Lou et al., 2001). Research has shown that students in three-person groups often ignore group members' questions, but students in pairs seldom do (Webb, Ender, & Lewis, 1986).

According to Fuchs et al. (2000), the observed differences may be due to three factors. First, dyadic peer communication is bilateral while group communication may be bilateral or multilateral. Second, high achievement students may be afforded more interaction, performance, and evaluation opportunities in small groups than in dyads where a more delicate balance of power exists. Third, dyads may simply permit greater interaction per individual than small groups.

Taking into account all available evidence, the best generalization that can be made according to Wilkinson and Fung (2002) is that smaller groups are better, but it depends somewhat on the nature of the task students are set in (e.g. ill-structured versus well structured tasks; see also Cohen, 1994). Further research is nevertheless needed.

Student Ability

Research indicates that high-ability students may be more capable of constructing high-quality elaborations than low-ability students (Fuchs et al., 1996). High-ability students tend to engage in more verbal interaction, make greater numbers of long task statements, explain more often, provide more demonstrations, ask more questions, and prefer more adaptive forms of help for themselves (i.e., forms of help relating to problem-solving strategies rather than the simple provision of answers). High-ability students who have greater oral language facility, have also been found to provide elaborations that not only incorporate greater conceptual focus but also foster more correct responses among classmates (Fuchs et al., 1996). In other research, King (1989) found students in uniform high-ability groups to pose more task-related questions, spend more time engaged in strategic behavior, and achieve higher levels of elaboration on a LOGO task when compared to students in uniform medium-ability groups. In other words, individual differences with regard to ability may play an important role in the outcomes of small group work. In the present study, differences in school type are regarded as differences in student ability because differences in student ability are related to differences in the type of Dutch secondary schools (see below).

School Subject

Certain school tasks may evoke gender-differentiated responses because they are associated with school subjects that already carry strong gender stereotypes. Research on course-taking patterns shows secondary school girls to lag behind boys in the number of mathematics and science courses that they enroll in. Stated differently: Boys are more likely than girls to take science courses (e.g., physics, biology, chemistry) while girls are more likely than boys to take courses in the humanities and social studies (Schneider, 2001). Research on gender and school learning has also show that boys and girls not only achieve differently in the areas of mathematics and science but also use different problem-solving strategies in these areas. Girls tend to use more concrete strategies, boys tend to use more conceptual or abstract strategies. Girls also consistently report lower levels of self-confidence than boys for the areas of mathematics and science and lower levels of perceived usefulness for these subjects. And both boys and girls consider science to be a male domain (Ambrose & Fennema, 2001).

Research on the effects of group versus individual learning within a CMC setting also reveal different findings depending on the subject area. The influence of group versus individual learning, for example, has been found to be larger for social studies and reading/writing (*ES* = +0.20) and smaller for mathematics/science/language arts (*ES* = +0.11). The effects of small group learning have also been found to be significantly enhanced when: (1) students employed specific collaborative learning strategies; (2) group size was small (i.e., two members), (3) the subject involved social science or computer skills rather than mathematics, science, reading, or language arts; and (4) the students in the group were all either relatively low in ability or relatively high in ability (Lou et al., 2001).

In other research, gender differences were clearly found for computer-related attitudes and behavior. Data on gender-role stereotypes suggest that men and boys more readily construe computers as a male domain than women and girls (Whitley, 1997). Finally, gender effects are particularly important when groups of students work on science related tasks (Peterson, Johnson, & Johnson, 1991; Scanlon, 2000). In sum, the preceding studies show the gender differences at school to affect collaborative group processes and the learning associated with different school subjects.

5.3 Research Questions

In the present study, the following research questions were addressed.

1) How can the interactional behavior of students in an asynchronous CSCL learning situation be characterized in terms of cognitive, affective, and regulative contributions and participation?
2) What is the quality of the process of knowledge construction by students in an asynchronous CSCL learning situation?
3) Do gender group composition or group size influence the number and quality of elaborations produced in an asynchronous CSCL learning situation?
4) Do school subject or type of school influence the number and quality of elaborations produced in an asynchronous CSCL learning situation?

5.4 Method

5.4.1 Research setting

This study was carried out within the context of a research project called "Computer-supported collaborative learning networks in primary and secondary education", funded by the European Community. Students of a Dutch high school worked together on a collaborative task in an asynchronous discussion forum on different subjects such as science and social science. The collaborative task lasted about six weeks.

5.4.2 Participants

The participants were 198 third and fourth year secondary school students (116 girls and 82 boys) from eight classes in a comprehensive secondary school located in the south of The Netherlands. The students were 14 to 16 years of age and volunteered with their teachers to participate in the study. The students were recruited from two different types of secondary education within the participating school, namely pre-university education (VWO) and senior secondary education (HAVO). VWO prepares students for university and lasts six years. HAVO prepares students for entry into higher professional education, but not the university, and lasts five years. The decision to admit a student to a VWO or a HAVO school is based on student ability. Dutch primary schools advise parents with regard to the type of secondary education most suited for their child and base their recommendations on national achievement test scores (CITO) and the general educational performance, interests, and motivation of the child.

The students had no prior experience with collaborative learning, either with or without computers. The subject areas included in the study were the natural sciences (i.e., biology and physics) and social studies (i.e., history and civics).

5.4.3 Formation of groups

Given that the school computer facilities were limited, students were obliged to share the available computers. Working in a group as a result of a shortage of computers can be regarded as a problem that interferes with one of the key benefits of working with computers namely, the receipt of immediate, detailed, and individualized feedback. However, a number of studies have shown working in a group with computers to also have a number of benefits (see, for example, Scanlon, 2000; Crook, 1994). In the present study, the students worked with the computers at two levels. First, they worked *around the computer* (Crook, 1994). Second, they worked *via the computer*. In other words, they worked interactively in small groups seated behind the computer and discussed, for example, their contributions before entering them into the database to communicate asynchronously via the computer with other students working on the same project.

For the present study, the students in each classroom were assigned by the teacher to different sized groups depending on the available computer resources in the classroom and the capacities of the students to work well with each other, or personality factors expressed by teachers as "domineering, shy, disturbed, assertive, kind, or considerate". The size of the groups varied from two to four students. Note that variations in group size and group composition within the context of group work with computers is quite common in realistic classroom settings (see also Eraut, 1995; Lipponen et al., 2003). A total of 73 groups was formed: 36 twosomes, 22 threesomes, and 15 foursomes. The distribution of the students according to subject area, school level, and gender composition of the CSCL groups is presented in Table 5.1.

Table5.1
Distribution of students according to subject area, school level, and gender

Subject Area	School level	Number of students	Number of groups	Mixed groups	Boys groups	Girls groups
Science	HAVO	49	12	7	2	3
Science	VWO	99	37	8	10	19
Social studies	VWO	50	24	22	1	1
Total		198	73	37	13	23

5.4.4 Collaborative task and procedure

Together with the researchers, the participating teachers selected a number of topics from the normal science and social studies curricula for the students to research across a period of six weeks involving six lessons (Appendix D). In the first lesson, the students were instructed on the use of the computer program Web Knowledge Forum (Appendix E). This introductory lesson took place in the computer room of the school and lasted one hour. In the second lesson, the teacher introduced the collaborative task and assigned the students to groups according to their interests and skills in working together. For science, the topics included: conservation of nature, magnetic attraction, thunder and lightning, biotechnology, nuclear energy, and medical applications of nuclear energy. For social studies, the topics included were: discrimination and racism, victims of discrimination, legislation, and discrimination at school. During this phase of the task, the groups of students formulated their own research questions and discussed what they already knew about the topic in order to activate any prior knowledge. Examples of the research questions were: "How do thunder and lightening come into being?" and "What kinds of racist and anti-racist organizations exist in The Netherlands, and what kinds of activities do they undertake?" To facilitate collaborative knowledge construction, the students were encouraged to post their research questions and answers on the WKF and to comment on each other's work using the WKF. During the next three lessons, the different groups of students tried to find the answers to their research questions by gathering information from the library, the Internet, and interviews - for example - with a local politician, an engineer, or a school leader. They also entered their knowledge into the WKF database (see below). In the last lesson, all of the groups summarized the information gathered to answer their particular research question and commented on the summaries provided by the other groups.

5.4.5 The learning environment: Web Knowledge Forum

To work with the computer during the collaborative task, the students used the Web Knowledge Forum (WKF), which is a software program developed by the Ontario Institute for Studies in Education from the University of Toronto to facilitate collaborative learning and the successor of the Computer-Supported Intentional Learning Environments (CSILE) (Scardamalia & Bereiter, 1992). The system involves a communal text-based database, which can be filled with contributions or “notes” from authorized students and teachers. The users can enter their own notes and/or build on the notes of others. They can also read and re-read all of the notes placed on the forum (i.e., within the database). In addition, they can see who has read and reacted to their notes and the notes of others. All of the notes are organized in a “view” or folder, a thematic discussion list created by the teacher or researcher. The WKF notes are structured in discussion threads, which allows users to easily see when a new discussion has been started (“New Note”) and when a reaction to a previous contribution has been posted (“Build-On Note”). An excerpt of a view, sorted by thread, and the content of two

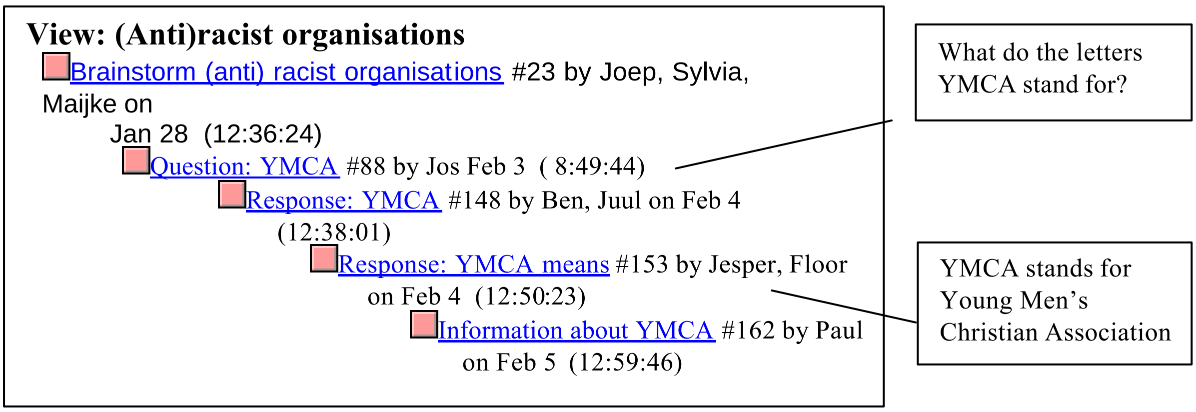

Figure 5.1
Example of a WKF discussion thread

notes are depicted in Figure 5.1. As can be seen, each line represents a separate note with its title, number, and author names, and date of posting. One of the advantages of a discussion forum such as the WKF is that the notes are posted for the duration of the project and thus without temporal constraints.

Learning through discussion in the WKF requires active participation via both writing (information-production) and reading (information-consumption) processes. Writing a note means that the participant joins a discussion via a “new note” or “build-on note” and that his or her note can be shared with and discussed by other participants. Reading a note means that the student does not contribute directly to the computer-mediated discourse (Guzdial, 1997; Lipponen et al., 2003). A high percentage build-on notes indicates a high level of collaboration (De Jong, Veldhuis-Diermanse, & Lutgens, 2002). To explore the extent to which discussions are sustained or endured, the length of a discussion thread in the present study was defined as the number of notes, including the initial note and all replies (Guzdial & Turns, 2000). The discussion thread depicted in Figure 5.1, for example, has a length of five notes. It should be noted that students and teachers can log in from other computers connected to the Internet, which means that they can work with the WKF database at any time and any place.

5.4.6 Data collection and preparation

A total of 899 notes from 42 different WKF views was saved and printed for analysis. Based on the assumption that learning can be characterized in terms of both individual cognitive activities and social processes (Salomon & Perkins, 1998; Shuell, 1996), a coding scheme involving five dimensions was developed to analyze the WKF notes (see Chapter 3).

The coding scheme

The cognitive dimension of the coding scheme refers to those thinking activities that students use to process learning content and attain learning goals. Different types of learning content are, for example, facts, concepts, formulas, reasoning, arguments, definitions, and conclusions. The affective dimension of the coding scheme refers to any emotional (written) remark concerned with the collaboration or the contributions of those involved in the collaborative task. The regulative dimension of the coding scheme refers to contributions intended to direct or redirect efforts during the conduct of a task and statements to help organize matters. The fourth dimension of the coding scheme concerns statements that are off-topic, which were coded as “non-task-related remarks”. The last dimension of the coding scheme concerns greetings or indications of entrance/departure of the communal database. In keeping with the work of Guzdial and Turns (2000), the cognitive dimension in the present study is taken to be an indicator of on-topic discussion - that is, discussion focused on class topics.

The *cognitive* dimension of the coding scheme covers 13 categories of interaction distributed as follows: three categories pertaining to the posing of questions (i.e., factual questions, comprehension questions asking for elaboration, and questions asking for verification); two categories pertaining to the provision of help (i.e., answers only, answers with elaboration); two categories pertaining to the input of new ideas (i.e., presentation of new ideas without elaboration, presentation of new ideas with elaboration); two categories pertaining to previously discussed ideas (i.e., references to previously discussed ideas, summarization); and four categories pertaining to the acceptance or rejection of ideas (i.e., acceptance without further elaboration, acceptance with further elaboration, rejection without further elaboration, and rejection with further elaboration). The *affective* dimension of the coding scheme involves one category of interaction pertaining to the process of collaboration (i.e., emotional reactions). The *regulative* dimension contains two categories of interaction pertaining to the conduct of the task (i.e., the planning of the task and instruction of the other student). After the inclusion of *greetings* and *non-task-related remarks* with one category each, the coding scheme contained a total of 18 categories.

Unit of analysis

Following Henri (1992) and Gunawardena, et al. (1997), each note in a view can be segmented into *units of meaning*. In the present study, the notes were broken up according to the categories included in the coding scheme. Although the length of a unit of meaning could vary from a single word ("No") to an extended paragraph, each unit was assigned to only one of the categories in the coding scheme. The scores for the student groups were then the number of units of meaning falling into the different categories of the coding scheme. The unit of analysis for all of the subsequent analyses was the group (i.e., twosome, threesome, or foursome). This unit of analysis was adopted because the process of knowledge construction that occurs during group interactions can be viewed as largely interdependent; that is, the questions and responses of one partner are, to a great extent, elicited or stimulated by the questions, statements, and responses of the other partner (King, 1994).

Coding of the notes

Prior to the coding of the notes, two of the researchers went through a training program of about 40 hours. The training program involved the formulation of the rules for segmentation of the notes into units of meaning, the coding of the notes, and learning to use the computer program Multiple Episode Protocol Analysis (MEPA) developed by Erkens (2001). The 899 notes were randomly assigned to two researchers for segmentation and coding. The researchers discussed any differences in the segmentation of the notes until agreement was reached. The segmentation process resulted in 1144 units of meaning. The inter-rater agreement for the coding of the notes was calculated on the basis of a random selection of 129 units from the 1144 units coded (11.3%). The percentage agreement was found to be 81.4 % and the Cohen's (1960) Kappa was .77. Considering Fleiss's (1981) general benchmark for

Kappa, a Kappa between 0.40 - 0.75 can be interpreted as intermediate to good, and a Kappa > 0.75 as excellent.

5.5 Data Analysis

Participation in the CSCL environment was defined in terms of the number of written notes produced by the participating groups. Writing or the production of information is regarded as a tool for thinking and considered critical for the articulation, explication, and externalization of one's ideas (King, 1990; Lipponen et al., 2002, 2003). The breadth of participation was defined in the present study as the number of groups actively writing notes divided by the total number of groups working in the database.

Two levels of elaboration were distinguished on the basis of the work of Webb et al. (1998) and used to characterize the contributions of the students in the database: high- versus low-level elaboration. *High-level elaboration* encompassed five of the categories from the cognitive dimension of the coding scheme, namely: comprehension questions asking for elaboration, answers with elaboration, presentation of new ideas with further elaboration, acceptance with further elaboration, and rejection with further elaboration. *Low-level elaboration* encompassed the other eight categories from the cognitive dimension of the coding scheme: factual questions, verification questions, answers only, presentation of new ideas without further elaboration, references to previously discussed ideas, summarization, acceptance without further elaboration, and rejection without further elaboration.

For each group, the frequencies of high- and low-level elaborations were calculated by summing the code frequencies for the five categories pertaining to high-level elaborations, on the one hand, and the eight categories pertaining to low-level elaborations, on the other hand. The percentage of high-and low-level elaborations was then calculated for each group of students by dividing the number of high-level elaborations and low-level elaborations, respectively, by the total number of units for that group. The total number of units for a group was calculated by summing the individual code frequencies for the 18 coding categories, which included greetings and "non-task related remarks".

The differences between the groups with regard to gender composition and group size were examined using analyses of variance (ANOVA) while the differences between the groups were examined using *t* tests (two-tailed) for independent samples. A significance level of 5% was used in all of the statistical tests. Given that the range of notes per group varied from 2 to 61 (M = 14.9; SD = 10.3), percentages were used in all of the calculations.

5.6 Results

The first research question was how the interactional behaviors of the students in an asynchronous CSCL situation can be characterized in terms of cognitive, affective, and

Table 5.2
Frequencies and percentages for different categories of interaction

	Number of units (*n* = 1144)				Percentages	
	M	*SD*	*SUM*	*%*	*M*	*SD*
1. *Cognitive contributions:*						
Comprehension questions	1.62	1.79	133	11.7	1.03	1.12
Answers with elaboration	1.17	1.84	96	8.4	.56	.92
New ideas with further elaboration	1.74	2.13	143	12.5	1.27	1.55
Acceptance with further elaboration	.00	.00	0	0	.00	.00
Rejection with further elaboration	.01	.11	1	0.1	.07	.06
Factual questions	.49	.92	40	3.5	.28	.49
Verification questions	.04	.19	3	0.3	.02	.10
Answers only	.56	1.42	46	4	.29	.71
New ideas without further elaboration	.16	.60	13	1.1	.09	.33
References to previously discussed ideas	1.02	1.55	84	7.3	.66	.95
Summarization	.66	.76	54	4.7	.42	.45
Acceptance without further elaboration	.05	.22	4	0.3	.03	.12
Rejection without further elaboration	.05	.27	4	0.3	.03	.16
2. *Affective contributions*	2.88	2.90	237	20.7	2.40	2.78
3. *Regulative contributions*:						
Planning of the task	.93	1.35	76	6.6	.78	1.12
Instruction of other student	.54	1.01	44	3.9	.43	.96
4. *Greetings*	1.40	2.60	115	10.1	.95	1.66
5. *Non-task-related remarks*	.62	1.06	51	4.5	.47	.87
Level of elaboration						
High-level elaborations:	4.55	3.67	373	32.6	2.86	2.02
Low-level elaborations:	3.02	3.40	248	21.6	1.81	1.67

regulative contributions and participation. A summary of the frequencies and percentages for the different categories of interaction can be found in Table 5.2. The results show the majority of the contributions to be cognitive (54.2%) and related to class learning topics, and therefore on-topic. Affective and regulative contributions were less frequent (20.7% and 10.5%, respectively). About 10% of the contributions were greetings and about 4.5% were non-task related.

The findings with regard to participation show the number of notes contributed to vary from 2 to 61 per group (M = 14.9, SD = 10.3) with an average of 2.5 notes per week across the six weeks of the project. The groups writing between 2 and 10 notes accounted for 40% of all the notes in the database. The groups writing between 10 and 25 notes accounted for 50% of all the notes in the database. And the groups writing more than 25 notes accounted for 10% of all the notes in the database. These findings suggest that the discussions were not dominated by a small number of groups, which means that participation was rather broad based.

The second research question addressed the quality of the process of knowledge construction by the students in an asynchronous CSCL situation. In order to answer this question, three aspects of the discussion notes were examined: (1) the percentage build-on notes and the average length of the discussion threads, (2) the content of the notes in terms of high- and low-level elaborations, and (3) the nature of the question-answer sequences.

The first aspect of the quality of the process of knowledge construction considered here was the percentage build-on notes and the average length of the discussion threads. Some 42% of the 899 notes could be characterized as build-on notes, which resulted in 418 threads. The length of the discussion threads varied from 1 to 22 notes (M = 10.9, SD = 9.5). Of the 418 threads, 58% contained only one note and probably contained an unanswered question or an isolated bit of information. Almost 75% of the threads contained one or two notes and involved a question followed by an answer. Only about 10% of the discussion threads

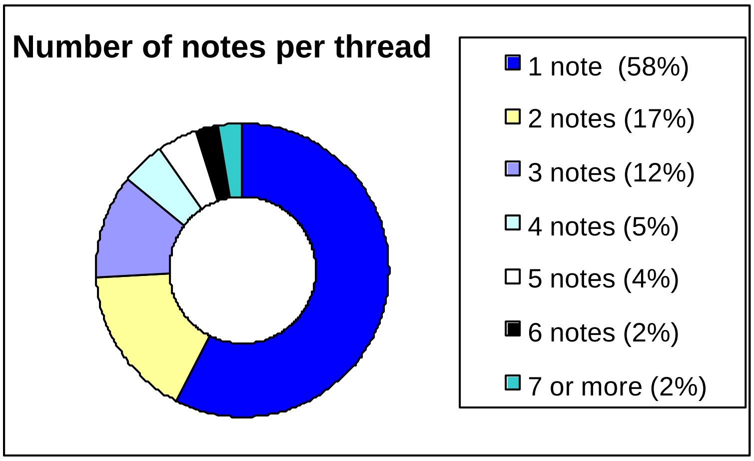

Figure 5.2
Overview of the number of notes for 418 discussion threads

contained five or more notes. The mean length of the discussion threads was 2.10 notes (*SD* = 2.0) with an average of one reaction to each new note. An overview of the number of notes per thread for the 418 discussion threads is presented in Figure 5.2.

The second aspect of the 899 notes analyzed to determine the quality of the process of knowledge construction concerned the number of high- versus low-level elaborations. As presented in Table 5.2, most of the cognitive contributions were found to be high-level elaborations (71.5%) with low-level elaborations occurring less frequently (28.5%). With regard to the high-level elaborations, the most frequently occurring categories were: the provision of new ideas with further elaboration, asking comprehension questions eliciting elaborated answers, and the provision of answers with elaborations. With regard to the low-level elaborations, references to previously discussed ideas were most frequent.

The third aspect of the quality of the process of knowledge construction considered here was the nature of the question-answer sequences. An overview of the posted question-answer sequences is displayed in Table 5.3. The results show 21.4% of the 164 posted questions to involve a simple question, 74.3% to involve a complex question, and 4.3% to involve a verification question. Of the 164 questions posted, 61 questions were not answered (37.2%). Of the 122 complex questions, 45.9% resulted in a complex question-complex answer sequence; 41.8% resulted in a complex question-no answer sequence; and 12.3% resulted in a complex question-simple answer sequence. Most of the simple questions triggered a simple answer (57.1%) and only occasionally a complex answer (17.1%).

Table 5.3
Overview of question–answer sequences posted

Type of sequence	Number of sequences	Percentage of sequences
Simple question-no answer	9	5.5
Simple question-simple answer	20	12.2
Simple question-complex answer	6	3.7
Complex question-no answer	51	31.1
Complex question-simple answer	15	9.1
Complex question-complex answer	56	34.1
Verification question-no answer	1	0.6
Verification question-simple answer	5	3.1
Verification question-complex answer	1	0.6
Total questions posted	164	100

The third research question was whether group composition in terms of gender and size influenced the number or quality of the elaborations provided in an asynchronous CSCL situation.

An overview of the interaction variables according to gender group composition and group size is presented in Table 5.4. Comparison of the mixed-gender groups, the boys-only groups, and the girls-only groups showed no significant differences in the average number of contributions (not in Table 5.4). However, the mixed-gender groups showed a non significant tendency to produce more high-level elaborations than the other groups. When significant differences were found for low-level elaborations, subsequent Bonferroni comparisons showed the mixed-gender groups to produce significantly more low-level elaborations than the girls-only groups ($p < .05$). Significant differences were also found for greetings with the girls-only groups producing significantly more greetings than the mixed-gender groups ($p < .01$).

No significant differences were found for the average number of contributions made by the twosomes, threesomes, and foursomes. However, significant differences were found for the percentages high- and low-level elaborations, affective contributions, and regulative contributions. Twosomes produced significantly more high- and low-level elaborations than foursomes ($p < .05$) while the foursomes produced significantly more affective contributions than the twosomes or threesomes ($p < .01$). Finally, the twosomes and threesomes differed significantly with regard to the percentage of regulative contributions made ($p < .01$) with the threesomes producing a significantly greater percentage than the twosomes.

The last research question was whether school subjects and/or type of school (ability) influenced the number of elaborations produced and their quality. The relevant results are displayed in Table 5.5. School subject did not influence the average number of contributions made by the students. Statistically significant differences were, however, found between the different school subjects for high- versus low-level elaborations, regulative contributions, and greetings. Students in the social science classes produced significantly more high- and low-level elaborations than the students in the natural science classes ($p < .01$) while the students in the natural science classes produced significantly more regulative contributions than the students in the social science classes ($p < .01$). Furthermore, the students in the natural science classes produced significantly more greetings than the students in the social studies classes ($p < .01$).

No statistical differences between the VWO students and HAVO students were found with regard to the average number of contributions. Statistically significant differences were, however, found with regard to the percentages high- and low-level elaborations, affective contributions, greetings, and non- task-related remarks. The VWO students produced significantly more high- and low-level elaborations ($p < .01$) and greetings ($p < .05$) than the HAVO students while the HAVO students produced significantly more affective contributions ($p < .05$) and non-task-related remarks ($p < .05$) than the VWO students.

Additional analyses showed the VWO students to post significantly more factual questions ($M = 4.16$, $SD = 4.46$) than the HAVO students ($M = 1.36$, $SD = 3.42$; $F\ (2,70) = 4.3$, $p < .05$). In addition, the VWO students posted significantly more comprehension questions (M = 14.39, SD = 13.46) than the HAVO students ($M = 0.69$, $SD = 2.41$, $F\ (2,70) = 10.26$, $p < .01$).

Table 5.4
Descriptive statistics for the interaction variables (percentages) according to gender group composition and group size with ANOVA results

	Gender group composition							Group size						
	Mixed (n = 36)		Boys-only (n = 14)		Girls-only (n = 23)			Twosome (n = 36)		Threesome (n = 22)		Foursome (n = 15)		
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*
Cognitive contributions														
High-level elaborations	36.02	15.78	35.91	21.33	29.54	16.19	1.13	38.62	16.81	33.12	19.26	24.01	8.82	4.26*
Low-level elaborations	26.84	18.42	26.01	25.22	14.59	19.17	3.30*	28.08	17.31	22.79	21.91	10.25	13.41	5.10*
Affective contributions	21.31	16.20	19.91	21.03	21.41	18.72	<1.00	16.24	10.97	14.88	13.56	41.77	21.52	19.50*
Regulative contributions	8.18	7.32	4.04	6.56	4.49	7.50	<1.00	6.03	7.02	13.58	12.97	11.74	5.25	5.43*
Greetings	2.24	5.42	5.26	8.96	18.47	14.31	20.34*	7.61	12.37	10.19	12.97	5.40	9.59	<1.00
Non-task-related remarks	5.12	7.32	4.04	6.56	4.49	7.50	<1.00	3.40	5.05	5.45	9.32	6.79	7.71	1.37

Note. n = number of groups
* p < .05

5.7 Discussion

In the present study, the influences of gender group composition, group size, and student ability as reflected by school type on the provision of elaborations by secondary school students working in a CSCL environment were examined. The focus of the study was not on individual learning outcomes but on the interactional behaviors of the students. In other words, examination of how a group of students contributes to a computer-mediated discussion forum can show us which types of behaviors promote or hinder successful collaborative learning. The mediating conditions as used in the present study can be regarded as necessary, but not sufficient conditions for demonstrating that the activity in the discussion forum will be associated with learning (Guzdial, 1997; Guzdial & Turns, 2000).

The first research question addressed the nature of students' interactional behavior in terms of cognitive, affective, and regulative contributions and their participation in general. About 55% of the student contributions was cognitive in nature; affective and regulative contributions were less frequent (about 20% and 10% of the student contributions, respectively). The large percentage cognitive contributions suggests that the students were on-topic (Guzdial & Turns, 2000; Schellens & Valcke, in press), but the percentage is considerably smaller than that found for Dutch university students working in a CSCL environment where cognitive contributions were found to reach percentages of 70% to 80% (Veldhuis-Diermanse, 2002) or for Flemish university students where cognitive or on-task contributions were found to reach percentages of 88% to 94% (Schellens & Valcke, in press). An explanation for this difference can be related to the level of the students. University students are probably more task-oriented than secondary school students. Finnish primary school students working in a CSCL environment, in contrast, produced percentages comparable to the ones found here (Lipponen et al., 2002). Affective contributions and greetings may serve an important social function under such CSCL circumstances and indicate, for example, active participation in the discourse, motivation, and group cohesion (Lipponen et al., 2002). The regulative contributions were used by the students in the present study to plan their activities as it was the first time that the students worked with the WKF program.

In the present study, 73 groups of students contributed 899 notes across a period of six weeks, with an average of 14.9 notes per group. The production of notes within the present context is relatively high when compared to the findings of other studies. When Guzdial (1997) and Guzdial and Turns (2000) studied 35 university-level electronic conferences, an average of only 4.3 to 5.4 notes (depending on the type of forum used) was found for a 10-week period. When Hara et al. (2000) conducted a study among graduate-level students in a CSCL situation, they found an average of 15 notes per student during a 15-week course. When Hsi (1997) studied eighth graders, an average of only 4.8 notes was found for an 18-

Table 5.5
Descriptive statistics for the interaction variables (percentages) according to school subject and school type with t-test results

	School subject					School type (ability level)				
	Natural Science (n = 49)		Social Science (n = 24)			HAVO (n = 12)		VWO (n = 61)		
	M	*SD*	*M*	*SD*	*t*	*M*	*SD*	*M*	*SD*	*t*
Cognitive contributions										
High-level elaborations	30.33	17.13	41.36	14.76	-2.70*	21.40	8.98	36.43	17.27	-4.41*
Low-level elaborations	17.76	17.97	33.15	17.57	-3.46*	6.75	10.18	25.98	18.97	-5.04*
Affective contributions	23.43	19.96	16.26	10.86	1.98	48.22	18.69	15.74	11.72	5.80*
Regulative contributions	12.22	10.00	3.86	5.06	4.74*	12.15	6.28	8.95	9.98	1.07
Greetings	10.99	13.23	1.69	5.09	4.31*	2.96	7.17	8.91	12.56	-2.27*
Non task related remarks	5.23	7.81	3.67	5.59	.87	8.46	8.26	3.98	6.75	2.03*

Note. n = number of groups
$p < .05$

week period. And Lehtinen et al. (2000) similarly found a small number of written contributions to be produced in a asynchronous CSCL environment.

Our findings show student participation in the CSCL situation studied here to be rather broad based; every group contributed to the discussion although differences in the levels of participation were observed. Both Guzdial and Turns (2000) and Stahl (1999) express concerns about low-level and uneven participation in CSCL environments. In contrast, Lipponen et al. (2003) argue that uneven participation and passive behavior are problems in traditional classroom settings as well.

The quality of the process of knowledge construction was defined using three indicators. The first indicator was the percentage build-on notes and the average length of the discussion threads. The percentage build-on notes was found to be rather low (42%) when compared to the findings of both Veldhuis-Diermanse (2002) and Lipponen et al. (2003) who reported percentages of 60% and 54%, respectively. The average number of notes in a thread was found to be only a little more than two. The discussion threads in online forums tend to be quite short (Guzdial, 1997; Guzdial & Turns, 2000; Lipponen et al., 2002, 2003), which suggests that discussions under such circumstances may not be very tightly connected and that such learning goals as the exploration of multiple perspectives on an issue or the development of a shared understanding of something may be very difficult to realize in such a context (Guzdial & Turns, 2000). When single notes were omitted from the analyses, as Lipponen (2000) did, the average length of the threads increased from 2.1 (*SD* = 2.0) to 3.6 (*SD* = 2.45). This suggests more sustained discussion and possibly consideration of multiple perspectives. The secondary school students participating in the present study were not necessarily fluent writers and may have encountered difficulties expressing themselves in a written form (Lipponen, 2000). In any case, the students were not accustomed to working in a CSCL situation using the WKF, which means that further research to examine the contributions of more experienced and/or older students may be merited.

The second indicator of the quality of the process of knowledge construction concerned the content of the notes in terms of high- and low-level elaborations. Most of the cognitive contributions of the students were found to be high-level elaborations (71.5%). And the majority of the discussions involving high-level elaborations included requests for (elaborated) information and the provision of new (elaborated) information, which means that the students rarely reacted to the elaborations provided by others. Asking for elaborations is obviously essential for students to construct collective knowledge and a shared understanding (Van Zee, 2000). And "explanation-oriented discourse" is the mode of discussion that promotes the construction of knowledge the most (Lipponen, 2000). Elaboration can lead to reflection, awareness, organization and reorganization, differentiation, fine-tuning, and the expansion of knowledge (Van Boxtel, Van der Linden, & Kanselaar, 2000b). In other words, elaboration is an important mediator of successful collaborative learning (Fuchs et al., 1998; King; 1999; Webb & Farivar, 1994,1999). Discussions with mostly low-level elaborations are factual in nature: students present factual statements or ask factual questions, which are then responded to with factual comments or answers and little or no further elaboration. Discussions of this type do not appear, thus, to deal with understanding but simply finding the right answers to the questions posed.

The third indicator of the quality of the process of knowledge construction concerned the nature of the question-answer sequences produced. According to King (1994), a clear relation exists between the types of questions posed and the answers provided during collaborative tasks. Factual questions elicit factual answers while higher-order questions elicit higher-order answers. Our findings support this observation. In general, factual questions were answered with factual answers and complex questions triggered complex answers or no answers at all. Higher-order questions triggered more elaborated explanations, which can positively influence the performance of both the provider of the elaboration and the recipient (King, 1999). The number of complex questions greatly exceeded the number of factual questions in the present study, which was an unexpected positive finding. However, more than 40% of the complex questions went unanswered while only 25% of the simple questions went unanswered. We agree with Lipponen (2000) that a possible explanation for this finding may simply lie in the fact that it is generally easier to formulate an answer to a simple factual question than to a complex question. Another possible explanation is the large number of messages posted, which can make it difficult for students to follow a discussion. The need to provide a written response may also interfere with the answering of complex questions and make comparison across CMC media and circumstances an interesting prospect for future research.

The third research question was whether group composition in terms of gender and size influenced the number or quality of the elaborations provided in an asynchronous CSCL situation. With regard to gender group composition, mixed-gender groups were found to produce more elaborations than single-gender groups. Other observations of students working collaboratively on a computer task show mostly mixed-gender groups to perform less well than single-gender groups (Underwood et al., 1990, 1994). These observations were not supported by the present findings. We did not found that mixed-gender groups were at a disadvantage over boys-only or girls-only groups with regard to the use of elaborations. However, girls-only groups used significantly more greetings than mixed-gender groups. According to Herring (2000), female talk tends to be more focused on social issues and more polite. The large numbers of greetings found in our study did not differ for the girls-only and boys-only groups, however; only the girls-only groups differed significantly from the mixed-gender groups with a greater percentage greetings found for the former when compared to the latter. The interactional behavior of secondary school girls working in a girls-only collaborative group thus appears to differ from the interactional behavior of secondary school girls working in a mixed-gender collaborative group. Furthermore, the behavior of secondary school boys with respect to greetings is different when they collaborate in a boys-only group versus a mixed-gender group. In other words, the interactive behavior of both girls and boys is influenced by the presence of the other sex.

With regard to group size, our findings showed no significant differences in the total number of contributions made by the twosomes, threesomes, or foursomes. This finding is contrary to our expectation as we expected the twosomes to produce more contributions due to the fewer number of participants involved in the communication (Fuchs et al., 2000; Strijbos et al., 2004). Significant differences across the different group sizes were, however, found for high- and low-level elaborations, affective contributions, and regulative contributions. Twosomes produced significantly more high- and low-level elaborations than foursomes, which is in line with the findings of a meta-analysis by Lou et al. (2001) who found dyads to more positively influence individual student learning than groups of three to five. The foursomes in the present study produced significantly more affective contributions than the twosomes and threesomes. Furthermore, the threesomes and foursomes appeared to need more regulative contributions to complete the present task than the twosomes.

The fourth and final research question addressed the influence of school subject and school type (ability) on the number of elaborations and quality of the elaborations produced by the students. With regard to school subject, our findings showed no significant differences between the school subjects with regard to the number of contributions. Our findings showed significant differences between natural-science and social-science subjects for high- and low-level elaborations, regulative contributions, and greetings. Although the designs of the research projects were basically the same, differences could arise due to the nature of the topics/subjects being studied. Discussions of "Keppler's law" may necessarily differ from discussions of "Racism", for example. Cohen (1994) and Webb and Farivar (1994) argue that the type of task assigned to a group may definitely influence how the group members interact. When the task has one correct answer, for example, there is little or no need for the group to engage in extended discussions. "Well-structured tasks" - in terms of Cohen (1994) - require only a limited exchange of information and thus a low level of cooperation. In contrast, when the task is less structured, more open or discovery based, and has no one correct answer, students are more dependent on each other and need to reach joint agreement, as there is often more than one way to solve a particular problem. More research on the nature of the tasks that tend to occur in CSCL environments is nevertheless needed.

With regard to school type, our findings showed no significant differences between the HAVO and VWO groups with regard to the number of contributions. Additional analyses, however, showed the VWO groups to ask significantly more questions than the HAVO groups. The VWO groups also produced relatively more elaborations, which is in keeping with the findings of Fuchs et al. (1996) and King (1989), showing a relation between student ability and the quality of elaborations. The discussions of the VWO students were much more on topic than the discussions of the HAVO students who spent more time on social interaction and thus produced a relatively greater number of affective contributions, greetings, and non-task-related contributions.

The results of the present study show an asynchronous CSCL environment to be fruitful for the promotion of collaborative learning when used in a normal secondary education setting. The findings also reveal considerable room for improvement with regard to the quality of the discussion in a CSCL environment. Improvements should be undertaken at both technical and pedagogical levels. At the technical level, CSCL environments provide only text-based tools for knowledge representations. The implementation of simulations, anchors, graphic tools, and linked WebPages could help students with limited writings skills to participate more actively and productively in such environments (Guzdial & Turns, 2000). On a different front, Scardamalia and Bereiter (1992) introduced the use of "thinking types" to scaffold students' interactive behavior and allow students to indicate the type of statement they are contributing to the discussion (e.g., "my theory" or "I need to understand"). Along these lines, King (1994) proposed the use of "prompts", for example, questions such as "what is the relation between…?" to stimulate the use of comprehension questions. Students must pose comprehension questions and provide elaborated answers to discuss effectively and in FTF collaborative learning situations, research shows explicit instruction on the provision and receipt of help to enhance students' interactional behavior and achievement. In other words, the results of the present study support the results of earlier studies showing a need to structure learning in small groups and feasibility of training such discourse features as help-seeking, help-giving, provision of reasons, and exploratory talk (Dawes, Mercer, & Wegerif, 2000; King, 1994, 1999; Webb & Farivar, 1994, 1999). Further research is needed to examine whether such instruction can also positively influence the interactions in a CSCL environment.

At the pedagogical level, it can be stated that CSCL technologies alone are insufficient to promote changes in school practices. The most important factor to enhance the quality of the discussions in a CSCL environment is the teacher. The teacher is needed to structure learning events, to provide advice and feedback, to verify and clarify things, and provide scaffolding as needed (Lipponen et al., 2002). In the present study, the teachers did not actively participate in the WKF forum. From the 899 notes contributed to the communal database, only 20 (or 2%) were posted by teachers. The lack of teacher involvement was mainly due to scarcity of computer facilities. Furthermore, the teachers found the following of all the online discussions in their classes to be very time-consuming. Similar findings have been reported by Hakkarainen, Lipponen and Järvelä (2002) with regard to Canadian and Finnish primary school teachers. Until recently, the significance of the teacher's role has not been emphasized in CSCL research (Hakkarainen et al., 2002). Further research is thus needed to explore the specific role of the teacher in CSCL environments.

In interpreting the results of the present study, some possible limitations should be kept in mind. First, the use of a relatively small number of classrooms from a single school limits the representativeness of the data. Second, pre-test data were not collected, which means that nothing is known about the interactional behavior of the students prior to the start of the CSCL project. Furthermore, the data in the present study were only collected on one occasion. In future studies, thus, data should be collected on more than one occasion in order to examine the stability of the interactional behavior of the students. Third, the present research was undertaken in a normal school setting where the teachers played an important role in the composition of the groups and the choice of the research subjects. The groups were not composed in the same manner across classrooms. The gender-group compositions and group sizes were therefore not equal across classrooms. Fourth, the data were collected for only two types of secondary schools and two grades, which means that generalizations with regard to other schools and other grades should not be made. Fifth, the data were collected for only two school subjects with different students for the subjects, which complicates comparison. Sixth, the quality of the process of knowledge construction was approached in terms of the provision of elaborations in the present study. The use of elaborations is only one aspect of the quality of the process of knowledge construction, however. Seventh, the participating teachers had no prior experience with collaborative learning in either FTF situations or CSCL situations. Although the teachers were not explicitly included in the discussion forums, they proved very active in the organization of the research projects within their classes. In future research, greater attention should thus be paid to helping teachers work effectively with their students in a CSCL environment.

Despite the aforementioned limitations, the present study sheds light on the interactional behavior of Dutch secondary school students working in a CSCL environment. It can be concluded that the students working in an asynchronous CSCL environment produce both high- and low-level elaborations. Although their WKF discussions tended to be fact-oriented and thus involve low-level elaborations, explanation-oriented discussions were also encountered. The posting of a large number of high-level elaborations by the participating students without explicit instruction or prompting to do so is also a very promising result.

Chapter 6
Student elaborations in a three-dimensional synchronous and asynchronous learning environment

6.1 Introduction

The introduction of computers into educational practice has changed the potential of learning support. Computer technology stimulates collaboration at a distance and provides space for learning groups using the internet (Shumar & Renninger, 2002). The communication within electronic learning environments has been mostly textual up until now, but new technologies have introduced a visual dimension. Three-dimensional (3D) virtual environments can now be created by programs that integrate text-based chat with 3D representations of a physical environment and 3D characters. The space itself and the spatial relations among the various users, virtual buildings, and virtual objects are represented in a realistic manner. Users are represented by 3D "Avatars."[5] An Avatar is a little 3D person who can communicate, walk, gesture, and express feelings. Users can thus interact with each other and with the environment and can operate actively on the environment by building new objects. The combination of different representational formats (e.g., graphics, animations, text, objects) and different communication formats (e.g., synchronous chat versus asynchronous internal telegrams) offers a rich learning environment (Ligorio, 2001). The software provides tools for the easy creation and visualization of 3D objects and spaces. And while the potential value of such software for educational purposes has been acknowledged by many researchers, actual application for learning purposes is still mostly exploratory and research on the nature of learning within such virtual environments is still scarce (Winn, 1993; Renninger & Shumar, 2002; Salis & Pantelidis, 1997).

In the present study, the process of knowledge construction by a virtual community of students working in a 3D virtual world will be examined. Before we introduce the specific research questions, we will first discuss the communication formats offered by the different learning environments (i.e., synchronous or asynchronous communication tools or a combination of the two) and the results of some studies of the use of these different communication formats in educational settings.

6.2 Learning in a three-dimensional virtual environment

In the research described in this chapter, desktop virtual reality software is used to create and visualize 3D objects and construct a 3D virtual world. The Active Worlds (AW) software

[5] The word "Avatar" was used in India to name an Indian God able to reincarnate himself with several faces. On the internet, the word "Avatar" is the "object" representing the embodiment of the user.

(http://www.activeworlds.com) is non-immersive virtual reality software, which means that no special gloves, masks or headgear are needed to enter the 3D virtual world.

Three features of the 3D virtual world created using the AW program can be considered relevant for education: the interface, the communication format and the construction of 3D objects (Van der Meijden, Janssen, & Ligorio, 2002). First, the 3D interface obviously differs from the typical 2D interface in that one can move in *all* directions within the 3D world: forward, backward, left, right, up, and down. In other words, the representation on the user's screen closely resembles a real world view. It should also be noted that moving in a 3D world gives the sensation of really being in another world. Although the AW program is not totally immersive, it can still create a feeling of presence. This feeling of presence is not created by the resemblance of the virtual world to the real world but by the actions and interactions of the individuals using the program (e.g., the construction of objects and chatting). Acting and reacting in chats indicate the presence of another person (Van der Meijden, 2002).

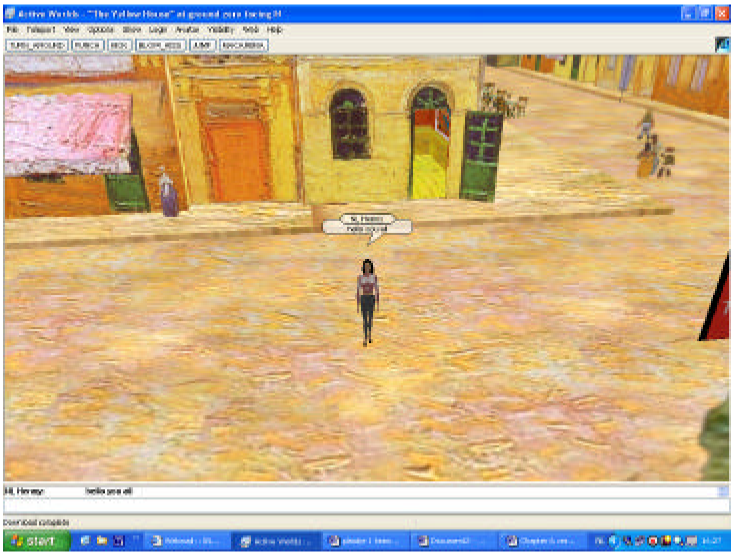

Figure 6.1
Avatar (NL Henny) in Active Worlds saying hello to you all

A second feature of particular relevance for education is the synchronous format of the communication or chatting within the virtual world created using the AW program. Chatting occurs while users construct or navigate the virtual environment. Users see the results of their efforts or the efforts of others and can then provide immediate feedback. While chatting, the words of the user appear above the head of his or her Avatar, and this format clearly differs thus from the usual chat format where only a name at the beginning of a line indicates who is speaking (see Figure 6.1). That is, the chat within the AW program is much more powerful than the chat within Internet Relay Chat (IRC) systems where the communicative context is strictly textual. The 3D aspect of the AW chat may also help us overcome some of the general problems associated with text-based synchronous chatting by providing facial expressions, gestures, and intonation (see Chapter 2). While "emoticons" can be used in a 2D system to express feelings, they are still quite static symbols. Avatars - in contrast - can wave, express happy or angry feelings by blowing a kiss or kicking something, and actually point at what they mean.

A third feature of particular relevance for education is the construction of 3D objects using the AW program. This constructive dimension means that users can build their own unique virtual world and further modify this as they build objects, decorate rooms, construct buildings, and so forth. Cognitive constructive activities can be supported by real constructive activities. According to Papert (1991), knowledge construction arises from physical interaction with objects in the world. In this case, a constructed virtual world is substituted for the real world, but the interactions within the virtual world can still generate knowledge construction. In 3D virtual worlds, users can see their own products, compare them to the products of others, reflect upon what has been done, explicitly consider what must still be done, and thereby regulate their own learning. And greater control over learning activities can trigger and promote self-regulated learning (Shuell, 2001) - which is the focus of considerable educational research today (see Simons et al., 2000a).

6.3 Combining different learning environments: "blended learning"

The combination of different learning environments in education is referred to as the 'blended learning" approach. The most important components of a blended learning approach are FTF meetings combined with the use of technology. For example in-class activities alternated with online activities such as synchronous or asynchronous communication, together with the use of websites to upload and download learning materials. Blended learning is recommended as a way to personalize collaboration and to stimulate involvement of students in the group. Moreover, the combination of both FTF and online communication may reinforce the learning process (Lockhorst, 2004). The introduction of blended learning is not yet common practice in primary or secondary education, as it is in companies or at university level, but it seems a promising arrangement for supporting the integration of technology in education (Voogt, Almekinders, Van den Akker, & Moonen, 2005).

Using the capabilities of the technology available to us today, realistic learning situations can be presented to learners to stimulate collaboration and the construction of knowledge (Kanselaar, de Jong, Andriessen, & Goodyear, 2000). That is, the members of a virtual community can take advantage of the capabilities of the technology in the form of simulations, multiple representations, and computer-mediated communication in addition to any FTF interactions that they may have. And educational environments that simultaneously employ different communication formats are generally assumed to be quite suited for the stimulation of collaborative knowledge construction (Ligorio, 2001). That is, the combination of different learning environments with different learning activities and different media appears to meet the needs of many learners by providing flexible learning arrangements, flexible learning content, flexible time, and flexible learning space (Collis & Moonen, 2001). And although the blended learning approach that merges different communication formats offers such flexibility and seems to be a promising approach in education, only a few studies have examined how the different communication formats interact with each other and affect each other.

Berge, Collins, and Dougherty (2000) describe three manners of merging different learning environments: (1) using internet technology to supplement FTF instruction, (2) using internet technology intermixed with FTF instruction, and (3) using internet technology instead of FTF instruction (so-called hyperlearning). In a *FTF class*, the whole class typically proceeds through the course content at the same time. Internet is used for the distribution of documents, including lecture notes, and to search for further information. In a *mixed mode class*, a significant portion of the instructional objectives can be met online (i.e., either synchronously or asynchronously). In a *hyperlearning class*, no FTF meetings are planned. Students meet online - both synchronously and asynchronously - to discuss topics, follow lectures, and search for information. Communication with teachers is only possible electronically. Hyperlearning has been developed for purposes of higher education and in-company training (Berge et al., 2000). The trend is towards a combination of synchronous and asynchronous communication formats in order to fully exploit the advantages of the two: the informal quick chat format and the asynchronous communication format that is more flexible with regard to time and thus allows greater reflection (Mason, 1999).

Combining face-to-face and online communication

Given that class discussion led by a teacher is one of the most widespread instructional strategies, most instructors do not provide learning environments in which discussion *and* student collaboration are implemented. And even when instructors do organize the learning environment to allow students to discuss and collaborate, participation is difficult to realize because some students simply do not participate (Dut-Doner & Powers, 2000). In order to overcome the problem of unequal participation, Dut-Doner and Powers implemented an online discussion forum in a preservice teacher course. The participants were 68 primary school teacher students divided into three online news discussion groups. The students communicated with their classmates and instructors to find the answers to a variety of questions and to share any concerns, problems, or feelings they had experienced during their preservice teaching. Dut-Doner and Powers concluded that the online discussion forum provided a teaching and learning tool that could not be duplicated within the classroom. They found: (1) self-directed discussion to create an environment for active participation for the majority of the teacher students, (2) the teacher students to rely upon each other for support and guidance, (3) the teacher students to share ideas with classmates in order to help them develop their professional knowledge of teaching, and (4) the teacher students to use high level reflection skills to integrate new information and expand their knowledge. Dut-Doner and Powers also found the teacher students to be willing to share their negative experiences more in the online discussion forum than in the FTF meetings. And a dynamic interplay between the classroom activities and the online activities was observed: in some cases, topics and contributions from the online discussion forum were "debriefed" during FTF meetings; on other cases, the students were found to continue the discussion of a topic started in a FTF discussion online.

Kleine Staarman (2003) studied 28 primary school students (grade six, age 11-12 years) using an online discussion forum to discuss the concept of horror stories. The purpose of the discussion was to familiarize students with the genre of horror stories, create common knowledge with regard to the topic, and make students aware of the different strategies used by authors to make a story scary and exciting to read. Kleine Staarman created two conditions: in one condition, the students participated individually in the online discussion forum; in the other condition, the students participated as dyads in the online forum. In the latter condition, the students were also able to talk about their contributions and revise them before their actual entry into the online discussion. Kleine Staarman (2003) found the students who worked in dyads to make nearly twice as many contributions to the online discussion as the students who worked individually; the contributions of the dyads were also of a more collaborative nature. Students who worked in dyads showed more awareness of the task and the necessary strategies - such as argumentation - than the students who worked individually. These results suggest that working in FTF dyads at a computer may be one means to foster online discussion and help sustain such discussions (Kleine Staarman, 2003).

Dietz-Uhler and Bishop-Clark (2001) conducted a study in which they examined the effects of synchronous and asynchronous computer-mediated communication on subsequent FTF discussions in an undergraduate introductory computer science course. All 56 of the students studied an article about internet censorship and then participated in one of three conditions: a condition in which the students discussed the article synchronously (chat), a condition in which the students discussed the article asynchronously (online discussion forum), and a condition in which the students did not discuss the article. Thereafter, the students from all of the conditions also discussed the article FTF. The results showed the participants from all of the conditions to positively evaluate the activities they engaged in. Nevertheless, the FTF discussion preceded by a computer-mediated discussion was judged to be more enjoyable and to offer a greater diversity of perspectives than the FTF discussions not preceded by computer-mediated discussion. The analyses of the contributions to the virtual chat room and the online discussion forum, however, showed the discussions to be equally on-task, meaningful, and relevant and participation to be more or less equal.

Oshima and Oshima (2002) conducted two studies in which they examined how asynchronous communication via a discussion forum either with or without additional FTF communication influences the learning activities of expert (graduate) and novice (undergraduate) students of educational science. In the first study, 19 graduate students participated in a postdoctoral psychology course. The objective of the course was to understand recent ideas regarding tool-mediated human activities. The participants in the second study were 5 students and an instructor in an education course on computers. The objective of this course was to understand recent ideas regarding the use of computers in education. All of the participants were asked to read some articles and discuss their views within the online discussion forum. Oshima and Oshima found: (1) those students who worked with both the asynchronous online discussion forum and synchronous FTF meetings to use the online discussion forum more efficiently when compared to those students who only worked with the online discussion forum; (2) both groups evaluated the online discussion forum as a powerful tool for improving their knowledge and some students actually thought that this would not be possible without the use of the discussion forum; (3) those students who worked with both the asynchronous discussion forum and synchronous FTF meetings produced a better description of their arguments; (4) the quality of the FTF communication of the students improved with the employment of the asynchronous communication facilities; and finally (5) the frequent externalization of students' thoughts within the online discussion forum facilitated FTF communication (Oshima & Oshima, 2002).

Combining synchronous and asynchronous communication

Given the advantages of both synchronous and asynchronous communication formats (see Chapter 3), Haythornthwaite, Kazmer, Robins, and Schoemaker (2000) interviewed 17 students enrolled in a graduate course for Library and Information Science on five occasions during the course. The course began with a single FTF campus session. After this session, the students returned home to complete the remainder of the course via the internet. Courses were conducted using a combination of synchronous and asynchronous communication formats. During online synchronous lectures, all of the students gathered virtually in the Internet Relay Chat (IRC) room. Students could submit chat questions during the lecture, and any text submitted to the chat room was visible to all members of the class. A "chalk board" was used to present discussion results to others. The lectures and chat activities from the IRC room were recorded and made available for later viewing. Haythornthwaite et al. found synchronous communication, particularly during the online lectures, to contribute much more to community building than asynchronous communication because the former provides a common meeting ground and temporal proximity, which are important elements for the building of a community. The online lectures provided both cognitive and emotional content but, perhaps more importantly, simultaneous many-to-many contact that appeared to stimulate a feeling of belonging. The online lectures thus supplied the students with an opportunity to "come together." Asynchronous communication was used to post the required course assignments and for private communication within pairs of students, which fostered intensive collaboration and strong ties between students (Haythornthwaite, 2002). The studies by Haythornthwaite (2002) and Haythornthwaite et al. (2000) demonstrate the potential of using multiple means of communication to sustain group interactions: public, private, synchronous, asynchronous, multi-party, one-on-one, distanced, and FTF.

Ohlund, Ho Yu, Jannasch-Pennell, and Digangi (2000) examined the use of asynchronous mailing lists and synchronous chat communication and then their impact on teachers' attitudes towards collaboration, task completion rates, and test performance. The participants were 161 primary school educators following an interactive web-based training course for computer skills. The participants could use a mailing list, chat sessions, or both communication formats. The results showed no differences between the teachers using the mailing list versus the chat room with regard to their attitudes towards collaboration. However, the chat communication format did increase the likelihood of completing course activities but no relation was found between the use of such a format and test performance (Ohlund et al., 2000).

Sotillo (2000) studied the discourse functions and syntactic complexity of the essays produced by two groups of students following an English as a second-language course. The participants were 25 university level students from two academic writing courses. The groups of 12 and 13 students, respectively, had to read the same textbooks, which were then discussed online. The task was to analyze and summarize the information discussed in the groups and then write an essay. The discussions were mediated by computers. One group discussed synchronously via Internet Relay Chat; the other group discussed in an asynchronous discussion forum. The study showed the synchronous communication to be informal, with short sentences, and significantly fewer errors than in the asynchronous discussion forum, where longer sentences were used, the syntax was more complex, and more errors were made.

Schwier and Balbar (2002) studied a educational communications and technology seminar in which seven graduate students participated using synchronous communication (chat) and asynchronous communication (bulletin board) along with FTF meetings. The course consisted of weekly chat meetings and monthly FTF meetings at the university. The course started with an online meeting. Every week, the instructor mailed study questions to the participants. The pattern for online discussion of each topic was to post all contributions to the asynchronous bulletin board in the first week and then meet synchronously in a chat room one week later to discuss the themes that emerged from the bulletin board. The seminar lasted twelve weeks. The students were expected to review the bulletin board postings before entering the chat session. During the synchronous discussion, all of the participants posed questions to each other, expressed different viewpoints, and requested reactions from either one person or the entire group. Schwier and Balbar (2002) found the synchronous communication to promote a strong sense of community but be less effective than asynchronous communication for dealing with content and issues on a deeper level. Asynchronous activities, in contrast, allowed for more in-depth discussion and reflection upon issues but lacked the community-nurturing benefits of synchronous chat sessions. Schwier and Balbar therefore conclude that synchronous and asynchronous communication formats appear to be suited for different aspects of learning (e.g., synchronous communication to enhance motivation and a sense of community; asynchronous communication to enhance reflection and deeper learning). And a combination of synchronous and asynchronous communication formats appears to be necessary to promote the type of engagement and depth of understanding required by a graduate seminar.

Summary of the findings

The findings from the aforementioned studies suggest that FTF discussions can improve the quality of online discussions and, conversely, online discussions can enhance the quality of FTF discussions. The results show a dynamic interplay between different learning settings and different communication formats. Some of the topics initially selected for online discussion were alternatively covered or expanded in the FTF classroom environment. Other topics emerging during a classroom session or online synchronous chat were later transferred to an asynchronous communication format for elaboration (e.g., the bulletin board or the asynchronous discussion forum). And, as already noted, clear language differences were observed between the synchronous chat format versus the asynchronous discussion forum format.

The results of the aforementioned studies show a combination of different learning environments with different communication formats to benefit learning. A FTF environment may be better than any type of online discussion for some topics. For example, FTF discussion may be better suited for critical evaluation than online discussion because critical evaluation requires a type of dynamic engagement that is difficult to replicate via a keyboard.

Some possible methodological limitations on the studies reviewed above should be mentioned. Almost all of the studies were conducted at the level of the university. Only the study by Kleine Staarman (2003) concerned primary school learning. The building of virtual learning communities online is presumably much more difficult at the primary school level or even the high school level than at the university level. FTF sessions in the classroom may thus be of critical importance for the development of a sense of community, for the joint generation of ideas, and for the provision of immediate feedback. Chat sessions appear to serve a similar function within the online environment. And asynchronous online communication appears to be suited for the elaboration of more or less established topics and deeper inquiry.

In the present study, a virtual learning environment was created in which both synchronous and asynchronous communication tools could be used and both textual and visual information could be contributed. The students had to collaborate on the construction and decoration of various 3D objects. And the interactional behavior of the students collaborating within this virtual world was then examined.

6.4 Research questions

In the present study, the following research questions were addressed.

1) How can the synchronous and asynchronous interactions of the students working in a 3D virtual learning environment be characterized in terms of cognitive, affective, and regulative interactions, and what is the quality of the knowledge construction process?
2) Do significant differences exist between the cognitive, affective, or regulative interactions of the synchronous versus asynchronous communication of the students working in a 3D virtual learning environment?
3) Does the incorporation of an asynchronous discussion format into a synchronous 3D virtual learning environment have a surplus value for the interactional behavior of students?

6.5 Method

6.5.1 Research setting

This study was carried out within the context of a research project funded by the European Community. The study involved long-distance collaboration between three Dutch and four Italian schools. Students worked together online on a collaborative task: the construction of several virtual houses within a 3D environment referred to as "Euroland." The students communicated with each other three times a week via a synchronous chat at fixed hours and also in between via an asynchronous discussion forum. The collaborative task lasted about eight months.

6.5.2 Participants

The virtual community of Euroland consisted of 42 students and 10 teachers connecting from seven different classrooms/schools (i.e., 4 Italian and 3 Dutch) together with 6 researchers. A total of 3 other teachers and some 162 students were further involved in the conduct of the in-classroom activities related to the construction of the virtual world (see Figure 6.2). One more teacher (i.e., The Hague) provided technical assistance for his students. The students ranged in age from 9 to 14 years, and they were all in either primary school or high school. For technical reasons, only a small group of students from each classroom - called the "citizen group" - could connect to Euroland. That is, none of the schools had sufficient computer facilities for the entire class to be online at the same time.

EUROLAND: Characteristics of participants and tasks			
Students	**Teacher involvement**	**Students online (citizens[6]) Involvement of the remainder of the classroom/school**	**Virtual house(s) as responsibility**
Modena eighth grade age: 13-14	2 teachers: Music	8 citizens Entire class of 18 students involved in collection of materials Sporadic connections	Dutch House of Music Collaboration on the Dutch House of Art
Rome eighth grade age: 13-14	3 teachers: English, Art, and Computer Science	10 citizens No further class involvement	Dutch House of Art
Noviglio (Milan) sixth grade age: 10-12	2 teachers: Social studies and English	6 citizens Entire class of 21 students involved in planning of virtual house and collection of materials Frequent connections	Dutch House of Food
Bari fourth grade age: 7-8	3 teachers: English, Computer Science, and a class assistant	4 citizens Four classes with a total of 73 students involved in planning and collection of materials (e.g., visit to local travel agencies)	Travel Agency
The Hague tenth grade age: 13-14	1 teacher: Science teacher for technical assistance	2 citizens No further class-involvement	Italian House of Art Other virtual houses for general use
Amsterdam: eighth grade age: 11-12	2 teachers: Classroom teacher and ICT assistant	6 citizens Entire class of 20 students involved in planning of virtual house and collection of materials	Italian House of Food
Amsterdam eighth grade age: 11-12	1 teacher: Classroom teacher	6 citizens Entire class of 30 students involved in planning and collection of materials.	Italian House of Music
Total number of citizens online: 42	**Total number of teachers involved: 10 online, 4 offline**	**Total number of students involved offline: 162**	**Total number of virtual houses: 7 cultural houses, 3 general purpose houses, 1 welcome area**

Figure 6.2
Overview of Euroland schools, teachers, classes, students, and tasks.

[6] One can enter Euroland as a guest ("tourist") or an inhabitant ("citizen"). A citizen has the privilege to construct 3D objects.

The citizen groups were composed of two to eight students selected on the basis of several criteria including English language skills, computer expertise, and a willingness to participate. The number of students meeting the inclusion criteria varied from classroom to classroom. The citizens were the representatives of the classrooms and responsible for putting the results of the work done in the classrooms online; they thus constituted a bridge between their classmates and Euroland. In Figure 6.2, a detailed overview of the characteristics of the Euroland participants from the different classrooms and the tasks assigned to the different classrooms is presented.

6.5.3 The three-dimensional virtual learning environment

The virtual environment where Euroland came to life was composed of two pieces of software involving different communication formats: Active Worlds (AW) and Web Knowledge Forum (WKF). With AW as developed by the Active Worlds Inc. (http://www.activeworlds.com), it is possible to create a virtual world of houses, roads, trees, objects, and include users as active participants (Bricken, 1991; Bricken & Byrne, 1992).

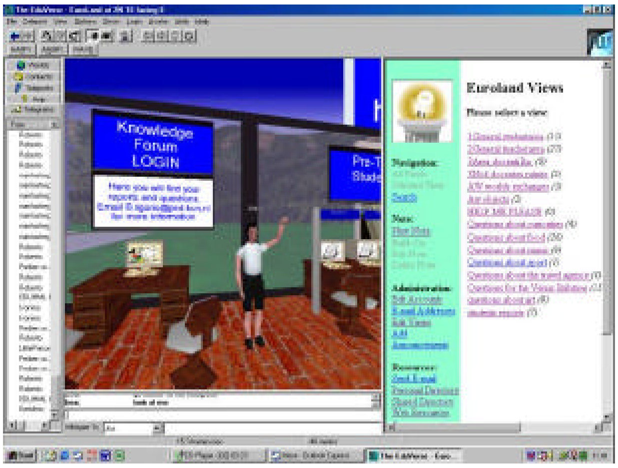

Figure 6.3
AW and WKF running at the same time

AW is desktop, internet-based, and multi-user software; that is, several users can use the software at the same time. Within he virtual worlds created using the AW software, the users are represented by avatars who can walk and fly through the virtual world. Avatars can also chat synchronously with other connected avatars. The AW software supports both visual (3D objects) and text-based (chat) communication at the same time. Although a few asynchronous tools are embedded in AW, such as internal telegrams, AW communication is largely synchronous.

WKF is an online discussion forum developed by Scardamalia and Bereiter (1994). At the center of WKF is a communal database, which can be filled with contributions or so-called "notes." All of the notes are saved in the database and thus available to all participants. The WKF also provides space for the sharing of documents and files in a so-called *Shared Directory*. The virtual space created with the combination of AW and WKF provides numerous opportunities for communication and collaborative learning (Ligorio, 2001). A click on the screen of one of the virtual computers located within Euroland activated a link to the WKF. In Figure 6.3, a computer screen with AW and WFK running at the same time is depicted.

6.5.4 Collaborative task and procedure

An empty virtual world was provided at the start of the project (see Figure 6.4). The intended content of the world was discussed among the project participants as suggested by the community of learners model (Brown & Campione, 1990). FTF brainstorm sessions were held in the different classrooms where one of the researchers also outlined the project and demonstrated the AW program.

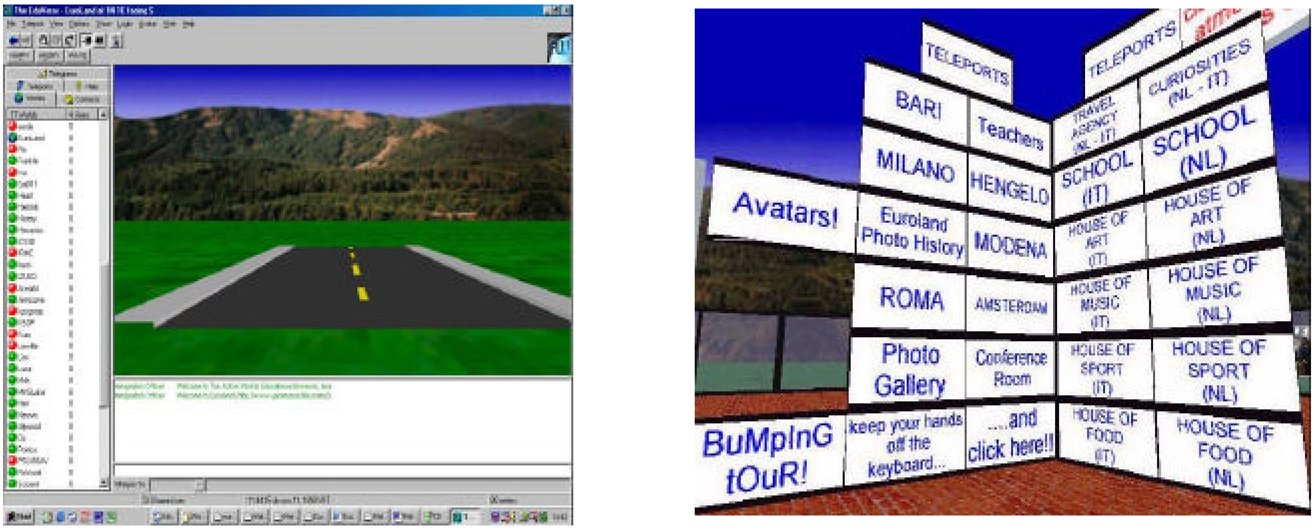

Figure 6.4
Euroland from an empty world to a world full of cultural houses and activities.

It was agreed that the virtual world would be referred to as "Euroland" in order to stress the international collaboration involved and that the world would include not only several "cultural" houses (e.g., Food, Music, Art, Sport, Curiosities, and Travel houses) but also houses for each school and a house for the teachers.

To establish individual accountability and positive interdependence (Johnson & Johnson, 1994), it was agreed that the Dutch students construct and decorate the Italian cultural houses and the Italian students construct and decorate the Dutch cultural houses. The students thus needed each other for information and the collection of materials. Every classroom was responsible for at least one house (see Figure 6.2). All of the classrooms were required to search for information, answer questions, provide help, and supply comments upon all of the 3D buildings - even when another classroom was responsible for them.

Three weekly synchronous meetings were scheduled for the citizen groups from the Dutch and Italian schools for instruction and technical guidance. Furthermore, the students could connect anytime they wanted from home or school to make textual contributions or construct 3D objects. The classroom and online activities took place from October 1999 through May 2000. The communication was in English, which was a second language for all of the participants.

6.5.5 Data collection and preparation

All of the synchronous communication in the form of chatlogs was saved by the researchers. The data from the asynchronous WKF was directly recorded by the software; this included all of the posted notes, views (i.e., folders where notes are organized thematically), and pictures and documents shared in the WKF directory.

The coding scheme

To examine the verbal contributions of the students to the chat sessions and the WKF, a coding scheme was used with five dimensions: cognitive, affective, regulative contributions, non-task-related remarks, and greetings (for an extended description of the coding scheme, see Chapter 3). The *cognitive* dimension refers to written contributions or statements that represent the thinking activities that students use to process the learning content and attain their learning goals. The *affective* dimension refers to any emotional written remark concerning the collaboration and contributions of those involved in the collaborative task. The *regulative* dimension refers to written contributions intended to redirect one's efforts during the conduct of a task and statements intended to help organize matters. Statements that are off-topic were coded as *non-task-related remarks.* The last dimension, *greetings*, refers to indications of entrance or departure from the communal database.

The cognitive dimension contains 13 categories distributed as follows: 3 categories pertaining to the posing of questions (i.e., factual questions, comprehension questions asking for elaboration, questions asking for verification); 2 categories pertaining to the provision of help (i.e., answers only, answers with elaboration); 2 categories pertaining to the input of new ideas (i.e., presentation of new ideas without elaboration, presentation of new ideas with elaboration); 2 categories pertaining to previously discussed ideas (i.e., references to previously discussed ideas, summary); and 4 categories pertaining to the acceptance or rejection of ideas (i.e., acceptance without further elaboration, acceptance with further elaboration, rejection without further elaboration, rejection with further elaboration). The affective dimension contains 1 category pertaining to the process of cooperation (i.e., emotional reactions). The regulative dimension contains 2 categories pertaining to the conduct of the task (i.e., the planning of the task, instruction of other student with regard to the AW program). The coding scheme - including greetings and non-task-related remarks - thus included a total of 18 categories.

Unit of analysis

Following Henri (1992) and Gunawardena et al. (1997), the *unit of analysis* for coding both the synchronous AW chat sessions and the asynchronous WKF views was the *unit of meaning*. The chats and notes were segmented into statements representing a single unit of meaning. Segmentation involved breaking the chat contribution or note into segments reflecting one of the categories in the coding scheme, according to their meaning. The length of a unit of meaning could vary from a single word ("No") to an extended paragraph, but each unit of meaning was assigned to only one of the categories from the coding scheme. The total interaction score for a chat session or a view was then the number of meaning units reflecting the different categories of the coding scheme. And this total score was the unit of analysis for subsequent analyses.

Coding of the interactions

Prior to the coding of the notes, two researchers went through a training program of about 40 hours. The training program involved the formulation of rules for the segmentation of the verbal contributions into units of meaning, the coding of these units of meaning, and learning to apply the Multiple Episode Protocol Analysis (MEPA), a computer program developed by Erkens (2001). From the synchronous interactions, a total of 176 chat contributions - or 6.7% of the total number of contributions - were randomly selected for coding by two researchers. From the asynchronous interactions, the contributions to the "Questions about Food" view and "Questions for the Venus Exhibition" view - or 75% of the total contributions - were selected for coding by two researchers. The interrater agreement was found to be 82% across the 18 interaction categories with a Cohen's (1960) Kappa of .80.

6.6 Data analysis

From the 44 chat sessions with a duration of one to two hours, 9 were selected for further verbal analysis. Chat sessions with only Italian students and thus in Italian or only Dutch students and thus in Dutch were excluded. Chat sessions involving only teachers were also excluded. From the 16 WKF views, 9 remained for analysis after application of the same selection criteria as for the chat sessions. A total of 2651 verbal interaction codes were assigned to the 9 chat sessions and the notes from the 9 WKF views. (See Appendix F for a list of all chat sessions)

In order to determine the quality of the knowledge construction process, the *cognitive* contributions were further analyzed in terms of high- versus low-level elaboration. This distinction is indirectly based on the work of Webb et al. (1998). *High-level elaboration* encompassed five categories from the cognitive dimension of our coding scheme, namely: comprehension questions asking for elaboration, answers with elaboration, presentation of new ideas with further elaboration, acceptance with further elaboration, and rejection with further elaboration. *Low-level elaboration* encompassed eight categories from the cognitive dimension of our coding scheme: factual questions, verification questions, answers only, presentation of new ideas without further elaboration, references to previously discussed ideas, summary, acceptance without further elaboration, and rejection without further elaboration. The level of elaboration was used to assess the quality of the knowledge construction process in both the synchronous chat sessions and the asynchronous WKF views. To further assess the quality of the knowledge construction process within the asynchronous WKF views, the average length of the discussion threads and the percentage build-on notes were also examined.

The differences between the synchronous chat sessions and the asynchronous WKF views were evaluated using the nonparametric Mann-Whitney rank sum test for independent samples (Siegel, 1956). A significance level of 5% was used in all of the statistical tests.

In order to examine the added value of combining a synchronous virtual environment with an asynchronous discussion forum, those sections of the synchronous chat sessions containing references to the asynchronous WKF were selected for more detailed examination. Thereafter, WKF-related chat sessions were qualitatively analyzed.

6.7 Results

6.7.1 Quantitative analysis of the verbal interactions

The collaborative activities of the students studied here resulted in: 44 chat sessions (approximately 80 hours of chat), 7 virtual houses with their cultural content and decorations, 4 houses constructed for social activities, 102 files uploaded to the Shared Directory in the WKF. In the WKF, 16 views (with a total of 159 notes) or folders were created: 5 views referring to the different cultural houses (i.e., Travel Agency, Houses of Food, Sport, Music, and Arts), 3 views for teacher reports (i.e., general teacher area, Italian teacher area, and Dutch teacher area), and 2 views for student reports. The remaining 6 views referred to specific topics: Venus exhibition, visiting other virtual worlds, building contest, photo gallery, curiosities, and Euroland in relation to the real world.

With regard to the first research question, we will start by considering how the *synchronous* interactions of the students working in a 3D virtual learning environment can be characterized in terms of cognitive, affective, and regulative contributions. The absolute frequencies and percentages for the different interaction categories are presented in Table 6.1.

Table 6.1
Frequencies and percentages for different categories of interaction in Euroland synchronous chats and asynchronous WKF views

	Synchronous chats Number of contributions (*n* = 2651)				Asynchronous WKF views Number of contributions (*n* = 162)			
	S	*M*	*SD*	*% (total)*	*S*	*M*	*SD*	*%(total)*
1. *Cognitive contributions*								
Asking factual questions	333	37.00	27.22	12.5	19	2.11	2.85	11.7
Asking comprehension questions	12	1.33	1.22	0.5	20	2.22	2.59	12.4
Asking verification questions	27	3.00	1.58	1.1	2	.22	.44	1.2
Answering without elaboration	186	20.67	19.10	7.1	15	1.67	3.20	9.3
Answering with elaboration	19	2.11	1.62	0.7	23	2.56	3.24	14.2
Accepting/rejecting without further elaboration	97	10.87	6.87	3.7	0	0	0	0
Accepting/rejecting with further elaboration	26	2.89	2.89	1.0	0	0	0	0
Providing non-elaborated information	199	22.11	20.70	7.5	3	.33	.50	1.9
Providing elaborated information	51	5.76	5.05	1.9	9	1.00	1.12	5.6
Referring to earlier information/summary	13	1.44	3.61	0.5	0	0	0	0
2. *Affective contributions*	417	46.33	23.32	15.7	12	1.33	2.24	7.4
3. *Regulative contributions*								
Planning of the task	549	61.00	21.45	20.6	10	1.11	1.69	6.2
Instruction of other student	205	22.78	12.84	7.7	4	.44	1.01	2.5
4. Greetings	478	53.11	19.75	18	45	5.00	4.06	27.8
5. Non-task-related remarks	39	4.33	5.32	1.5	0	0	0	0
Level of elaboration								
High level elaboration	108	12.00	8.51	4.1	52	5.78	4.87	32.1
Low level elaborations	855	95.00	74.99	32.3	39	4.33	5.77	24.0

for both the synchronous AW chats and asynchronous WKF views. The categories of *referring to earlier information* and *summary* were collapsed together as well as the categories of *accepting* or *rejecting ideas with further elaboration* and *accepting* or *rejecting ideas without further elaboration* due to small frequencies for the individual categories. The results with regard to the synchronous AW chats showed 36.5 % of the contributions to be of a cognitive nature. Regulative and affective contributions were less frequent with 28.3% and 15.7% of the contributions, respectively. About 18 % of the contributions was greetings and 1.5% was non-task-related remarks. The quality of the knowledge construction process in the synchronous AW chats was next considered in order to obtain an answer to the first research question. In order to do this, the contributions were analyzed with respect to high- versus low-levels of elaboration. As presented Table 6.1, most of the contributions involved low-level elaboration: 88.8% of the cognitive contributions (i.e., 32.3% of all chat contributions). Conversely, only 11.2% of the cognitive contributions (i.e., 4.1% of all chat contributions) involved high-level elaboration. Closer inspection of the categories involving a low level of elaboration showed the following categories to be most frequent: *answering without elaboration*, *providing new ideas or information without elaboration*, and *accepting/rejecting without further elaboration*. Closer inspection of the categories involving a high level of elaboration showed *asking comprehension questions, answering with elaboration,* and *accepting/rejecting with further elaboration* to each constitute no more than 1% of all chat contributions while the category *providing new ideas or information with elaboration* constituted less than 2% of all contributions.

With regard to the asynchronous communication, we will start by considering how the *asynchronous* interactions of the students working in a 3D virtual learning environment can be characterized in terms of cognitive, affective, and regulative contributions. A total of 159 notes were contributed to the WKF across the study period of eight months. During the first two months of Euroland, less than five notes were contributed to the WKF. The results presented in Table 6.1 show 56.3 % of all the contributions to the asynchronous WKF to be of a cognitive nature. Regulative and affective contributions were less frequent with 8.7% and 7.4% of the total contributions, respectively. About 27.8% of the contributions were greetings, and there were no non-task-related remarks.

In order to determine the quality of the knowledge construction process in the asynchronous WKF, two aspects of the relevant discussions were examined: (1) the percentage build-on notes and average length of the WKF discussion threads, and (2) the content of the WKF views in terms of high- versus low-level elaborations.

The WKF findings - from the 9 analyzed views - showed 52 of the 99 notes to be characterized as build-on notes (52%). There were 69 discussion threads with a length of 1 to 4 notes. Of the 69 discussion threads, 38% contained only one note - which was probably a question without an answer or the provision of an isolated bit of information without any further reaction. The mean length of the discussion threads was 1.74 (*SD* = .68), which means that not every new note received a reaction. Almost 90% of the discussion threads contained 1 or 2 notes, implying a question-answer sequence; 10% contained 2 to 4 notes; and only one thread contained 4 notes. A graphic representation of the number of turns for the WKF discussion threads is presented in Figure 6.5.

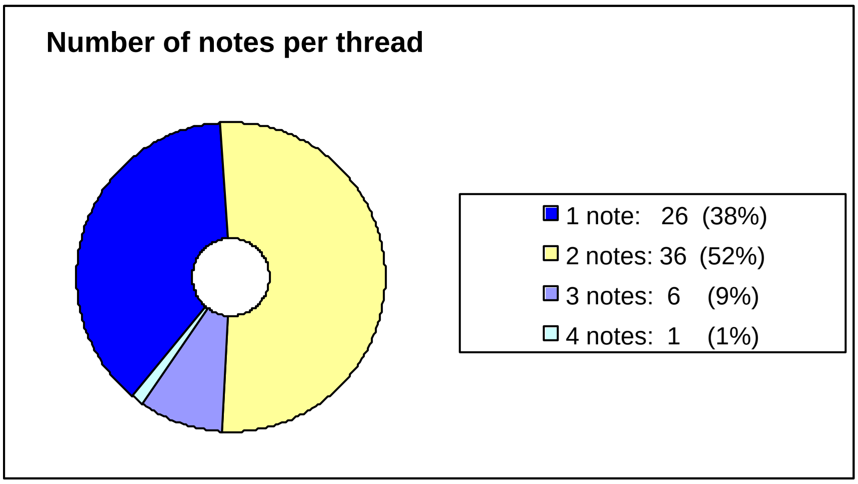

Figure 6.5
Overview of the number of notes characterizing 69 WKF discussion threads

With regard to the number of high- and low-level elaborations produced in the asynchronous WKF views, inspection of Table 6.1 shows many of the cognitive contributions to be high-level elaborations: 57.1% of the cognitive contributions (i.e., 32.1% of all contributions). Low-level elaborations occurred less frequently: 42.9% of the cognitive contributions (i.e., 24% of all contributions).

Table 6.2
Overview question–answer sequences posted within the WKF views

Type of question-answer sequence	Number	Percentage of all q-a sequences
Simple question, no answer	10	24%
Simple question, simple answer	4	10%
Simple question, complex answer	1	2%
Simple question, multiple answers	4	10%
Complex question, no answer	10	24%
Complex question, simple answer	2	5%
Complex question, complex answer	4	10%
Complex question, multiple answers	4	10%
Verification question, no answer	2	5%
Verification question, simple answer	0	0%
Verification question, complex answer	0	0%
Total questions asked	41	100%

The most frequent forms of high-level elaboration used within the WKF views were: *asking comprehension questions* and *answering with elaboration*. The most frequent low-level elaborations occurring within the WKF views were: *asking factual questions* and *answering without elaboration*. The categories *accepting/rejecting with further elaboration* and *accepting/rejecting without further elaboration* as well as the categories *referring to earlier information* and *summary* were not observed in the asynchronous WKF views.

An overview of the question-answer sequences produced in the asynchronous WKF views is displayed in Table 6.2. The results show 46% of the 41 posted questions to be simple questions, 49% to be complex questions, and 5% to be verification questions. Some 22 of the 41 questions or 54% went unanswered. Inspection of the sequence simple question-multiple answers showed 4 simple questions to receive 13 answers: 5 answers with elaboration and 8 answers without elaboration. Inspection of the sequence complex question-multiple answers showed 4 complex questions to receive 27 answers: 26 answers with elaboration and 1 answer without elaboration. Verification questions were rare, and the two that occurred went unanswered.

Table 6.3
Comparison of interaction categories for AW chats and WKF notes with Mann-Whitney test results (expected value of E(U) = 40.5, all corrected for ties)

	Sum Rank synchronous chats (n = 9)	Sum Rank asynchronous notes in views (n = 9)	Mann-Whitney U	Z
Cognitive contributions				
Asking factual questions	126	45	0.00	-3.96**
Asking comprehension questions	81	90	48.00	0.64
Asking verification questions	124	47	2.00	-4.34**
Answering without elaboration	122.5	48.5	3.50	-3.69**
Answering with elaboration	123	58	40.50	-0.05
Providing non-elaborated information	126	45	0.00	-3.61**
Providing elaborated information	112.5	58.5	13.50	-2.47*
Affective contributions				
Affective contributions	126	45	0.00	-3.65**
Regulative contributions				
Regulative activities (e.g., planning, monitoring)	126	41	0.00	-3.39**
Regulative instruction	125	43	1.00	-3.73**
Greetings	126	45	0.00	-3.95**
Level of elaboration				
Low-level elaborations	126	45	0.00	-3.71**
High-level elaborations	104	67	22.00	-1.72

* p < .05; ** p < .01

In order to answer the research question regarding possible differences between the students' interactions in synchronous versus asynchronous 3D virtual learning environments, nonparametric Mann-Whitney ranking sum tests for independent samples were applied. The categories of *accepting/rejecting without elaboration, accepting/rejecting with elaboration, referring to earlier information/summary,* and *non-task-related remarks* were not observed in the asynchronous views and therefore excluded from the analyses.

An overview of the 11 interaction categories provided in the AW chat sessions and the WKF views is presented in Table 6.3. Comparisons of the interactions in the synchronous and asynchronous environments showed statistically significant differences with regard to the *affective* and *regulative* categories, and *greetings*. Statistically significant differences were also found for the specific cognitive categories of *asking factual questions, asking verification questions*, *answering without elaboration, providing non-elaborated information*, and *providing elaborated information*. The aforementioned cognitive differences also meant significant differences in the provision of *low-level elaborations* in favor of the asynchronous WKF environment. No significant differences were found for the cognitive categories of *asking comprehensive questions* or *answering with elaboration.* Similarly, no significant differences were found between the synchronous chat sessions and asynchronous WKF notes for the provision of high-level elaborations.

6.7.2 Qualitative analysis of the verbal interactions

In order to examine the possible added value of the incorporation of an asynchronous communication tool (e.g., the WKF) into a synchronous virtual environment (e.g., AW) and thereby address our last research question, a qualitative analysis of the synchronous AW chats and asynchronous WKF notes was next undertaken.

```
Bea:        --------
3dme3[1]:   this is the Web Knowledge Forum
bea:        good. Now click on this computer screen
bea:        right, you know that?!?! Great
3dme3:      we have a lot of experience with WKF
bea:        I just added you as teacher
3dme3:      great, thanks
bea:        you can add who you want
3dme3:      can I add students?
bea:        here, there are teacher and student reports on what they did in the
            class
3dme3:      great, we will make use of that
bea:        sure you can add your students and anyone else you think is necessary
bea:        you may read some of the reports to get an idea of what the others did
bea:        and post your own report
3dme3:      I will do that
bea:        ------
```

NB. Participants: 3dme3 (teacher from Amsterdam) and Bea (tutor).

Figure 6.6
Chat excerpt in which the function of the WKF is explained (example 1)

The chats were screened for references to the asynchronous discussion forum and vice versa: that is, the WKF notes were also screened for references to the relevant chat sessions. The following two examples involving excerpts from a chat session and the related WKF notes are presented to illustrate the integration of activities from the two formats and thereby demonstrate the added value of combining different communication formats for collaborative learning purposes.

```
Author: 3dme3            #147

View: 2General Teacher Area
Creation Date:  April 14 2000 ( 0:44:14)
```

Real contacts

```
Hi Euro-friends,

We have had the pleasure to meet teachers and students from "The Hague Montessori
Lyceum" at January 10th. It was very nice to see the faces behind the nicknames. Our
students learned a lot of the "Montessorians.” Through other notes I have seen that
Euroland is running already 3 months now and there has been built a lot. The OSB has
joined later and a lot has to be done. Our systems are being replaced and Euroland
cannot be reached through the "governments provider" Kennisnet (Knowledgenet). We are
urgently searching for an alternative. We hope to be up and running soon. We are 22
students from OSB class 3dme (take a look at the pictures taken by two students of
the school in The Hague).

Like to hear from you

Regards, teacher 3dme3
```

Figure 6.7
WKF note related to chat excerpt presented in Figure 6.6 (example 1)

In Figure 6.6, a chat excerpt in which a new participant (nicknamed 3dme3) is introduced to Euroland by the tutor Bea is presented. The introduction of this newcomer is facilitated by “showing” documents in the WKF already produced by other participants. By reading the reports, the newcomer is brought up to date and can easily enter the community knowing what has been done so far by whom. When this teacher from Amsterdam connects for the first time, the tutor introduces the WKF to clarify the goals of the project and the content of the WKF. The newcomer is already familiar with the WKF program and, later in the project, the teacher indeed posts his reports on the WKF (see Figure 6.7) as promised in the AW chat (see Figure 6.6).

A second example involves a chat about an exhibition constructed by a participant who is a very skilled builder. This student, Ivo, has built and decorated an exhibition involving several paintings on the topic of “Venus.” He has invited other Eurolanders to visit his exhibition and to answer the following question: “Which one of the paintings do you think is the oldest?”

Author: Ivo Note #125

View: Questions for the Venus Exhibition
Creation Date: April 11 2000 (15:22:01)

The Oldest?

Hi Euro-friends,

Can you guess which one is the oldest Venus in this exhibition? And why do you think so?

Author: Bart Note # 145
View: Questions for the Venus Exhibition
Creation Date: April 17 2000 (12:28:03))
Builds On: The oldest?

Rubens

Hi Ivo,

We have made an excursion to your Venus exhibition and we will try to answer the questions as good as we can (we are 11 years olds from a primary school in Amsterdam)

We had a long discussion about which painting can be the oldest. We thought that very difficult because we thought that there were about 5 paintings that could be the oldest.
We made a decision on the painting of Rubens: The toilet of Venus. Why? well, basically we think because of the brown colours and the light but it could also be one of the other dark paintings.
Bartolino

NB. Participants: Ivo (student from the Hague) and Bartolino (teacher from Amsterdam)

Figure 6.8
WKF Notes with question and answer regarding the Venus Exhibition (example 2)

In the second note, a teacher from a primary school in Amsterdam, Bart, responds to Ivo's note and posts the results of his class's discussion in the WKF view "Questions for the Venus Exhibition" (Figure 6.8). Later on, Ivo and some other participants discuss the answer provided by the Amsterdam classroom in a synchronous chat, as presented in Figure 6.9.

In this chat session, the teacher from Amsterdam is astonished by the answer to the question provided by Ivo. His classroom had decided that another painting was the oldest and posted their answer on the discussion forum. Ivo knew their answer but did not want the other students to know it, as he explains in the chat: "But I want to keep them guessing". Ivo explains that the oldest painting in his exhibition is a fresco from Pompeii, destroyed in 79 AD. This example demonstrates the interplay between the discussion forum and the chat. In this chat, the teacher also finds out why Ivo did not react to the answer provided by the Amsterdam students. Due to the availability of the discussion forum to all participants, other students would now know the answer and further reflection or discussion in their classrooms would presumably come to a halt.

```
Manta:        How are you, Ivo?
Ivo:          Oh hello Manta, how are you??
Ivo:          I'm fine, I have a Venus exhibition
Ivo:          No, nr 2 is the oldest
Bartolino:    nr 2 eh, ... haven't thought for a moment about nr 2.
Bartolino:    Looks pretty new with the green colours on it
Ivo:          But it's the one, it's pre Jesustic
bea:          that is??
Ivo:          From before Jesus
Ivo:          Just made up that word
Ivo:          It's a fresco
Bartolino:    Are you kidding me.... it could easily be a modern painting
bea:          yea well ... it does look old
Ivo:          Maybe, but enlarge it and you'll see the cracks in the wall


bea:          Ivo .. you should put a note in WKF about this discovery
Ivo:          I've seen it live...
bea:          really?? where?
Ivo:          But I want to keep them guessing...
Ivo:          In Pompeii
Bartolino:    Oh I do believe you I am only astonished. haven't thought for a
              moment that this could be the oldest
 [April 19 2000]
```

NB. Participants: Manta (teacher from Milano), Ivo (student from The Hague), Bartolino (teacher from Amsterdam), and Bea (tutor).

Figure 6.9
Chat excerpt regarding oldest Venus painting question (example 2)

6.8 Discussion

The present study addresses the question of how the interactional behaviors of students collaborating synchronously and asynchronously in a 3D virtual learning environment can be characterized in terms of cognitive, affective, and regulative contributions. The question of whether differences exist in interactional behaviors of students communicating in a synchronous versus asynchronous learning environment is addressed with a focus on the process of knowledge construction. Finally, whether the introduction of an asynchronous discussion format into a synchronous 3D virtual learning environment appears to have some added value for the collaborative learning and interactions of students is explored. The focus of the present study was not on the individual learning outcomes of students but on the interactions between students participating in Euroland and the process of knowledge construction.

The first research question was how the *synchronous* and *asynchronous* interactions of students working in a 3D virtual learning environment can be characterized in terms of cognitive, affective, and regulative characteristics and the quality of the knowledge construction process. Although many of the contributions in the *synchronous* AW chat sessions were found to be of a cognitive nature, the percentage of cognitive statements is relatively small when compared to the findings of our first study in which Dutch primary school children collaborated synchronously in a chat format and cognitive statements reached a much higher percentage (see Chapter 4). The differences in the results of these two studies may be due to differences in the collaborative tasks used. The design of collaborative learning tasks can differ with respect to the kind of product that is asked for, the tools or resources that are available, and the activities that are requested (Van Boxtel, 2000). According to Cohen (1994), moreover, there is a difference between the type of interaction called for by a routine academic learning task versus a non-routine or conceptual learning task where the objective is learning for understanding or conceptual learning and the task is typically ill structured. In an ill-structured collaborative task, students often depend upon each other and must reach joint agreement in order to attain a solution. And tasks with a relatively higher need to establish common ground are likely to lead to different interaction processes than tasks with a defined solution path (Strijbos et al., 2004).

The large amount of affective statements and greetings observed in synchronous AW chats of the present study may serve important social functions, such as the activation of students to undertake certain activities in Euroland, increase motivation, and the creation of group cohesion (Lipponen et al., 2002). The regulative statements were used by the students to plan their activities, instruct other students in cases of technical problems, and help others with the construction of virtual 3D objects. Students in a CSCL environment may need to regulate not only their own learning but also the learning of their partners and a reasonable portion of the contributions observed in the present study may therefore be devoted to the general regulation of the learning process (De Jong, Kollöffel, Van der Meijden, Kleine Staarman, & Janssen, 2005). The small amount of non-task-related remarks is in line with the findings of Jonassen and Kwon (2001), who found the quality of student interactions in a computer-mediated environment to be lower than the quality of FTF interactions but more task oriented than FTF student interactions.

In the synchronous chat discussions, the frequency of high-level elaborations was found to be low, and since we defined the process of knowledge construction as the provision of high-level elaborations, the quality of the process of knowledge construction was also considered to be low. There are three possible explanations for the limited incidence of high-level elaborations. First, it is possible that students, in general, do not provide many high-level elaborations in discussions with their peers (Fuchs et al., 1999; Fuchs et al., 1994; Webb, 1989; Webb & Farivar, 1994). Support for this explanation is provided by Dutch studies of student interactions in different collaborative settings either with or without the use of computers (Kleine Staarman et al., 2005). A second possible explanation for the low frequency of high-level elaborations in the chat sessions may lie in the fact that the students had both synchronous and asynchronous communication tools at their disposal and that the students may therefore have opted for use of the asynchronous WKF for purposes of elaboration and reflection. According to Veermans and Veldhuis-Diermanse (2001), synchronous communication via a chat program tends to be fleeting with very short contributions, numerous turns, and little time for reflection. In this case, however, the students could be expected to provide a relatively larger number of high-level elaborations in the WKF views, which they did not (see below). A third possible explanation for the low incidence of high-level elaborations in the chat sessions may simply lie in the use of computers for collaboration purposes. The use of the computer influences the type of talk with extensive discussion not occurring much when working with computers (Wegerif & Mercer, 1997). All three explanations may hold in the present study.

With regard to the characteristics of the interactions of the students working in an *asynchronous* 3D virtual learning environment, the majority of the contributions in the asynchronous discussion forum were found to be of a cognitive nature, which shows the students to be "on topic" (Guzdial & Turns, 2000). This finding is in line with the results of Finnish research requiring primary school children to collaborate in a CSCL environment (Lipponen et al., 2002). Cognitive contributions in the present study were frequent while regulative and affective contributions were less frequent, which suggests that the students in general did not use the asynchronous communication format to regulate or monitor their learning. About one third of the WKF contributions were greetings: "Hi, friends from Amsterdam, how are you?". In fact, almost every WKF contribution started with a word of welcome and ended with farewell greetings. This is probably due to the intervals between the contributions in the asynchronous views and the fact that the students contributing a message did not know when the message would be read and by whom. No non-task-related remarks were observed whatsoever in the asynchronous views, which is in keeping with the findings Jonassen and Kwon (2001) mentioned with regard to the interactions of students within computer mediated environment.

The quality of the knowledge construction process within the asynchronous WKF learning environment was defined in terms of three indicators: the percentage of build-on notes and length of the WKF discussion threads, the level of elaboration contained in the notes, and the sequences of questions and answers. With regard to the first indicator, almost 50% of the notes were build-on notes. The average number of notes in a thread was found to be less than two, which is low. The participants in Euroland appeared to use the discussion forum to pose questions and answer these questions but the discussion stopped there. Only a few threads contained three or more notes, so we can conclude that the use of the discussion forum was characterized by a large amount of new topics, which were not necessarily considered from multiple perspectives or subjected to sustained discussion (Guzdial & Turns, 2000). The findings with regard to the percentage of build-on notes and the length of the discussion threads are comparable to the findings of other studies (Guzdial & Turns, 2000; Lipponen et al., 2000, 2003; Veldhuis-Diermanse, 2002). One possible explanation for this finding may lie in the participants in Euroland not being accustomed to work in a CSCL situation using the WKF. The students were indeed found to carry out their main activities -

namely, chat discussions and the construction of 3D objects - in the AW environment. Perhaps the students were not fully aware of the possibilities of the WKF discussion forum and thus its utility for elaboration and reflection purposes in particular.

The second indicator of the quality of the knowledge construction process involved the content of the notes. Most of the cognitive statements in the asynchronous WKF views were found to be high-level elaborations, discussions in which explanations were explicitly asked for, and elaborated answers were provided. The students did not react to the elaborations provided by others. In fact, the categories *accepting/rejecting with elaboration* and *without elaboration* did not occur in the asynchronous views. Asking for elaboration is essential for the advancement of collective knowledge and understanding (Van Zee, 2000). In FTF collaborative learning situations, research shows explicit instruction on the asking of questions and giving of answers can enhance the interactional behaviors and achievements of students (Dawes, Mercer, & Wegerif, 2000; King, 1994, 1999; Webb & Farivar, 1994, 1999). The importance of elaboration as a mediator of successful collaborative learning has also been demonstrated in other studies (Fuchs et al., 1998; Van Boxtel et al., 2000b).

The third indicator of the quality of the knowledge construction process concerned the characteristics of the question-answer sequences observed. The findings in our study support the relations indicated by King (1994): factual questions are generally answered with factual answers and complex questions generally elicit complex answers. King (1999) found higher-order questions to trigger elaborated explanations, which positively influenced the performance of both the provider and the recipient. The students in our study posted just as many factual questions as complex questions, and the percentage of questions that received no answer was more or less similar for both types of sequence. In other research (Lipponen, 2000) and the second study reported on in this thesis, the percentage of questions without an answer was higher than the percentages found for the Euroland data. In the aforementioned studies, the percentage of complex questions that remained unanswered was higher than the percentage of simple questions presumably because it is harder and more time-consuming to formulate an answer to a complex question than to a simple question. In Euroland, the percentage of questions without an answer was found to be the same for both simple and complex questions. Some 20% of both simple and complex questions received multiple answers, moreover. That is, a student in Euroland could post a question and receive a number of answers from students at another school or in another country. A nice example is a question concerning the Dutch national dish. When one of the Italian students asked the Dutch students "What is the Dutch national dish?", the answer "pea soup" evoked several subsequent reactions. The Italian students wanted to know what the ingredients were, the Dutch participants explained that the soup is made of peas, leeks, onions, and pork meat. And once the Italian students knew what pea soup was, they responded by placing a sign in the virtual world with the text "Can you really eat that?"

The second research question was whether significant differences existed between the interactions of the students in the synchronous versus asynchronous communication tools within the 3D virtual learning environment. As discussed earlier, the incidence of cognitive contributions was relatively low in the synchronous AW chat sessions and higher in the asynchronous WKF views. The incidence of high-level elaborations in the asynchronous WKF views was fairly low, which may be due to the fact that the students were simply not familiar with this asynchronous learning environment and needed to learn how to use the environment before they could concentrate on the learning content (Zahn, Barquero, & Schwan, 2004). The students were also confronted with an unknown learning environment and a collaborative learning task that required them to perform many different actions, such as chatting with other students in English - which was a second language for all of the participants, navigating around a virtual world, directing the movements of an avatar, constructing 3D objects, and actively processing the information provided. All of these activities could easily overburden the cognitive capacities of the participants according to cognitive load theory (Bodemer, Ploetzer, Feuerlein, & Spada, 2004). And the participants in Euroland may thus have been engaged in all kinds of new activities at the expense of elaboration upon the content.

Given the low incidence of high-level elaborations in the WKF, statistically significant differences in the provision of high-level elaborations were not detected for the synchronous versus asynchronous communication formats. Students used both the synchronous AW chat and asynchronous WKF discussion formats to occasionally ask comprehension questions and occasionally provide elaborated answers. In contrast, the students were found to use significantly more low-level cognitive, affective, and regulative statements and greetings in the synchronous chat sessions than in the WKF views. The chat sessions appeared to lend themselves to the establishment of interpersonal relationships, the acquisition of building skills, and immediate contact with others while the discussion forum appeared to be more suited for the storage of information, provision of elaborations, and reflection. These findings are in keeping with the results of a study by Schwier and Balbar (2002) who found an asynchronous communication format to allow for greater depth of discussion and reflection than a synchronous chat format, which was found to be of great value for building a sense of community.

We think that the introduction of an asynchronous discussion format into a synchronous 3D virtual learning environment had a surplus value for the collaborative interactions of the students. The two examples presented above illustrate the integration of activities from the different communication formats and thereby demonstrate the enriching effect of using a combination of communication formats. During the course of the Euroland project, moreover, the complexity of the integrated activities was found to increase. Initially, chatting was the most relevant communication tool but, later, the use of the different communication tools became more reciprocal (Ligorio, 2001). The task of constructing several cultural houses required collaboration between the different partners and therefore mutual dependence, which indeed triggered considerable discussion in both communication formats. Ideas and suggestions coming from the chat sessions and discussion forum also found there way into the construction of various objects in the 3D world. The materials and information stored on the WKF could be read and re-read by the participants who could then reflect upon the information, discuss the information, and elaborate upon the information as described in the Venus exhibition example. The two communication formats with their own unique characteristics proved complementary: the synchronous chat with its short contributions, numerous turns, and little time for reflection was complemented by the asynchronous discussion forum with its capacity to store information, as a contrast to the immediateness of the synchronous chat. In our opinion, the complementary nature of the different communication formats demonstrates the added value of the introduction of an asynchronous discussion format into a synchronous 3D virtual learning environment.

In further interpreting the results of the present study, a number of possible methodological limitations should be kept in mind. To start with, the participants in the Euroland project consisted of a very diverse group of individuals from Italy and the Netherlands. The number of participants varied from two to eight per classroom. The groups from the different classrooms were not composed in the same manner, and there were also individual participants without any classroom activities to accompany their participation, thus. Furthermore, the collaborative task was carried out with respect to a number of very different domains including music, English, art, and social studies. Second, the language used in Euroland was English, which was a second language for all of the participants. While chatting, the teachers sometimes helped the students formulate their contributions, which clearly influenced the quality of the discussions in both the AW chats and WKF discussion forum. Considerable variety was also observed in the language skills of the Italian and Dutch students and teachers. Third, learning outcomes were not examined, which means that no conclusions can be drawn with regard to just how much the students learned from their participation in Euroland. As already noted, the focus of the present study was not on learning outcomes but on the knowledge construction process itself while participating in a 3D virtual world. Fourth, the collaborative task was very complex and long term, which made it hard to accomplish without the support of a research team. In a subsequent study, we therefore employed a briefer collaborative task (Van der Meijden et al., 2002). Fifth, a team of researchers provided technical guidance and tutoring within the context of the present study and thus participated actively in Euroland. The need for guidance and tutoring by experts was determined on the basis of the novelty and complexity of the project (Ligorio, 2001). In the future, however, greater attention should be paid to just how the teachers themselves can best be helped to work effectively with students in a 3D collaborative learning environment. A final possible limitation on the present study concerns the computer skills of the different participants and the varying features of the classroom contexts. The computer skills of the participants varied widely, and very different classroom activities were often undertaken on the behalf of the Euroland project. Obviously, such background variation may have influenced the virtual building activities and interactions of the Euroland participants. In other words, the present results hold for only the Euroland project and cannot as yet be generalized to other 3D virtual learning environments or CSCL tasks.

The results of the present study show the embedding of an asynchronous communication tool within a synchronous 3D learning environment to promote collaborative knowledge construction. The students working in a 3D virtual learning environment were found to provide both high- and low-level cognitive elaborations. The results also suggest that additional measures should be taken to enhance the quality of the interactions that occur within virtual learning environments. The students in the present study were not explicitly trained on the provision of elaborated explanations, for example, while research shows such training to be very effective. Students working in a virtual learning environment should also therefore be explicitly taught to pose comprehension questions and provide elaborated answers in order to discuss effectively. Once students are trained on how to interact more effectively online, the use of high-level elaborations may be more apparent than in the present study. Computer skills for the navigation and use of a 3D virtual environment were also not explicitly trained within the context of the present study. Nevertheless, such computer training may similarly promote more effective collaborative learning. And although CSCL environments have been found to promote the process of knowledge construction, such technology alone is not sufficient to promote the *active, self-regulated, constructive, cumulative,* and *goal-oriented* learning that occurs during social interaction. In the present study, the interactional behaviors of students collaborating within a virtual learning environment utilizing both synchronous and asynchronous communication formats were examined and found to be very productive. Additional research is nevertheless needed to examine the exact roles of the different communication formats in the knowledge construction process.

Chapter 7
Conclusions and discussion

7.1 Introduction

In the present thesis, the process of knowledge construction via CSCL was examined. In three studies, the following research question was addressed: *Does CSCL elicit knowledge construction in the form of elaborations?* Knowledge construction was viewed from a cognitive elaboration approach in which it is assumed that interaction with others can lead to the active processing of information by individuals and thereby modification of cognitive structures (Van Boxtel, 2000). Knowledge construction was operationalized as the provision of elaborations such as the posing of comprehension questions requiring explanations, the supply of answers with arguments or justification, the presentation of new ideas accompanied by explanations, and the acceptance or rejection of ideas coming from others accompanied by arguments for doing this.

The focus of the present research was on the quality of the student interactions that occurred *during* their collaborations and not on the actual learning outcomes themselves because we wanted to know more about those processes that lead to the provision of elaborations by students working in a CSCL environment and CSCL as a vehicle for knowledge construction. When working in a CSCL environment, students must verbalize their thoughts, ideas, and reactions to other students. Such verbalization can prompt elaborated cognitive processing and thereby the construction of knowledge (Van Boxtel, 2000). Several studies in face-to-face (FTF) learning situations have indeed shown elaborative talk to contribute to the use of more elaborate conceptions in subsequent situations (Webb & Farivar, 1994, 1999; King 1994, 1999). The quality of elaborated responses has also been shown to be associated with achievement while simply the provision of the correct answer to a question without further elaboration has not (Webb, 1989, 1991). The benefits of elaboration have thus been examined in various collaborative contexts but never within a CSCL environment.

The interactions of students working in a CSCL environment was examined within three educational settings: (1) a setting with a synchronous communication (chat) format, (2) a setting with an asynchronous communication (discussion forum) format, and (3) a setting with a combination of both synchronous (chat) and asynchronous communication (discussion forum) formats. All of the studies were conducted in Dutch primary or high schools, and the communication was realized via the internet. All of the studies were conducted in authentic school learning environments using the electronic facilities provided by the school and not an laboratory setting.

In this chapter, a summary and general discussion of the results of the three studies will first be presented. The most interesting aspects of the interactions of the students working in the different learning environments will be considered in sections 7.2 and 7.3. Second, some major theoretical and methodological issues will be addressed in sections 7.4 and 7.5. The means available to us to improve the process of knowledge construction at different levels and the utility of the coding scheme developed here will be considered, for example. Third, implications for educational practice and recommendations for future research will be pointed out in sections 7.6 and 7.7, respectively. And finally, some new questions generated by the results of this thesis will be raised for further reflection in section 7.8.

7.2 Interpretation of the results of the three empirical studies

Section 7.2 highlights the most interesting results and conclusions with regard to the interactional behavior of the students in the three studies separately. The findings will also be considered in the context of related studies and will be discussed from a broader perspective. In section 7.3 the results of the three studies will be connected and the five main interaction categories will be considered from an overall view. Special attention is paid to the structure of the task and the role of the teacher within the three settings.

7.2.1 Student elaborations in a synchronous computer-supported collaborative learning environment

In the first study, the interactions of Dutch primary school students working collaboratively on a mathematics task were examined in terms of the provision of high- and low-level cognitive elaborations, regulative and affective contributions, and task performance. The students worked in two different collaborative settings. In the one setting, the students worked FTF; in the other setting, the students worked at a distance and communicated via a synchronous chat computer program.

Cognitive interactions

In both settings, more than 50% of all the contributions to the interaction could be classified as cognitive but involving mainly low-level elaborations. In the FTF condition, the percentage of the contributions involving cognitive elaboration actually reached 70%. There was a positive relation between the provision of high-level elaborations and the performance scores for all of the dyads (CSCL and FTF dyads combined). That is, if dyads produced more elaborations, they also tended to achieve higher on the mathematics task. This finding supports the results of other research for students working in FTF collaborative settings (King 1994, 1999; Webb & Farivar, 1994, 1999; Webb, 1989, 1991). Due perhaps to the small number of dyads producing many high-level elaborations in general, statistically significant differences between the dyads working in the different settings could not be detected.

Regulative interactions

The dyads in the CSCL environment provided about three times as many regulative contributions as the dyads working in the FTF setting. As illustrated in the transcribed interaction excerpts, the students working in the CSCL environment had to devote time to specification of which mathematics problem was currently being handled or going to be handled next. The fact that the students working in the CSCL environment could not see each other, for example, made such questions as "Are we doing problem nine right now?" necessary for successful completion of the task. Furthermore, the members of the dyads were dependent on each other for successful completion of the mathematics problems and therefore had to carefully coordinate their collaboration in order to reach agreement on the answers (Erkens, Jaspers, Prangsma, & Kanselaar, 2005). These kinds of regulative interactions probably influenced the amount and quality of the cognitive interactions (see also Lockhorst, 2004). Although the CSCL environment did not stimulate the provision of more high-level elaborations, in sum, it did stimulate more explicit regulation of the students' collaborative learning.

Affective interactions

In both the FTF learning environment and the CSCL environment, virtually no affective interactions were observed. This was probably due to the restricted amount of time allotted for completion of the task and the fact that the students did not need to know each other better for the conduct of this single task (see section 7.3.1 further below). This finding is supported by the results of a study by Van der Meij, de Vries, Boersma, Pieters, and Wegerif (2005) on the CSCL interactions of Dutch primary school students. The incidence of affective utterances was found to increase over time, which suggests that the growth of a social bond between interaction partners and efforts to realize such a bond take time (Van der Meij et al., 2005). As the CSCL dyads produced more affective contributions than the FTF dyads in this study, it appears that the students working in the CSCL environment tried to compensate for the lack of social presence with the production of affective interactions (see Chapter 3).

Computer skills

One possible explanation for why the interactive contributions of the students working in the CSCL environment in particular consisted of mainly low-level as opposed to high-level elaborations may lie in part in the fact that the students were actually involved in a dual task. The computer and typing skills of the students working in the CSCL environment were found to play a prominent role in their performance scores. That is, those dyads involving students with high-level computer skills achieved higher performance scores than those dyads involving students with low-level computer skills. The differences in the performance scores for those students with high- versus low-level computer skills may be due to the fact that the students with low-level computer skills had to attend to two different sets of skills, namely those skills needed to solve the mathematics problems and those skills needed to type and use the computer. Such a dual task can easily overburden the capacities of young students according to cognitive load theory (Bodemer et al., 2004), and attention to the content of the mathematics task may decrease as greater attention is required for the typing task itself (Wegerif & Mercer, 1997). Students with high-level computer skills can focus on the problem-solving process. The finding that the computer skills of the students working in a CSCL environment affected their performance is in line with the results of research by Lockhorst (2004) who found university students with fewer computer skills to need more time to get accustomed to a CSCL environment. Those university students with fewer computer skills also experienced greater technical problems, which resulted in less participation in the CSCL environment and less interaction. In sum, a lack of basic computer skills may hinder the process of knowledge construction within a CSCL environment and thereby undo the positive effects of educational technologies at times.

Ability level

The dyads within the first study reported on in this thesis were composed according to the mathematics ability of the students. Both the low/medium-ability dyads and the medium/high-ability dyads in the FTF setting were found to produce more high-level elaborations than their counterparts in the CSCL environment. Within the FTF setting, the medium/high-ability dyads provided significantly more high-level elaborations than the low/medium-ability dyads. Within the CSCL environment, however, the different ability level dyads did not differ significantly with regard to the provision of high-level elaborations, which was probably due to the small number of high-level elaborations produced in this setting in general. The findings within the FTF setting are in keeping with the findings of previous research (Fuchs et al., 1996) showing high-ability students to be more capable of constructing high-level elaborations than low-ability students. The high-ability students were also found to participate more in the relevant verbal interactions, provide more elaborations in general, provide more high-level elaborations in particular, and achieve better than the low-ability students in the aforementioned study. However, only the data from the FTF setting within the present study support the foregoing observations. That is, the CSCL environment appeared to negatively affect the role of the high ability students examined in our first study.

Conclusions

With respect to the process of knowledge construction in the form of the provision of high-level elaborations while collaborating with other students to solve a mathematics task, the FTF setting was found to generally constitute a better learning environment than the CSCL setting. However, the synchronous CSCL environment was found to stimulate more explicit regulation of the collaborative learning process and more affective contributions to the interaction than the FTF environment. The computer skills of the students working in the dual-task CSCL environment were also found to influence their provision of high-level elaborations. When a lack of basic computer skills is controlled for, however, it is possible that a more even balance for the provision of high-level elaborations across the FTF and CSCL settings may be found or even a slight advantage for students working in a CSCL environment. Only future research will say.

7.2.2 Student elaborations in an asynchronous computer-supported learning environment

Given the findings of the first study, we next wanted to gain greater insight into factors that appear to further affect the knowledge construction process among students working in a CSCL environment. We were also curious as to whether the collaborative learning results in an asynchronous environment - where there is more time to think before interacting - would resemble the results in a synchronous learning environment or not. In the second study reported on here, therefore, we examined the interactions of Dutch high school students collaborating in an asynchronous CSCL environment with respect to the number and nature of cognitive, regulative, and affective contributions and the influences of gender group composition, group size, student ability, and the subject of the task on the provision of elaborations. The students were recruited from two different types of Dutch secondary schools, namely pre-university level (*VWO*) schools and senior secondary education level (*HAVO*) schools. The collaborative groups involved two, three, or four students and included both single gender (i.e., all male or all female) and mixed gender groups. The students collaborated in a discussion forum called the Web Knowledge Forum (WKF) for such different subject areas as science and social studies.

The participation of the students in the discussion forum was analyzed in terms of not only who participated with whom (i.e., the broadness of participation) and the extent of the participation (i.e., sustained discussion) but also in terms of whether the students discussed the subjects to be studied or not (i.e., “on-topic" discussion). Participation in the CSCL discussion forum was broad based, which means that all of the collaborative groups contributed to the discussion and the discussions were not dominated by a small number of groups. There were no requirements with regard to the number of notes to be contributed by the students on a weekly basis, but students were asked to read the notes of others and react to these. This structure may have stimulated students to contribute notes (Lockhorst, 2004) as the production of notes was found to be relatively high when compared to the findings of other studies (Guzdial & Turns, 2000; Hara et al., 2000; Hsi, 1997; Lehtinen et al., 2000).

Cognitive interactions

More than 50% of the students' contributions were found to be cognitive in nature, and most of the cognitive contributions were found to involve high-level elaborations (i.e., the provision of new ideas with further elaboration, the asking of comprehension questions eliciting elaborated answers, and the provision of answers with elaboration). This was an important finding, and the percentages are in line with the findings of both Lipponen et al. (2002) and Lockhorst (2004). However, the percentages are not in line with the findings of Veldhuis-Diermanse (2002) and Schellens and Valcke (in press) who reported even higher percentages of cognitive contributions. For further discussion of the results, see section 7.3.1 below. Suffice it to say that the asynchronous discussion forum appears to be "explanation oriented" and therefore promising for the promotion of knowledge construction (Lipponen, 2000). The students in the second study clearly reflected upon the notes of others, asked for explanations, and provided elaborated information.

G*ender group composition* influenced the provision of elaborations. Mixed-gender groups generally produced more high-level and low-level elaborations than single-gender groups. That is, mixed-gender groups were not found to be at a disadvantage relative to single-gender groups, which is in contrast to the results of other research involving students working collaboratively on a computer task (Underwood et al., 1990,1994).

Group size was found to influence the provision of high-level elaborations. Dyads generally produced more high-level and low-level elaborations when compared to the threesomes and foursomes, which is in line with the results of a meta-analysis by Lou et al. (2001). The differences may be due to the fact that group communication can be bilateral or multilateral while dyadic communication is always bilateral (Fuchs et al., 2000). The dyads were also found to stay more "on topic" than the threesomes and foursomes who provided more affective and regulative contributions than the dyads

S*tudent ability* also influenced the provision of high-level elaborations. The high-ability *VWO* groups produced more elaborations than the low-ability *HAVO* groups who devoted more time to the social interaction itself, produced more affective contributions, and entered more non-task-related remarks. In research by Fuchs et al. (1996) and King (1989), a relation was already demonstrated between student ability and the quality of the elaborations provided in collaborative settings without the support of computers. The present study demonstrates a positive relation between student ability and the provision of high-level elaborations in a CSCL environment.

Furthermore*, subject area* or the topic of the collaborative task also influenced the provision of elaborations with clear differences in the provision of high- versus low-level elaborations for science versus social science subjects. The social science subjects elicited more high-level elaborations. Apparently, discussion of a science phenomenon such as gravity elicits a different kind of interaction than discussion of a such a social science topic as racism.

Regulative interactions

The regulative contributions that we observed concerned the planning of the collaborative learning activities as it was the first time that the students had worked with the WKF program. Previously established guidelines (see Appendix D) provided information on what the students should do, and this pre-imposed structure may account for the small number of regulative interactions found to be necessary (Lockhorst, 2004). The threesomes and foursomes produced more regulative contributions than the dyads presumably because the students in the threesome and foursomes had to manage different sources of information and different opinions, which increased coordination and group management efforts (Strijbos et al., 2004).

Affective interactions

The affective contributions served a social function and were found to indicate active participation and group cohesion as in other studies (Lipponen et al., 2002; Lockhorst, 2004). A remarkable finding was that the girls-only groups used significantly more greetings than the mixed-gender groups, but not significantly more than the boys-only groups. Although Herring (2000) has argued that female talk tends to be more focused on social issues and tends to be more polite than male talk, the boys in the boys-only groups also appeared to be very polite as indicated by the high number of greetings produced by them. However, the affective contributions of the boys and girls participating in the present study were clearly affected by the presence of the opposite sex.

Build-on notes

To gain greater insight into the knowledge construction process itself, the discussion threads and questions posed within these discussion threads were analyzed. The percentage of the notes that were build-on notes was relatively low when compared to the findings of Veldhuis-Diermanse (2002) and Lipponen et al. (2003). The average number of notes within a discussion thread was only a little more than two (i.e., a question followed by a reaction), which suggests that the discussions within the WKF were not very tightly connected and that the subjects to be studied were typically not considered from multiple perspectives (Guzdial & Turns, 2000). Exploration of multiple perspectives and development of a shared understanding are apparently difficult to realize within a CSCL environment. Furthermore, the high school students participating in the present study may have encountered difficulties expressing themselves in a written form, which may have influenced the depth of the discussions they pursued (Lipponen, 2000).

Question-answer sequences

With regard to the question-answer sequences, most of the questions could be regarded as complex questions requiring explanations or elaborations. The large number of complex questions responded to with a complex answer accounted for the high percentage of high-level elaborations provided in the WKF. This is an important finding and in keeping with the findings of King (1994) who demonstrated a relation between the types of questions posed and the answers provided during collaborative FTF tasks with higher order questions in particular eliciting higher order answers. The results of our second study demonstrate a similar relation between the types of questions posed and the answers provided within a CSCL environment. However, almost half of the complex questions went unanswered, and a possible explanation for this may lie in the fact that it is easier and less time consuming to formulate an answer to a simple question than to a complex question (Lipponen, 2000). Another possible explanation for the lack of response to the complex questions posed at times may lie in the fact that the students simply did not read all of the contributions within a discussion thread or re-read certain contributions and thereby see that the posed question was not answered. An online intervention from the teacher to direct attention to unanswered questions might have stimulated the students to respond and thereby enhanced the quality of the knowledge construction process. Research by Veldhuis-Diermanse (2002) has indeed shown moderation of a CSCL environment by a teacher to increase the number of cognitive learning activities and the quality of the knowledge constructed.

Conclusions

Collaboration in an asynchronous learning environment was found to elicit the provision of numerous high-level elaborations. Considerable affective contributions were also found to be produced. The larger the group and the lower the ability level of the students, moreover, the greater the number of affective contributions. Finally, group size, student ability level, and the topic of the task (i.e., academic subject area) were also found to influence the provision of high-level elaborations.

7.2.3 Student elaborations in a three-dimensional synchronous and asynchronous learning environment

Looking back upon the results of studies one and two, differences in the interactions within the synchronous and asynchronous CSCL environments were observed. The designs of the studies and the ages of the participants were quite different, however. In order to determine whether actual differences exist between the use of synchronous and asynchronous communication formats, on the one hand, and whether the use of both formats has any surplus value for knowledge construction purposes, on the other hand, a third study was undertaken. This study examined the interactions of Italian and Dutch primary and secondary school students collaborating synchronously and asynchronously within a three-dimensional virtual learning environment called "Euroland". The learning occurring within this particular CSCL setting can be construed as an example of so-called "blended learning" because different forms of FTF communication and various electronic communication tools are combined (see Chapter 6). Both Veldhuis-Diermanse (2002) and Lockhorst (2004) have recently pointed out the need to incorporate FTF meetings into CSCL tasks as students report feeling more compelled to participate in the CSCL system when they actually have to meet and work with fellow students in real life. The FTF meetings, however, must be clearly complementary to the CSCL task and mostly aimed at team building as opposed to substantive matters in order not to disturb the online discussion (Lockhorst, 2004).

Cognitive interactions

The interactions produced using the two communication formats - namely, the synchronous chat and asynchronous discussion forum - were analyzed. About one third of the contributions to the *synchronous* chat sessions was of a cognitive nature, and the number of high-level elaborations provided by the participants was about 5% higher than in the first study but still quite low relative to the FTF interactions in the first study or the asynchronous interactions in the second study. There are three possible explanations for the absence of numerous high-level elaborations within the chat format. First, it is possible that collaborating students do not provide high-level elaborations automatically (Fuchs et al., 1994, 1999, Webb, 1989; Webb & Farivar, 1994; Staarman et al., 2005). Second, the students in our third study had both synchronous and asynchronous communication formats at their disposal and may have opted to use the asynchronous format for matters requiring deeper reflection and/or more careful formulation. However, participants would than have provided a larger number of high-level elaborations within the discussion forum as was the case now. A third possible explanation for the relatively low provision of high-level elaborations when using the synchronous chat communication format may simply stem from the use of the computer for direct (i.e., synchronous) communication. The participants may be more concerned with the typing of their contributions than content matters and certainly the provision of high-level elaborations (Wegerif, 1997). All three explanations may hold for the findings of the third study. Yet another factor may have influenced the nature of the communication within the synchronous chat format in our third study and that was the enthusiasm of the students to undertake the joint creation of something within a 3D environment. The students quickly searched for the information and materials needed to construct objects. They chatted and constructed 3D objects at the same time, which left little time for extended reflection or the typing of long sentences in the chat window.

More than 50% of the contributions to the *asynchronous* discussion forum was of a cognitive nature and found to involve mainly high-level elaborations (i.e., complex or comprehension questions requiring answers with elaboration). The participants used the *asynchronous* communication format to pose complex questions, which gave the other participants time to reflect and discuss. On many occasions, the answers were not formulated by a single participant but collaboratively by a number of the group members. And on other occasions, the answer actually reflected the outcome of a classroom discussion.

Regulative interactions

The students provided significantly more regulative contributions in the synchronous chat sessions than in the asynchronous discussion forum. The regulative contributions concerned the planning of the collaborative activities, the instruction of other students with respect to technical difficulties, and the helping of others with the construction of 3D virtual objects. The finding of relatively fewer regulative contributions in the asynchronous environment suggests that the students did not use the asynchronous communication format to regulate or monitor the collaborative learning process.

Affective interactions and greetings

The large number of affective statements produced in the synchronous chat format can be seen to serve important social functions including the activation of students to undertake certain activities in Euroland, the increase of motivation, and the creation of cohesion. The students got to know each other and developed an interest in each other. About one third of the asynchronous WKF contributions were greetings. In fact, almost every WKF contribution started with a word of welcome and ended with farewell greetings. This was probably due to the relatively longer interval between the contributions to the asynchronous WKF and the fact that the students contributing a message did not know when the message would be read by someone or by whom.

Build-on notes

As in the second study, the quality of the knowledge construction process within the *asynchronous* discussion forum was examined in terms of the percentage build-on notes and the average length of the discussion threads. About 50% of the notes was found to be build-on notes, which is more than in the second study and comparable to the findings of Lipponen et al. (2003). However, the average number of notes in a discussion thread was found to be less than two; only one thread contained more than four notes; and it can therefore be concluded that the quality of the knowledge construction process was not very high. In the terms of Guzdial and Turns (2000), the discussion was not very sustained and the topics were not considered from multiple perspectives.

Question-answer sequences

The number of complex versus factual questions was found to be about the same. The percentages of the complex versus simple questions that did not receive an answer were also about equal. In the second study and in other research (Lipponen, 2000), the percentages of questions without an answer were higher than the percentages found here, which is an important finding. One possible explanation for this finding is the presence of an online "forum moderator" (i.e., teacher) who sometimes referred to the asynchronous discussion forum during the chat sessions in the third study here and posed such questions as "Did you answer the question of the Dutch student about the Venus exhibition?" This type of moderation has been shown to exert a positive influence on the cognitive interactions that occur in online discussions (Veldhuis-Diermanse, 2002).

Conclusions

We can conclude that large differences exist in the interactions that occur using synchronous chat versus asynchronous discussion formats to communicate for collaborative learning purposes. Asynchronous communication was associated with the provision of high-level elaborations while synchronous communication was associated with the provision of low-level elaborations and regulative and affective contributions. We can also conclude that the different communication formats do not interfere with each other but, rather, complement each other. The synchronous chat format involved frequent short contributions, little time for reflection, and considerable social talk (i.e., affective interactions and greetings). Low-level elaborations also occurred using the synchronous chat format and mostly concerned the building activities themselves. The asynchronous WKF communication format, in contrast, was used for more reflective interaction. Complex questions were posed, and the participants were found to take time to reflect upon the questions and discuss them before they provided an answer using this communication format. In contrast to the fleeting character of the chat format, where information literally disappears from the screen, information is stored permanently on the WKF and thus available for later reading and re-reading. Finally, we can conclude that the combination of synchronous chat and asynchronous WKF communication formats appears to have some surplus value when used within a collaborative learning environment. The synchronous format supports the necessary interactions needed to collaboratively complete a task while the asynchronous format stimulates cognitive elaboration on the relevant learning material.

7.3 Interpretation of the overall results

The results of the three studies reported on here show CSCL environments to provide important opportunities for knowledge construction. First, CSCL environments offer all kinds of opportunities for the exchange of information, transfer of ideas, and provision of explanations, in sum for all kind of verbalizations. In all of the studies reported on here, a substantial number of cognitive contributions was found to occur. Second, CSCL environments provide a place for the storage of information and thereby opportunities for later consideration of the archived information.[7] Third, CSCL environments provide access to information from the "outside world," which may increase the authenticity of the learning process and relevance of the information to be learned (Lockhorst, 2004).

Only a general comparison across the three studies is possible due to large differences in the characteristics of the tasks used (i.e., task duration, task structure, topics to be studied), types of schools involved (i.e., primary versus high schools, Dutch versus Italian schools), and types of learning environments considered (i.e., 2D versus 3D, synchronous versus asynchronous or both communication formats). Furthermore, substantial differences in the participants existed with regard to age (i.e., anywhere from 10 to 17 years), language skills, and computer skills. No data were collected on the personal characteristics of the participating students. Individual students do not always have equal opportunities for involvement in group work. Extroverted, dominant, outgoing, and energetic students are more likely to be the most active and influential members of the group. Furthermore, no information was collected on the learning goals of the individual students or their intentions to seek help; that is, certain students may have been afraid to ask questions even when they did not understand or agree with the group (Nelson-Le Gall, 1992). The level of prior knowledge on the part of the participants was also not measured even though this may have influenced the question-asking behavior of the students (Van der Meij, 1990).

7.3.1 Student interactions across the studies

Cognitive interactions

In almost all of the CSCL settings considered here, the majority of the contributions could be classified as cognitive, which shows the CSCL environments to stimulate the exchange of substantive information for completion of the collaborative task. When the two computer–mediated communication formats are both available for use, the asynchronous communication format is found to stimulate more cognitive interactions relative to the synchronous communication format. A larger number of high-level elaborations is also provided within the asynchronous environments as opposed to the synchronous environments. The percentages of cognitive contributions made by the primary and high school students studied here were lower than the percentages observed for university students (Veldhuis-Diermanse, 2002; Schellens & Valcke, in press). Age may play a role in this difference along with student ability and computer skills. In the studies by Veldhuis-Diermanse (2002) and Schellens and Valcke (in press), moreover, FTF meetings were also organized to enhance online interaction between the participants and teachers moderated the online discussions. In the study by Schellens and Valcke, the students also had to follow a number of strict rules (e.g., post at least two

[7] An exception was the first study, where no information was stored

contributions a week), evaluation was based upon participation, and the teacher intervened at least once a week.

As stated in section 7.2, the *asynchronous* discussion forum was used by the participants in our studies to provide extensive information and to request explanations, offer time to reflect, and discuss an answer prior to its actual posting. Our findings thus support a relation between questions and answers within a CSCL environment. The *synchronous* chat was used for social talk, simple questions, and quick reactions - which is in line with the fleeting character of the synchronous communication format (Veerman & Veldhuis-Diermanse, 2001). In the synchronous learning environment, very few questions requiring explanations were posed and very few answers including explanations or justifications were thus provided.

Research on FTF collaboration has shown academic discussions among peers to typically not include many elaborations (Fuchs et al., 1994, 1999; Webb, 1989; Webb & Farivar, 1994). In most research, the knowledge constructed by students within a CSCL environment has also been found to not be of a very deep level (Guzdial & Turns, 2000; Lipponen et al., 2002, 2003; Schellens & Valcke, in press; Veldhuis-Diermanse, 2002). Explicit training to improve the collaborative interactions between students working in both FTF and CSCL settings has been shown to be effective (Cohen, 1994; Fuchs et al., 2001; Webb & Farivar, 1994, 1999; Wegerif, Mercer & Dawes, 1999b). Based on the findings of the present research, we also think that explicit instruction on how to interact most effectively and productively could improve the quality of the interactions between students working in a CSCL environment. If students learn how to pose comprehension questions, probe for relations, and ask for explanations, the provision of high-level elaborations may automatically increase. Students can be taught to explain how the solution to a problem can be reached and to not provide the immediate solution to a problem. The results of other research studies also stress the need to structure small group learning and train such discourse features as help seeking, help giving, the provision of reasons, and exploratory talk (Dawes, Mercer, & Wegerif, 2000; King, 1994, 1999; Webb & Farivar, 1994, 1999). Further research is nevertheless needed to demonstrate the effectiveness of explicit training on how to interact most effectively in CSCL environments.

Regulative interactions

The students collaborating in a synchronous CSCL setting provided far more regulative contributions than the students collaborating in an asynchronous CSCL setting or FTF setting. Working in a synchronous learning environment apparently requires considerable attention to the regulation (i.e., planning and monitoring) of not only one's own learning process but also that of the other participants (i.e., instruction of other students and regulation of the collaboration). When students collaborate at a distance, greater effort appears necessary to establish common ground or a common frame of reference (Erkens et al., 2005). The students working in the 3D virtual environment in the third study, for example, had to agree on the form of virtual objects prior to their actual construction, which resulted in a greater number of regulative activities. The regulative process appears to be quite similar across various contexts, but the exact nature of the regulation may vary for individual versus collaborative context (i.e., the specific context, specific task goals, and social aspects of the learning environment) (De Jong et al., 2005).

Affective interactions

In all three studies, the number of affective contributions was found to be low. In the first study, affective contributions were rare. The FTF dyads did not exchange personal information as they were classmates and already knew each other quite well. The CSCL dyads chatting at a distance knew that they had to collaborate only once with this partner. And in both cases, the interactions were aimed at the very concrete solution of mathematics problems. In both the second and third studies, the percentage of affective contributions was higher than in the first study. One possible explanation for this discrepancy may be the longer duration of the tasks to be performed in the second and third studies. When students collaborate for a longer period of time, they get to know each other better and want to know more about each other (Gillies & Ashman, 1998; Van der Meij et al., 2005)

Greetings

The number of *greetings* appeared to increase with task duration. The mathematics task in the first study had to be completed within a single session, which more or less obliterated the need for greetings. In the other two studies, the duration of the task was much longer and the number of greetings much greater. In the second study, the students worked within the CSCL environment for weeks. In the third study, they worked within the CSCL environment for months. Task duration thus might be a factor to be explored in future research on the stimulation of successful collaboration within a CSCL environment.

Non-task related remarks

The percentage of *non-task related remarks* across the three studies proved very low. The students discussed mostly substantive matters as indicated by the substantial number of cognitive contributions across the different studies. This is an important finding and in keeping with the results of Jonassen and Kwonn (2001) who also found the interactions within a CSCL environment to be largely task oriented. CSCL settings as well as FTF collaborative settings thus appear to motivate students to stay on topic (Slavin, 1995).

Conclusions

Overall we can conclude that the process of knowledge construction is fostered by having students work in a CSCL environment. The students studied here were found to be very task oriented and rarely distracted. Our findings further show an asynchronous environment to be the best environment for a deeper mastery of the concepts and material to be learned. If, in contrast, social interaction is the learning objective, a synchronous environment appears to be most suited although a sufficiently long task duration might occur for such social interactions to emerge. The results of our research also showed the students collaborating in a CSCL environment to work best in dyads as opposed to larger groups. Group composition in terms of sex and student ability also influenced the nature of the collaborative interactions.

7.3.2 The collaborative task

The collaborative tasks used in the three studies reported on here differed in terms of - among other things - task duration, degree of structure (i.e., well-structured versus ill-structured tasks), and subject area (i.e., topic to be studied). With regard to the duration of the tasks used within the three studies, the range was from less than one hour to eight months. The possible influence of the duration of the task on the interactions of the students has already been discussed (see section 7.3.1 above). Van Boxtel (2000) has further shown several other task characteristics to influence the interactions of students working collaboratively such as the degree of task structure.

The structure of the tasks used in the three studies greatly differed. A mathematics task developed to promote logical reasoning (Ros, 1994) was used with the sixth grade students in the first study. The task had a detailed "pre-imposed structure", which means that all parts of the task, the learning goals, the nature of the participation, and the type of interaction were described (Lockhorst, 2004). The students had less than one hour to solve 15 balance-beam problems, and most of the problems had only one right answer. Collaboration was required, and the students had to discuss the solutions with each other before writing them down on paper (FTF setting) or typing them into the chat program on the computer (CSCL setting). In fact, there was little room for extensive discussion of the solutions. In the second and third studies, in contrast, the tasks were more complex and ill structured. The task in the second study had a moderate pre-imposed structure. The time available for the task was about six weeks, and the students set the learning goals for the topics to be studied themselves. The task guidelines (see Appendix D) provided general information on the steps to be taken. The task in the third study had virtually no pre-imposed structure. The time available was almost an entire school year, and only some very global guidelines were provided at the beginning of the task. All of the plans, proposals, and decisions regarding the 3D objects and their location in the virtual world were made by the students themselves. The students created their own virtual world on the basis of their own shared goals and desires.

The differing degrees of structure associated with the tasks in the three studies probably affected the interactions of the students. Tasks with ill-structured solutions require more intensive group interaction than tasks with well-structured solutions simply because no student has all of the knowledge necessary to solve a task with an ill-structured solution and other students are therefore needed to complete such a task (Cohen, 1994; Webb & Farivar, 1994). Students must also have opportunities to discuss solutions available to them. As the results of the first study show, problems with only one right answer do not elicit many elaborative discussions. And in keeping with this, Schellens and Valcke (in press) have pleaded for a careful balance between a very rigid pre-imposed structure and a very loose pre-imposed structure. The results of their research show a clearly pre-imposed task structure to foster specific task-oriented communication while an overly rigid task structure can inhibit the occurrence of such types of cognitive processing as explication, the testing of tentative constructions, and the application of newly constructed knowledge. Lockhorst (2004) and Strijbos (2004) have also argued that the predetermined structure of a CSCL task should not be overly rigid in order not to disturb the natural course of interaction. Very little is known about the relations between task structure and the quality of student interactions (Veerman, 2000), which means that additional research on the structure of the tasks used in CSCL environments is needed.

7.3.3 The role of the teacher

The role of the teacher in the online environments for the three studies reported on here was quite different. Although all of the teachers played a role in the relevant organizational matters, classroom activities, and evaluation activities, not all of the teachers participated in the online activities. In the first study, the task was organized in such a manner that online teacher involvement was not required and the online participation of the teachers was found to be zero.

In the second study, the teachers were actively involved in the development, planning, and organization of the relevant lessons but their online involvement was largely passive and restricted to the reading of the contributions of their students. Only 2% of all the contributions was produced by the teachers although teacher involvement was sometimes needed, as illustrated by the following example. Within the science group investigating the phenomenon of “thunder and lightening,” students discussed online the best position to take in a meadow without any available shelter from the lightening. The students agreed that the person should lie down. But how? Some of the students stated that the person should lie down in an extended position while others stated that the person should make him/herself as small as possible and curl up in order to avoid the provision of a positive and negative pole. The students themselves did not succeed in finding a solution to the problem. And in this particular discussion, thus, guidance from a teacher would have been helpful, guiding the students to the best solution.

In the third study involving the Euroland project, the online participation of the teachers greatly exceeded the participation of the teachers in the other two studies. This is not surprising as students, teachers, and researchers all acted as participants in the Euroland project. The participation of the teachers and researchers affected the discussions. Ligorio, Talamo and Simons (2002) found the online tutors in the Euroland project served primarily a regulative function. The tutors defined the responsibilities of the different classrooms involved in the project and identified topics to be discussed during the chats. However, it was also found that all of the participants contributed to the regulation of the collaborative task.

The teachers in all three studies were not familiar with FTF collaborative learning, CSCL, or the guidance of students collaborating within a CSCL environment. Given that our primary interest was in the interactions of the students collaborating within a CSCL environment, the teacher's role was not taken further into account. The role of the teacher as online tutor and the conditions under which teacher guidance can effectively stimulate the process of knowledge construction will nevertheless be briefly considered further in section 7.4.2.

7.4. Theoretical considerations and steps to improve the knowledge construction process

In the three studies reported on here, a constructivist perspective was adopted on learning, which was assumed to involve a self-regulated, constructive, and collaborative process of knowledge construction. The focus of our inquiry was further on the occurrence of elaborations as a critical aspect of the process of knowledge construction. The studies in the present thesis indeed show CSCL environments to offer ample opportunities for the exchange of ideas, experiences, and information among students and provide a learning environment for collaborative knowledge construction in a realistic setting (Kanselaar et al., 2000). However, the quality of the knowledge construction process viewed in terms of the provision of high-level elaborations was not very high. Recall that high-level elaboration was operationalized as the posing of comprehension questions requiring explanations, the supply of answers with arguments or justification, the presentation of new ideas accompanied by explanation, and the acceptance or rejection of the ideas of others accompanied by arguments for doing so.

Does the generally low incidence of high-level elaborations provided by the students working in the CSCL environments studied here mean that these environments did not lead to interactions beneficial for learning and that we should therefore not stimulate the use of CSCL environments within the school context? We think not. Collaborative learning as a teaching method reflects the more general importance of collaboration in society today. Collaboration as well as the use of new technologies are often required in daily practice outside schools, within professional organizations, and - in fact - throughout society as a whole. The introduction of (computer-supported) collaborative learning in schools is believed to prepare students for adequate adult functioning (Van der Linden et al., 2000). However, additional effort appears to be needed to achieve real knowledge construction and go beyond the simple exchange of information. More specifically, the process of knowledge construction within

CSCL environments may be improved with more explicit training of discussion skills (section 7.4.1), increased teacher guidance (section 7.4.2), the inclusion of certain critical features in the learning environment (section 7.4.3), and better structuring of the collaborative task (section 7.4.4).

7.4.1 Improvement of the interactional behavior: train discussion skills

Although the incidence of high-level elaborations was minimal, it can still be concluded that the CSCL environments effectively fostered learning. The students were able to complete the assigned tasks, which were sometimes very complex, and to collaborate effectively. They were found to effectively regulate their own learning and the learning of others (De Jong et al., 2005); they successfully established relations with others at a distance and even across national borders; and they developed the language and computer skills necessary for effective collaboration (Van der Meijden & Ligorio, 2004).

The low incidence of high-level elaborations provided by the students nevertheless suggests that such a discussion feature as the provision of elaborations must be trained and practiced. That is, students must be trained to collaborate and discuss effectively. A good example of such a training program for primary school students is the “Talking Lessons” program introduced by Dawes (1997). During the course of talking lessons, the children are encouraged to undertake various activities designed to foster the exchange of opinions, the description of pictures and/or events, listening, the summary of stories and facts, the evaluation of suggestions, and the comparison of ideas. At the high school level, such talking lessons may be replaced by instruction and training on the pragmatic ground rules for exploratory talk, the provision of critique, and the receipt of critique (among other things).

7.4.2 Increase teacher guidance

In the present research, we did not pay specific attention to the role of the teacher in the organization and monitoring of the CSCL process or the online activities of the participating teachers. However, CSCL changes the work of the teacher on a number of levels and greater attention to the role of the teacher in CSCL at school is therefore called for. Teachers must, for example, shift from whole class to small group instruction, from lecture and recitation to coaching (i.e., become “the guide on the side” rather than “the sage on the stage”; Johnson & Johnson, 1994), and clearly act as a facilitator within the electronic learning environment. Instead of posing closed questions and providing the answers directly, teachers must encourage students to pose their own questions and find their own answers. Teachers must serve as guides or tutors who intervene as necessary, provide individual feedback, and act as a facilitator as opposed to a content expert. However, teachers will not find much support in the relevant research literature for even when publications directly tackle teacher roles in ICT-based environments, elements for (technology-supported) classroom management are only implicitly provided (Dillemans et al., 1999).

While increased attention is being paid to the role of the teacher as coach or facilitator for collaborative learning groups, the role of the teacher as participant in small collaborative groups is still quite unclear (Van Boxtel, 2000).

Within the research on CSCL, there is considerable debate on the role of the teacher as online tutor. The role of the teacher can range from being the general leader of a discussion to the provider of answers only when asked to total absence. Some authors emphasize the importance of active and visible online tutors to motivate and maintain a discussion (Mazzolini & Maddison, 2003). Other authors argue that instructor participation should not be overdone and largely limited to the stimulation of students to think by posing questions (i.e., asking for explanations), pointing out relations, comparison of concepts, and the provision of alternative viewpoints (Hogan, Nastasi, & Pressley, 2000). Veldhuis-Diermanse (2002) argued that tutoring in a CSCL environment can increase the number of cognitive learning activities and the quality of the constructed knowledge. Mazzoni and Maddison (2003), in contrast, found students to contribute less and a decreased length of discussion thread in cases of frequent tutor postings. Lockhorst (2004) found no significant correlations between the number of tutor interventions and student communication with respect to the content of a task. Both passive and active tutor roles were associated with active student participation. Furthermore, the students were directed both in their work on the content and in the regulation of their collaboration. The students participating in Lockhorst's studies also reported being satisfied with the frequency and content of the tutor interventions although some of the students suggested that a more active role on the part of the teachers may have helped them and motivated them more. Ligorio et al. (2002) have argued that online tutoring is a complex activity involving four different levels of functioning: (1) the managerial level, which means the coordination of activities in line with the general aims of the collaborative task; (2) the social level, which pertains to contributions aimed at the support of social and interpersonal relationships; (3) the pedagogical level, which refers to substantive content matters; and (4) the technical level, which refers to contributions concerned with specific technical problems (e.g., computer connections, server availability). Dawes (1997) has stressed the importance of input from the teacher within a CSCL environment and argued that such input may, in fact, be critical: "Computers can provide children with some interesting and worthwhile tasks to work on together, but only the teachers can help them to work together effectively" (Dawes, 1997, p. 195).

The results of the aforementioned studies show teacher guidance or online tutoring within a CSCL environment to be a complex matter. We nevertheless think that the teacher has an important role to play in the guidance of the learning process within a CSCL environment and particularly the monitoring of the online activities in both synchronous and asynchronous CSCL environments, in the provision of both cognitive and regulative feedback, and in the stimulation of students to provide feedback in order to improve the level of elaboration that occurs in the discussions undertaken.

7.4.3 Include critical features in the computer-supported learning environment

The use of different teaching methods and communication formats or the adoption of a so-called blended-learning approach as described in Chapter 6 and realized in the third study appeared to be very effective. The different communication formats and FTF meetings complemented each other. The events that occurred in the FTF classroom setting often had their reflection in the CSCL environment and vice versa. And the results of other research (Lockhorst, 2004, Veldhuis-Diermanse, 2002, Voogt et al., 2005) support the positive results found here. A FTF meeting appears to constitute an essential starting point for a CSCL task and, given that evaluation of the collaborative process constitutes one of the five key features of collaborative learning (Johnson & Johnson, 1994), a FTF meeting to complete and evaluate the CSCL task appears to be essential as well.

While the CSCL environments in the first and second studies included only text-based tools for knowledge representation, certain critical features may also be included under such circumstances to promote the process of knowledge construction. As suggested by King (1994), prompts such as questions asking "what is the relation between…?" may help students formulate a question and stimulate the use of comprehension questions. The WKF program (Scardamalia & Bereiter, 1992) used in the second study has introduced "thinking types" to allow students to indicate the type of statement they are contributing (e.g., "I need to understand" or "my theory…"). The introduction of such features into text-based environments has been found to encourage students to participate. Furthermore, the implementation of simulations, anchors, graphic tools, and linked WebPages has also been found to help students with limited writings skills participate more actively and productively in CSCL environments (Guzdial & Turns, 2000). And the use of supplemental graphic images has been found to facilitate reasoning activities (Löhner, Van Joolingen, Savelsberg, & Van Hout-Wolters, in press). The representation of key features in the form of pictures or symbols on the computer screen can provide anchors, help sustain a discussion, and thereby facilitate learning (Guzdial & Turns, 2000).

The students who participated in the third study reported on in this thesis were triggered to interact via the use of an avatar. Relative to communication in two-dimensional, text-based virtual environments, communication in 3D environments with embedded communication tools and the presence of avatars has been found to provide a greater sense of place, greater closeness within the group, and richer communication (Dalgarno, 2002). Such nonverbal signals as head nods or other indications of agreement and disagreement were easily represented by the movements and gestures of the avatar representing the participating student, which means that not all nonverbal information had to be replaced by written text (Barile & Durso, 2002) and enriched communication as a result.

In sum, we think that the embedding of such visual elements as buttons with prompts to pose comprehensions questions in a text-based CSCL environment and the presence of avatars in a 3D virtual reality environment promote participation and communication and can thereby enhance the quality of the knowledge construction process.

7.4.4 Structure the collaborative task

As already mentioned, the structure of a collaborative task can influence the interactions of the students involved. When the task is well defined and the problems have only one right answer, elaborated discussion may not occur. When the task is ill defined and the problems have more than one possible answer, considerable and often elaborate discussion may occur. The development of collaborative tasks for CSCL environments takes considerable time and energy. Attention must be paid to the amount of time available, the type of task, the learning goals, the final product, and both the type and amount of instruction to be provided. Pedagogic materials or best practices are not yet available to support teachers in their efforts along these lines (Dillemans et al., 1999).

One framework for the design of CSCL tasks has been developed by Strijbos et al. (2004). The framework consist of six steps: (1) determination of the learning objectives; (2) determination of the type of interaction desired; (3) selection of the most suitable type of task; (4) determination of the level of pre-structuring required for interaction; (5) determination of group size and group composition; and (6) determination of the type of computer use (i.e., individual or in dyads) best suited to support learning and stimulate interaction. The framework is intended to help teachers achieve the types of interaction that they want by making them aware of the influence of the various decisions made along the way.

Lockhorst (2004) provides a much more flexible set of design principles concerned with (1) the type of task; (2) the structure of the task; (3) the CSCL environment; and (4) the guidance provided by the teacher. With regard to the type of task, specific learning goals, a shared goal, and mutual interdependence embedded in the task have all been found to promote student participation and discussion. With regard to the structure of the task, a balance between external versus self-management of the learning process must be found and may depend on prior experience with working in CSCL environments. Regarding the CSCL environment itself, the environment should be easy to access and user-friendly. Students use only those functionalities needed to perform a task. And CSCL environments need such functionalities as notification of changes in the environment or the introduction of new features to support the online communication. Finally, with regard to teacher guidance, a balance must be found between teacher interventions and student communication. An active teacher can help guide students to find the answers to their questions. Adherence to the aforementioned design principles can help teachers develop suitably structured CSCL tasks and thereby stimulate the more widespread introduction of CSCL.

7.5 Methodological considerations

Increased interest in collaborative learning highlights the need for adequate instruments to characterize the interactions of students working in a CSCL environment. In order to map the process of knowledge construction, a coding scheme was developed within the context of the present research (see Chapter 3). The focus of the coding scheme was on the provision of cognitive contributions and particularly high-level elaborations while working in a CSCL environment. The coding scheme was developed on the basis of several empirical studies of the content of CSCL interactions. In contrast to most studies (see the critique of Strijbos, 2004), the procedures used for data reduction, segmentation, and coding have been extensively described for the studies in this thesis. Probably due to the intensive training program for the coders, the experiences with the coding scheme were very good. The classification of statements led to few disagreements, and the reliability of the coding across the different categories was found to be quite high for all of the studies as expressed by Cohen's Kappa's of .77 (study 2), .80 (study 3), and .93 (study 1). Using Fleiss's (1981) general benchmark for the Kappa, a Kappa of 0.40 to 0.75 can be interpreted as intermediate to good; a Kappa greater than 0.75 as excellent. It can therefore be concluded that the interrater reliability was excellent for the studies reported here.

Despite the good reliability of the coding conducted here, the use of a coding scheme to map the interactions of students working together has been criticized in general (Barnes & Todd, 1977, 1995; Edwards & Mercer, 1987). Edwards and Mercer have argued that the use of a coding scheme is based on the assumption that particular categories of speech mean the same thing on each occasion that they occur. The use of a coding scheme does not take into account that "things said at the ends of lessons carry a wealth of shared and implicit understanding, established during the lesson, that they could not carry at the start. And, since the raw data of speech are lost in the process of coding, it then becomes impossible to reconstruct the way in which that 'common knowledge' was created" (Edwards & Mercer, 1987 p. 5). Crook (1994) has also emphasized the limitations of a coding scheme to map the development of shared knowledge over time. However, in a more recent study, Wegerif and Mercer (1997b) acknowledged that the use of a coding scheme allows researchers to handle large amounts of data, provides visible and replicable criteria for categorization of a data set, provides a basis for systematic comparison across different collaborative groups, and yields insightful and valuable results. The limitations of using a coding scheme can be minimized when the analyses are illustrated by transcribed excerpts with supplemental commentary (Wegerif & Mercer, 1997b). In the present thesis, use of a coding scheme allowed us to analyze a large body of data, compare different collaborative groups, and also compare different communication formats. Annotated excerpts from the actual chat sessions and the discussion forum were also presented for illustrative purposes.

In the present thesis, the process of knowledge construction was examined as opposed to learning outcomes using - for example - pre- and post-tests. This means that no conclusions can be drawn with regard to what the students actually learned from working in a CSCL environment. Strijbos (2004) has argued that performance scores may not always sufficiently express what students have or have not learned. Only in the first study learning outcomes expressed as performance scores were measured. An example from the first study concerns whether the primary school children really know what happens when the fulcrum of a balance beam is not in the middle. It is quite possible, for example, that one member of the dyad cannot explain the situation while the performance of the dyad proved sufficient. Interviews with individual children following completion of a collaborative task may thus be needed to provide a check on their learning and understanding.

All of the studies in this thesis were conducted within the normal classrooms and, in most cases, the topic of the task to complete was part of the usual curriculum. The ecological validity of the procedures followed in the studies was thus very high, but this had severe consequences for the design of the research studies. In addition to major differences in the collaborative tasks themselves, the levels of education involved, the grade levels of the students, and the ages of the participants, there were major differences in the composition of the collaborative groups. The groups were not all composed in a similar manner, and their composition often depended on the number of students in the classroom, the percentages of girls and boys within a classroom, the availability of internet-connected computers for collaboration, and the teachers' choices for group composition. Such fundamental and widespread differences obviously make the present findings difficult to generalize.

Despite the aforementioned restrictions, the findings of the present studies provided some major insights into the interactions of students working in a CSCL environment. The activities of the students were found - for example - to be largely task oriented. The quality of the knowledge construction process was found to be higher for students working in dyads as opposed to threesomes or foursomes. Group composition in terms of sex was found to affect the interactions of the students. Group composition in terms of student ability was also found to influence the interactions of the students in a manner that has also been found to characterize the FTF interactions of students working collaboratively. And the use of synchronous and asynchronous communication formats appeared to be complementary.

7.6 Implications for educational practice

The purpose of this thesis was to determine if the implementation of CSCL in Dutch primary and secondary schools using different communication formats effectively promoted the process of knowledge construction in terms of high-level elaborations or not. Our findings showed the CSCL environments to provide sufficient opportunities for knowledge construction although the quality of the actual knowledge construction process was found to be fairly superficial. In section 7.4.1, it was suggested that the introduction of a training program to develop the collaborative skills of students could be quite helpful. Students can be prompted and trained to ask comprehension questions and questions requiring an explanation. They can also be trained to help others discover and understand the solution to a problem and not just provide a solution directly.

Just as other educational innovations, CSCL must be implemented very carefully into educational practice. Simply providing synchronous and/or asynchronous communication tools does not insure effective collaboration and leaning. CSCL must be treated as a means to achieve certain learning goals and not as a learning goal itself. The application of CSCL in classroom practice means that the answers to a number of very specific questions must first be sought: the types of communication formats to be used, the types of tasks to be used, the objectives to be achieved, the composition of the learning groups, the subject areas to be studied, and the level and nature of the teacher guidance to be provided.

Teachers generally lack time and are not able to design CSCL tasks without extensive support. In Dutch teacher education, very little attention is currently paid to collaborative learning whether with or without the support of computers (Bolhuis, 2000; De Kock, 2005). The effectiveness of collaborative learning has nevertheless been demonstrated for several subject areas (see Chapter 2), and we therefore recommend special training for teachers to enhance their knowledge of collaborative learning and how to organize CL and CSCL environments most effectively. The work of Johnson and Johnson (1998) and Joyce and Showers (1995) suggests, moreover, that such professional development efforts are not realized within a few workshops but require, rather, an entire program that includes coaching, study groups, and peer visits.

Krol (2005) has recently stressed the importance of the formation of teacher teams and leadership teams in order to develop a coherent vision on the implementation of CL. Leadership teams can develop methods to support teachers in the long run. And teacher teams can stimulate teachers to use CL and CSCL on a more widespread basis. That is, after the initial training sessions have come to an end, the focus of leadership teams should not be on the more widespread application of CL but on the promotion of teacher collaboration in order to stimulate teachers to use (computer-supported) collaborative learning (Krol, 2005).

For the implementation of CSCL in educational practice, teacher training is possibly more important because of the introduction of technology for collaboration. Voogt et al. (2005) proposed the establishment of a teacher network to foster collaboration between teachers, which can serve as a type of training follow-up. A teacher network can be implemented by linking teachers in person or electronically. And an online community can be established for the development of personal computer skills, the design of CSCL tasks, and discussion of common problems related to the technology.

Our data show both the AW and WKF programs to have great educational value. The two programs were easy to use, even for primary school children with very little knowledge of English. The programs can be easily introduced into schools. However, the schools must have a sufficient number of computers and the computers must be fast enough. Not all schools possess the number of computers needed, and many schools have internet connections that are too slow for an entire class to work on a database at the same time.

During the introduction of the AW and WKF software into the schools as part of the present study, it became clear to us that we were actually introducing three different innovations at the same time. Collaborative learning, learning with the aid of computers, and the concept of knowledge construction were all new for most of the teachers participating in our studies. The introduction of CSCL into the classroom and the adoption of a new teaching role was found to give rise to a fear of losing control, a fear of insufficient subject expertise, and/or a fear of computers at times. It is therefore recommended that a learning community of teachers be established within the schools and adequate educational guidance be provided for teachers working with CSCL for the first time.

7.7 Recommendations for future research

In the present research, the interactions of students collaborating in a CSCL environment were explored. Many factors were found to influence the interactions of the students including the duration of the task, the structure of the task, the characteristics of the learning environment, group composition, and the role of the teacher as CSCL tutor. In addition to the recommendations for further research mentioned in connection with the various findings summarized in the preceding, some other topics should be considered in future research.

The influences of group size and group composition

The influence of group size on the interactions of students collaborating in school settings has only been examined in a few studies (Fuchs et al., 2000). Lou et al. (2001) showed group size to be significantly related to learning outcomes and, more specifically, pairs of students working together to achieve higher learning outcomes than students working in groups of three to five. According to Wilkinson and Fung (2002), smaller groups generally achieve better, but this depends on the nature of the collaborative task (e.g., ill- versus well-structured). Webb et al. (1991) have shown low-ability students to learn more in heterogeneous groups than in homogeneous groups; medium-ability students to perform better in homogeneous groups; and high-ability students to do well in both types of groups. More recently, Webb, Nemer, and Zuniga (2002) have shown the following to be necessary for heterogeneous groups to function well: higher-ability students should collaborate fully with lower-ability members of the group and welcome their participation; higher-ability students should share their own knowledge but also ask for suggestions and corrections from others.

Within the CSCL research tradition, very little attention has been paid to the influence of students ability level. Veldhuis-Diermanse (2002) recommended heterogeneous grouping on the basis of prior knowledge and interest as the students then bring their specific knowledge and experiences to the situation and this tends to stimulate interaction.

Student grouping in terms of gender or ethnicity may also influence the interactions and learning outcomes of students collaborating in a CSCL environment (Wilkinson & Fung, 2002). Further research is thus called for to examine the relations between group size and group composition and the influence of such on the interactions and learning outcomes of students working in CSCL environments in a much more detailed manner.

The influence of the CSCL environment

In the 3D environment involving the use of both synchronous and asynchronous communication formats (study 3), the two tools were found to be used in a complementary manner. Use of the asynchronous communication format was also stimulated by use of the synchronous chat format and vice versa. Additional research on the specific influences of the different communication formats and other tools available within CSCL environments is nevertheless needed.

Another important topic for future research is the role of the avatar within the CSCL environment. In text-based CSCL environments, paraverbal (e.g., intonation, voice characteristics) and nonverbal signals are absent and are therefore sometimes replaced by verbal text (Barile & Durso, 2002). Does the presence of an avatar representing the user online with a capacity to move, gesture, and express feelings nonverbally provide a greater sense of place, a greater feeling of belonging, and a richer form of communication than the absence of such (Dalgarno, 2002)? Can a 3D environment using avatars compensate for the lack of a "social presence" (Short et al., 1976) associated with the use of networked computers? Research along these lines is still in its infancy, and many questions have yet to be answered.

Blended learning

The adoption of a blended-learning approach involving a combination of different learning environments appears to be promising for education. The combination of FTF classroom sessions, synchronous and asynchronous online communication, and self-paced Web-based study offers a wide variety of learning means (see Chapter 2). For CSCL, we recommend inclusion of a FTF kick-off meeting at the start of the CSCL task. The aim of this is twofold. First, the students must acquaint themselves with the relevant software and the collaborative task. Second, students prefer working with peers they know and a FTF meeting - aimed at teambuilding - allows the students to get to know each other better (Lockhorst, 2004). The blending of different learning environments and methods poses interesting questions for educational researchers. Does a "best" blend exist and, if so, what is it? The results of a recent meta-analysis by Bernard et al. (2004) provide inconclusive evidence with respect to the learning outcomes of education at a distance versus traditional classroom instruction: Some of the applications for learning at a distance produced far better results than traditional classroom instruction and some produced far worse results. Further research is thus needed to answer such questions as the following. What learning activities must take place, and in what types of environments are these learning activities known to occur (e.g., in FTF, synchronous, asynchronous, 2D, and/or 3D environments)? How can involvement in learning activities best be promoted? How can online collaboration and people learning from such online collaboration be insured? Which types of environments promote online collaboration and self-paced learning? What types of evaluation are necessary, at what points, and under which circumstances? Are FTF meetings necessary to evaluate group processes or other processes?

7.8 In closing

At this moment, CSCL is used in mainly higher education to support new ways of learning with a focus on learning in interaction with others. We explored CSCL at the primary and secondary school levels in an effort to determine if new ways of learning with a focus on learning in interaction with others can also be effectively undertaken at these levels. That raises the first essential question. Did the students in our studies actually learn? Did they collaborate effectively? Did their experiences with CSCL make them more aware of their learning? And do the students apply what they have learned in other situations? In other words: Does transfer take place?

Another question that goes beyond the boundaries of the present thesis is prompted by the results of a recent study by Lockhorst (2004) who reported online tutors to have the impression that student feedback was more effective than the feedback provided by teachers. Peer revision of compositions written by others is considered a new way of learning (i.e., both the writing skills of the other and one's own writing skills may improve as a result) (Fitzgerald, 1987). Along these lines, the provision of feedback on the contributions of others in a shared database is considered an essential component of the learning of post-secondary students involved in so-called "virtual action learning" (Baeten, 2003). The question, then, is whether virtual action learning is also applicable at the levels of primary and/or secondary education? Should greater attention also be paid to the provision of peer feedback within the context of traditional classroom learning? And what are the long-term effects of peer feedback?

To conclude, we cannot - as yet - provide clear guidelines for the implementation of CSCL or blended learning in general. The results of our studies nevertheless suggest that considerable attention should be paid to the exact nature of the collaborative tasks, the learning environment, the communication tools made available for use, and the alternation of FTF learning and online learning. Although teachers may recognize CSCL as beneficial for the learning of their students, it is difficult for individual teachers to implement CSCL methods all on their own. The establishment of teacher networks for collaboration and support thus appears to be essential. Students will not exchange ideas, elaborate on the responses of others, or reflect upon the learning process unless teachers organize the learning environment to prompt such interaction. Students in the formal education context must be given explicit opportunities to jointly construct their knowledge, just as people who jointly construct knowledge in other social contexts.

List of Tables and Figures

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References

Abrami, P. C., Chambers, B., Poulsen, C., De Simone, C., d'Apollonia, S., & Howden, J. (1995). *Classroom connections: Understanding and using cooperative learning*. Toronto: Harcourt Brace.

Ambrose. R., & Fennema, E. (2001). Gender and school learning: Mathematics and science. In N. Smelser & P. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 5972-5976). Oxford: Elsevier.

Anderson, J., Reder, L., & Simon, H. (1996). Situated learning and education. *Educational Researcher 25*(4), 5-11.

Anderson, J., Reder, L., & Simon, H. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher 26*(1), 18-21.

Anderson, J., Greeno, J., Reder, L., & Simon, H. (2000). Perspectives on learning, thinking, and activity. *Educational Researcher 29*(4), 11-13.

Antillanca, H. B., & Fuller, D. A. (1999). Refining temporal criteria to classify collaborative systems. *International Journal Human-Computer Studies, 50*, 1-40.

Austin, R. (1997). Computer conferencing: Discourse, education and conflict mediation. *Computers & Education, 29*(4), 153-161.

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

Austin, R. (1997). Computer conferencing: Discourse, education and conflict mediation. *Computers & Education, 29*(4), 153-161.

Azmitia, M. (1988). Peer interaction and problem solving: When are two heads better than one? *Child Development, 59*(1), 87-96.

Baeten, J. (2003). Virtual action learning: 40% meer plezier. [Virtual action learning: 40% more pleasure]. Paper presented at Surf Onderwijs Dagen 2003, Utrecht. [Online January 2005] Retrieved from: http://www.surf.nl/owd2003/index.

Barile, A., & Durso, F. T. (2002). Computer-mediated communication in collaborative writing. *Computers in Human Behavior, 18*(2), 173-190.

Barnes, D., & Todd, F. (1977). *Communication and learning in small groups*. London: Routledge & Kegan Paul

Barnes, D., & Todd, F. (1995). *Communicating and learning revisited. Making meaning through talk*. Portsmouth: Boyton/Crook

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy.* New York: Academic Press.

Bereiter, C. (1994). Constructivism, socioculturism, and Propper's world 3. *Educational Researcher 23*(4), 21-24.

Berge, Z., Collins, M., & Dougherty, K. (2000). Design guidelines for web-based courses. In B. Abbey(Ed.), *Instructional and cognitive impacts of web-based education*, (pp.32-55). London: Idea Group Publishing.

Bernard, R., Abrami, P., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P., Fiset, M., & Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research 74*(3), 379-439.

Blanton, W., Moorman, G., & Trathen, W. (1998). Telecommunications and teacher educations: A Social constructivist review. *Review of Research of Education, 23*, 235-275.

Bodemer, D., Ploetzner, R., Feurlein, I., & Spada, H. (2004). The active integration of information during learning with dynamic and interactive visualisations. *Learning and Instruction 14*(3), 325-341.

Boekaerts, M., & Simons, P. R. J. (1995). *Leren en instructie: Psychologie van de leerling en het leerproces* [Learning and instruction: Psychology of the learner and the learning process]. Assen: Van Gorcum.
Bolhuis, S. (2000). *Naar zelfstandig leren. Wat doen en denken docenten?* [Towards independent learning: What do teachers do and think?] Doctoral Dissertation. Radboud University, Nijmegen: The Netherlands.
Bodemer, D., Ploetzner, R., Feurlein, I., & Spada, H. (2004). The active integration of information during learning with dynamic and interactive visualisations. *Learning and Instruction 14*(3), 325-341.
Bonk, C. J., Hansen, E. J., Grabner-Hagen, M. M., Lazar, S. A., & Mirabelli C. (1998). Time to "connect": Synchronous and asynchronous case-based dialogue among preservice teachers. In C. J. Bonk, & K. S. King (Eds.), *Electronic collaborators. Learner centered technologies for literacy, apprenticeship, and discourse,* (pp. 289-314). Mahwah, NJ: Lawrence Erlbaum Associates.
Bordia, P. (1997). Face-to-face versus computer-mediated communication: A synthesis of the experimental literature. *Journal of Business Communication, 34*(1), 99-120.
Brandon, D. P., & Hollingshead, A. B. (1999). Collaborative learning and computer-supported groups. *Communication Education* 48, 109-126.
Bricken, M. (1991). Virtual reality learning environments: potential and challenges. *Computer Graphics,* (25)3, 178-84.
Bricken, M., & Byrne, C. (1992). *Summer students in virtual reality: A pilot study on educational applications of virtual reality technology*. Seattle, WA: Human Interface Technology Laboratory at the University of Washington, Technical Publications R-92-1.
Brown, A.L., & Campione, J.C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice,* (pp. 229-270). Cambridge, MA: MIT Press, Bradford Books.
Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher: 17*(1), 32-42.
Brown, A. L., & Campione, J.C. (1990). Communities of learning or a context by any other name. In D. Kuhn (Ed.), *Contributions to human development*, 21, 108-126.
Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *Journal of the Learning Sciences, 6*(3), 271-315.
Chou, C. C. (2001). Formative evaluation of synchronous CMC systems for a learner-centered online course. *Journal of Interactive Learning Research, 12*(2-3), 173-192.
Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher 28*(2), 4-15.
Cohen, A., & Scardamalia, M. (1998). Discourse about ideas: Monitoring and regulation in face-to-face and computer-mediated environments. *Interactive Learning Environments, 6*(1-2), 93-113.
Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37-46.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2^{nd} ed.), Hillsdale, NJ: Lawrence Erlbaum Associates.
Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1-35.
Cole, M., & Wertsch, J. (1996). Beyond the individual-social antimony in discussions of Piaget and Vygotsky. *Human Development, 39*(5), 250-256.
Collins, J., & Syred-Paul, A. (1997). Children as researchers using CD-Rom encyclopaedias. In R. Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 168-177). Clevedon, England: Multilingual Matters.

Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectations*. London: Kogan Page.

Crook, C. (1994). *Computers and the Collaborative Experience of Learning*. London: Routledge.

Dalgarno, B. (2002). The potential of 3D virtual learning environments: A constructive analysis. *E-Journal of Instructional Science and Technology 5*(2). [On line, April 2004], Available: http://www.usq.edu.au/electpub/e-jist/docs/Vol5%20No2/Dalgarno%20-%20Final.pdf.

Damon, W., & Phelps, E. (1989). Critical distinctions among three approaches to peer education. *International Journal of Educational Research (13)*1, 9-19.

Damon, W., & Phelps, E. (1998). Problem solving with equals: peer collaboration as a context for learning mathematics and spatial concepts. *The journal of Educational Psychology,* 81(4), 639-646.

Dawes, L. (1997). Teaching talking. In R. Wegerif & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 189-195). Clevedon, England: Multilingual Matters.

Dawes, L., Mercer, N., & Wegerif, R. (2000). *Thinking together: A programme of activities for developing thinking skills at KS2*. Birmingham, England: Questions Publishing Company.

De Corte, E. (2001) Instructional Psychology. In N. Smelser & P. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 7569-7573). Oxford: Elsevier.

De Corte, E., Greer, B., & Verschaffel, L. (1996). Mathematics learning and teaching. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 491-549). New York: Macmillan.

De Jong, F. (1992). *Zelfstandig leren: Regulatie van het leerproces en leren reguleren : Een procesbenadering* [Independent learning: Regulation of the learning process and learning to regulate: A process approach]. Doctoral Dissertation, Tilburg University, The Netherlands.

De Jong, F., Veldhuis-Diermanse, A. E., & Lutgens, G. (2002). Computer-supported collaborative learning in university and vocational education. In T. Koschmann, R. Hall & N. Myake (Eds.), *CSCL2: Carrying on the conversation* (pp. 111-129). Mahwah, NJ: Lawrence Erlbaum Associates.

De Jong, F., Kollöffel, B., Van der Meijden, H., Kleine Staarman, J., & Janssen, J. (2005). Regulative processes in individual, 3D, and computer-supported cooperative learning contexts. *Computers in Human Behavior 21*(4), 645-670.

De Kock, A. (2005). *Arranging learning environments for new learning; Educational theory, practical knowledge and everyday practice*. Doctoral Dissertation. Radboud University, Nijmegen, The Netherlands.

De Laat, M. (2002) Network and content analysis in an online community discourse. In G. Stahl (Ed), *Computer support for collaborative learning: Foundations for a CSCL community* (pp. 625-626). Hilsdale, NJ: Lawrence Erlbaum Associates.

De Lisi, R., & Goldbeck, S. L. (1999). Implications of Piagetian theory for peer learning. In A. M. O'Donnell, & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 3-37). Mahwah, NJ: Lawrence Erlbaum Associates.

Dewey, J. B., A. (1991). Knowing and the known. In J. A. Boydston (Ed.), *John Dewey: the later works, 1949-1952* (Vol.16). Carbondale, IL: SIU Press.

Dietz-Uhler, B., & Bishop-Clark, C. (2001). The use of computer-mediated communication to enhance subsequent face-to-face discussions. *Computers in Human Behavior 17*(3), 269-283.

Dillemans, R., Lowyck, J., Van der Perre, G., Claeys, C. & Elen, J. (1998). *New technologies for learning: Contribution of ICT to innovation in education*. Leuven: University Press.

Dillenbourg, P. (Ed.) (1999). *Collaborative learning: Cognitive and computational approaches*. Amsterdam: Pergamon, Elsevier.
Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Reiman (Eds), *Learning in humans and machines: Towards an interdisciplinary learning science* (pp. 189-211). Oxford, England: Elsevier.
Driver, R., Asoko, H., Leagh, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher 23*(7), 5-12.
Dutt-Doner, K., & Powers, S. (2000). The use of electronic communication to develop alternatives avenues for classroom discussion. *Journal of Technology and Teacher Education 8*(2), 153-172.
Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology, (AECT)* (pp. 170-198). New York, NY: Simon & Schuster Macmillan.
Dykes, M. E., & Schwier, R. A. (2003). Content and community redux: Instructor and student interpretations of online communication in a graduate seminar. *Canadian Journal of Learning and Technology, 29*(2), 1-12.
Edwards, D., & Mercer, N. (1987). Common knowledge. London: Methuen.
Eraut, M. (1995). Groupwork with computers in British primary schools. *Educational Computing Research, 13*(1), 61-88.
Erkens G. (1997). Coöperatief probleem oplossen met computers in het onderwijs[Cooperative problem solving with computers in education]. Doctoral Dissertation, Utrecht University, The Netherlands
Erkens, G. (2001). *Multiple Episode Protocol Analysis (MEPA)* [Computer software]. Utrecht: Utrecht University, The Netherlands.
Erkens, G., Jaspers, J., Prangsma, & Kanselaar, G. (2005). Coordination processes in computer supported collaborative writing. *Computers in Human Behavior 21*(3), 463-486.
Fabos, B., & Young, M. (1999). Telecommunication in the Classroom: Rhetoric versus reality. *Review of Educational Research, 96*(3), 217-259.
Fjermestad, J., & Hiltz, S.R. (1999). An assessment of group support systems experimental research: Methodology and results. *Journal of Management Information Systems, 15*(3), 7-150.
Fitzgerald, L. (1987). Research on revision in writing. *Review of Educational Research 57*(4), 481-506.
Fitzpatrick, H., & Hardman, M. (2000). Mediated activity in the primary classroom: Girls, boys, and computers. *Learning and Instruction, 10*(5), 431-446.
Fleiss, J. L. (1981). *Statistical methods for rates and proportions*. New York: Wiley.
Fuchs, L. S., Fuchs, D., Bentz, J., Phillips, B. Hamlett, C. (1994). The nature of student interactions during peer tutoring with and without prior training and experience. *American Educational Research Journal 31*(1), 75-103.
Fuchs, L. S., Fuchs, D., Hamlett, C. L., & Karns, K. (1998). High-achieving students' interactions and performance on complex mathematical tasks as a function of homogeneous and heterogeneous pairings. *American Educational Research Journal, 35*(2), 227-267.
Fuchs, L. S., Fuchs, D., Karns, K., Hamlett, C. L., Dutka, S., & Katzaroff, M. (1996). The relation between student ability and the quality and effectiveness of explanations. *American Educational Research Journal, 33*(3), 631-664.
Fuchs, L. S., Fuchs, D., Kazdan, S., & Allen, S. (1999). Effects of peer-assisted learning in reading with and without training in elaborated help giving. *Elementary School Journal, 99*(3), 201-219.

Fuchs, L. S., Fuchs, D., Kazdan, S., Karns, K., Calhoon, M. B., Hamlett, C. L., & Hewlett, S. (2000). Effects of workgroup structure and size on student productivity during collaborative work on complex tasks. *Elementary School Journal, 100*(3), 183-212.

Gillies, R., & Ashman, A. (1998). Behavior and interactions of children in cooperative groups in lower and middle elementary grades. *Journal of Educational Psychology, 90*(4), 746-757.

Gunawardena, C. N. (1995) Social presence theory and implications for interaction and collaborative learning in computer conferences. *International Journal of Educational Telecommunications, 1*(1-2), 147-166.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research, 17*(4), 397-431.

Greeno, J. G. (1997). On claims that answer the wrong questions. *Educational Researcher 26*(1), 5-17.

Guzdial, M. (1997). *Information ecology of collaborations in educational settings: Influence of tool*. [Online February 2, 2004]. Retrieved from: http://guzdial.cc.gatech.edu/papers/infoecol/Default.html.

Guzdial, M., & Turns, J. (2000). Effective discussion through a computer-mediated anchored forum. *Journal of the Learning Sciences, 9*(4), 437-469.

Hakkarainen, K. (1998). *Epistemology of scientific inquiry and computer -supported collaborative learning*. Doctoral Dissertation University of Toronto, Canada.

Hakkarainen, K., Lipponen, L. Järvelä, S. (2002). Epistemology of inquiry and computer-supported collaborative learning. In T. Koschmann, R. Hall & N. Myake (Eds.), *CSCL2: Carrying on the conversation* (pp. 129-157). Mahwah, NJ: Lawrence Erlbaum Associates.

Hakkarainen, K., Järvelä, S., Lipponen, L., & Lehtinen, E. (1998). Culture of collaboration in computer-supported learning: A Finnish perspective. *Journal of Interactive Learning Research, 9*(3-4), 271-288.

Hakkarainen, K., Lipponen, L., Järvelä, S., & Niemivirta, M. (1999). The interaction of motivational orientation and knowledge-seeking inquiry in computer-supported collaborative learning. *Journal of Educational Computing Research, 21*(3), 263-281.

Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science, 28*(2), 115-152.

Haythornthwaite, C., (2002). Building social networks via computer networks. Creating and sustaining distributed learning communities. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities. Learning and change in cyberspace* (pp. 159-190). Cambridge: University Press.

Haythornthwaite, C., Kazmer, M., & Robins, J. (2000). Community development among distance learners: Temporal and technological dimensions. *Journal of Computer Mediated Communication 6*(1). [Online July, 2004. Retrieved from: http://www.ascusc.org/jcmc/vol6/issue1/haythornthwaite.html.

Henri, F. (1992). Computer conference and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing: The Najaden papers* (pp. 117-136). London: Springer-Verlag.

Herring, S. C. (1993). Gender and democracy in computer-mediated communication. *Electronic Journal of Communication, 3*(2). [Online December 2003]. Retrieved from http://ella.slis.indiana.edu/~herring/ejc.txt.

Herring, S. C. (2000). Gender differences in CMC: Findings and implications. *Computer Professionals for Social Responsibility Newsletter*. [Online December 2003]. Retrieved from:http://www.cpsr.org/publications/newsletters/issues/2000/Winter2000/herring.html

Herrington, J., & Olivier, R. (2000). Using situated learning and multimedia to promote higher-order thinking. *Journal of Interactive Learning Research 10*(1), 3-24.

Hewitt, J., & Scardamalia, M. (1998). Design principles for distributed knowledge building processes. *Educational Psychology Review, 10*(1), 75- 96.

Hogan, K., Nastasi, B., & Pressley, M. (2000). Discourse patterns and collaborative scientific reasoning in peer and teacher-guided discussions. *Cognition and Instruction*, *17*(4), 379-432.

Hogan, K., & Tudge, J. (1999). Implications of Vygotsky's theory for peer learning. In A. O'Donnell, & A. King (Eds.), *Cognitive perspectives on peer learning (pp. 39-65).* Mahwah, NJ: Lawrence Erlbaum Associates

Hollingshead, A. B., McGrath, J. E., & O'Conner, K. M. (1993). Group task performance and communication technology: A longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research, 24*(3), 307-333.

Hsi, S. (1997). *Facilitating knowledge integration in science through electronic discussion: The multimedia kiosk forum.* Unpublished Doctoral dissertation, University of California at Berkeley. [Online January 2004]. Retrieved from: http://www.concord.org/~sherry/dissertation.

Hughes, M., & Greenhough, P. (1989). Gender and social interaction in early LOGO use. In J. H. Collins, N. Estes, W. D. Gattis, & D. Walker (Eds.), *The sixth international conference on technology and education*, Vol 1. Edinburgh: CEP.

Johnson, D. W., & Johnson, R. (1990). Impact of group processing on achievement in cooperative groups. *Journal of Social Psychology, 130*(4), 507-516.

Johnson, D. W., & Johnson, R. T. (1994). *Learning together and alone: Cooperative, competitive, and individualistic learning* (4th ed.). Boston, MA: Allyn and Bacon.

Johnson D, & Johnson, R. (1998). Effective staff development in cooperative learning: Training, transfer and long-term use. In E. Brody & N. Davidson (Eds.), *Professional development for cooperative learning. Issues and approaches* (pp. 223-242). NY: State University of New York Press.

Johnson, S. D., Aragon, S. R., Shaik, N., & Palma-Rivas, N. (2000). Comparative analysis of learner satisfaction and learning outcomes in online and face-to-face learning environments. *Journal of Interactive Learning Research, 12*(4), 29-49.

Jonassen, D., & Kwon, H. (2001). Communication patterns in computer mediated versus face-to-face group problem solving. *Educational Technology Research and Development 49*(1), 35-52.

Joyce, B., & Showers, B. (1998). Student achievement through staff development. London/New York: Longman.

Kagan, S. (1994). *Cooperative learning* (10th ed.). San Juan Capistrano, CA: Kagan Cooperative Learning.

Kanselaar, G., De Jong, T., Andriessen, J., & Goodyear, P. (2000). New technologies. In R.-J. Simons, J. Van der Linden & T. Duffy (Eds.), *New Learning* (pp. 55-81). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Kanselaar, G., & Erkens, G. (1996). Interactivity in cooperative problem solving with computers. In S. Vosniadou, E. De Corte, R. Glaser, & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 185-203). Mahway, NJ: Lawrencece Erlbaum Associates.

Keller, J. (1983). Motivational design of instruction. In C. Reigeluth (Ed.), *Instructional design theories and models: An overview of their current status* (pp. 386-434). Hillsdale, NJ: Erlbaum.

King, A. (1989). Verbal interaction and problem-solving within computer-assisted cooperative learning groups. *Journal of Educational Computing Research, 5*(1), 1-15.

King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Educational Research Journal, 27*(4), 664-687.

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Educational Research Journal, 31*(2), 338-368.

King, A. (1999). Discourse patterns for mediating peer learning. In A. M. O'Donnell & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 87-115). Mahwah, NJ: Lawrence Erlbaum Associates.

King, A., Staffieri, A., & Adelgais, A. (1998). Mutual peer tutoring: Effects of structural tutorial interaction to scaffold peer learning. *Journal of Educational Psychology, 90*(1), 134-152.

Kirschner, P. A. (2001). Using integrated electronic environments for collaborative teaching/learning. *Learning and Instruction, 10*(1), 1-9.

Kleine Staarman (2003). Face-to-face talk to support computer-mediated discussion in a primary school literacy practice. *Reading, Literacy, and Language*, July 2003, 73-81.

Kleine Staarman, J., Krol, K., & Van der Meijden, H. (2005) Peer interaction in three collaborative learning environments. *Journal of Classroom Interaction, 40*(1).

Kneser, C., & Ploetzner, R. (2001). Collaboration on the basis of complementary domain knowledge: observed dialogue structures and their relation to learning success. *Learning and Instruction, 11*(1), 53-83.

Kourilsky, M., & Wittrock, M. (1992). Generative teaching: An enhancement strategy for the learning of economics in cooperative groups. *American Educational Research Journal, 29*(4), 861-876).

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

Krol, K. (2005). *Toward interdependence. Implementation of cooperative learning in primary schools*. Doctoral Dissertation. Radboud University Nijmegen, The Netherlands

Kumpulainen, K., & Mutanen, M. (1999). The situated dynamics of peer group interaction: An introduction to an analytic framework. *Learning and Instruction, 9*(5), 449-473.

Kumpulainen, K., & Mutanen, M. (2000). Mapping the dynamics of peer group interaction: A method of analysis of socially shared learning processes. In H. Cowie & G. Van der Aalsvoort (Eds.), *Social interaction in learning and instruction: The meaning of discourse for the construction of knowledge* (pp. 145-160). Amsterdam: Pergamon.

Lakkala, M., Muukonen, H., Ilomaki, L., Niemivirta, M., & Hakkarainen, K. (2001). Approaches for analyzing tutor's role in a networked inquiry course. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *European perspectives on computer-supported collaborative learning.. Proceedings of the First European Conference on CSCL* (pp.389-397). Maastricht, The Netherlands: University of Maastricht.

Larson, C. O., Dansereau, D. F., O'Donnell, A. M., Hythecker, V. I., Lambiotte, J. G., & Rocklin, T. R. (1985). Effects of metacognitive and elaborative activity on cooperative learning and transfer. *Contemporary Educational Psychology, 10*(4), 342-348.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* New York: Cambridge University Press.

Lave , J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (2000). Computer-supported collaborative learning: A review. In H. Van der Meijden, R.J. Simons, & F. De Jong (Eds.), *Computer-supported collaborative learning networks in* *primary and secondary education. Final Report 2017.* Annex 1 (pp.1-47). Radboud University Nijmegen, The Netherlands.

Leseman, P. P. M., Rollenberg, L., & Gebhardt, E. (2000). Co-construction in kindergartners' free play: Effects of social, individual and didactic factors. In H. Cowie & G. Van der Aalsvoort (Eds.), *Social interaction in learning and instruction: The meaning of discourse for the construction of knowledge*. Amsterdam, Netherlands: Elsevier

Light, P., & Light, V. (1999). Analysing asynchronous learning interactions: Computer-mediated communication in a conventional undergraduate setting. In K. Littleton & P. Light (Eds.), *Learning with computers: Analysing productive interaction* (pp. 162-178). London: Routledge.

Light, P., Littleton, K., Bale, S., Joiner, R., & Messer, D. (2000). Gender and social comparison effects in computer-based problem solving. *Learning and Instruction, 10*(6), 483-496.

Ligorio, M. B. (2001). Integrating communication formats: Synchronous versus asynchronous and text-based versus visual. *Computers & Education 37*(2), 103-125.

Ligorio, M. B., Talamo, A., & Simons, R.J. (2002). Synchronous tutoring of a virtual community. *Mentoring & Tutoring 10*, 137-152.

Lipponen, L. (1999). The challenges for computer supported collaborative learning in elementary and secondary level: Finnish perspectives. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference*. Palo Alto, CA: Stanford University. [Online May 2003]. Retrieved from: http://kn.cilt.org/csc199/A46/A46.htm.

Lipponen, L. (2000). Towards knowledge building: From facts to explanations in primary students' computer mediated discourse. *Learning Environments Research, 3*(2), 179-199.

Lipponen, L. (2002). Exploring foundations for computer-supported collaborative learning. In G. Stahl (Ed.), *Computer support for collaborative learning. Proceedings of the Computer supported collaborative learning 2002 Conference* (pp.72-81). Hilsdale NJ: . Associates

Lipponen, L., Rahikainen, M., Hakkarainen, K., & Palonen, T. (2002). Effective participation and discourse through a computer network: Investigating elementary students' computer-supported interactions. *Journal of Educational Computing Research, 27*(4), 355-384.

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction, 13*(5), 487-511.

Lockhorst, D. (2004). *Design principles for a CSCL environment in teacher training*. Doctoral Dissertation, Utrecht University, The Netherlands.

Lodewijks, J. (1993). *De Kick van het kunnen. Over arrangementen en engagement bij het leren.* [Arrangments and engagement in learning] Inaugurele Rede. Tilburg University, The Netherlands

Löhner, S., Van Joolingen, W., Savelsberg, E., & Van Hout-Wolters, B. (in press). Students' reasoning during modeling in an inquiry learning environment. *Computers in Human Behavior*

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

Marjanovic, O. (1999) Learning and teaching in a synchronous collaborative environment. *Journal of Computer Assisted Learning 15*, 129-138.

Mason, R. G. (1999). *Globalising education*. London: Routledge.

Mazzolini, M., & Maddison S. (2003). Sage, guide or ghost? The effect of instructor intervention on student participation in online discussion forums. *Computers & Education 40*(3), 237-253.

McConnell, D. (2000). *Implementing computer supported collaborative learning*. London: Kogan Page.
McWhaw, K., Schnackenberg, H., Sclater, J., & Abrami, P. (2003) From co-operation to collaboration. Helping students become collaborative learners. In R. M. Gillies , & A. F. Ashman (Eds.), *Co-operative Learning. The social and intellectual outcomes of learning in groups*. (pp 69-86) London: Routledge.
Meloth, M. S., & Deering, P. D. (1994). Task talk and task awareness under different cooperative learning conditions. *American Educational Research Journal, 31*(1), 138-165.
Meloth, M. S., & Deering, P. D. (1999). Peer group learning. Hillsdale, NJ: Lawrence Erlbaum Associates.
Mercer, N. (1995). *The guided construction of knowledge: Talk amongst teachers and learners*. Clevedon: Multilingual Matters.
Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and Instruction, 6*(4), 359-377.
Mercer, N., & Wegerif, R. (1999). Is 'exploratory talk' productive talk? In K. Littleton & P. Light (Eds.), *Learning with computers: Analysing productive talk*. London: Routledge.
Mercer, N., Wegerif, R., & Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. *British Educational Research Journal, 25*(1), 95-111.
Moore, M. G., (1993). Theory of transactional distance. In D. Keegan (Ed.), I (pp.22-38). London: Routledge
Muukkonen, H., Hakkarainen, K., & Lakkala, M. (1999). Collaborative technology for facilitating progressive inquiry: Future learning environment tools. In C. Hoadley (Ed.), *Proceedings of CSCL '99. The third international conference on CSCL.* Mahwah, NJ: Lawrence Erlbaum Associates. [Online March 2001]. Retrieved from: http://kn.cilt.org/cscl99/A51/A51.HTM
Nelson–Le Gall, S. (1992). Children's instrumental help-seeking: Its role in the social acquisition and construction of knowledge. In R. Hertz-Lazarowitz, & N. Miller (Eds.), *Interaction in cooperative groups: A theoretical anatomy of group learning*, (pp. 49-86). Cambridge: University Press.
Nelson–Le Gall, S., Gumerman, R. A., & Scott–Jones, D. (1983). Instrumental help-seeking and everyday problem-solving: A developmental perspective. In B. M. DePaulo, A. Nadler, & J. D. Fisher (Eds.), *New directions in helping*, *2*,(pp. 265-283). San Diego, CA: Academic Press.
Neuage, T. (2002). Conversational analysis of chat room talk. Doctoral Dissertation University of South Australia. [Online September 2003]. Retrieved from: http://se.unisa.edu.au/phd/storm/theories.html.
Newman, D. R., Webb, B., & Cochrane, C. (1995). A content analysis method to measure critical thinking in face-to-face and computer supported group learning. *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century, 3*(2), 56-77.
Nolan, D. J., & Weiss (2002). Learning in cyberspace. An educational overview of virtual community. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities. Learning and change in cyberspace*, (pp. 293-320). Cambridge: University Press.
Ocker, R. J., & Yaverbaum, G. J. (2001). Collaborative learning environments: Exploring student attitudes and satisfaction in face-to-face and asynchronous computer conferencing settings. *Journal of Interactive Learning Research, 12*(4), 427-448.
O'Donnell, A., & O'Kelly, J. (1994). Learning from peers: Beyond the rhetoric of positive results. *Educational Psychology Review, (6)*4, 321-349.
Ohlund, B., Chong, H. Y., Jannash-Pennell, A., & Digangi, S. (2000). Impact of asynchronous and synchronous internet-based communication on collaboration and

performance among K-12 teachers. *Journal of Educational Computing Research, 23*(4), 405-420.
Olaniran, B. A., Savage, G. T., & Sorenson, R. L. (1996). Experimental and experiential approaches to teaching face-to-face and computer-mediated discussion. *Communication Education, 45*(3), 244-259.
O'Malley, C. (Ed.) (1995). *Computer supported collaborative learning*. Berlin: Springer Verlag.
Oshima, J., & Oshima, R., (2002). Coordination of asynchronous and synchronous communication: Differences in qualities of knowledge advancement discourse between expert and novices. In T. Koschmann, R. Hall, & N. Myake (Eds.), *CSCL 2. Carrying forward the conversation* (pp. 55-85). Mahwah, NJ, Lawrence Erlbaum Associates.
Papert S. (1991) Situating Constructionism. In I. Harel & S. Papert. (Eds.), *Constructionism.* Norwood, NJ, Ablex Publishing.
Pena-Shaff, J. B., Martin, W., & Gray, G. (2001). An epistemological framework for analyzing student interactions in computer-mediated communication environments. *Journal of Interactive Learning Research, 12*(1), 41-68.
Pena-Shaff, J. B., & Nicholls, C. (2004). Analysing student interactions and meaning construction in computer bulletin board discussions. *Computers & Education 42*(3), 243-265.
Peterson, R., Johnson, D. W., & Johnson, R. T. (1991). Effects of cooperative learning on perceived status of male and female pupils. *Journal of Social Psychology, 131*(5), 717-735.
Phelps, E., & Damon, W. (1989). Problem solving with equals: Peer collaboration as a context for learning mathematics and spatial concepts. *Journal of Educational Psychology, 81*(4), 639-646.
Phillips, D. C., (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher 24*(7), 5-12.
Phillips, D. C., (1995). Response to Ernst Von Glaserfled. *Educational researcher 25*(6), 20.
Phillips, D. C., (2000). An opinionated account for the constructivist landscape. In D. C. Phillips (Ed.), *Constructivism in education. Opinions and second opinions on controversial issues*. (pp.1-17) Chicago, IL: The University of Chicago Press
Piaget, J. (1926). *Judgment and reasoning in the child*. New York: Harcourt.
Pilkinton, R., & Walker, S. (2003). Facilitating debate in networked learning: reflecting on online synchronous discussion in higher education. *Instructional Science, 31*, 41-63.
Preece, J. (2001). *Online community. Designing usability, supporting sociability.* New York: John Wiley & Son.
Rheingold, H. (1993). *The Virtual Community: Homesteading on the Electronic Frontier.* CA: Addison-Wesley Publishing Co. [Online March 2005]. Retrieved from: http://www.well.com/www/hlr/vcbook/vcbookintro.html.
Ros, A. A. (1994). *Analyse en effecten van uitleg door leerlingen en leerkrachten* [Explanation by students and teachers: Analyses and effects]. Groningen: RION, The Netherlands.
Roschelle, J. (1992). *What should collaborative technology be? A perspective from Dewey and situated learning.* Paper presented at the ACM Conference on Computer Supported Collaborative Learning.
Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed), *Computer-supported collaborative learning* (pp. 69-97). Berlin: Springer Verlag.
Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2001). Methodological issues in the content analysis of computer conference transcripts. *International Journal of Artificial Intelligence in Education, 12*, 8-26.

Salis, C. & Pantelidis, V.S. (1997). Designing virtual environments for instruction: concepts and considerations. *VR in the Schools 2(4).* [Online April 2004]. Retrieved from: http://www.coe.ecu.edu/vr/vrits/vris2-4.htm

Salomon, G., & Globerson, T. (1989). When teams don't function the way they ought to. *International Journal of Educational Research 13*(1), 89-98.

Salomon, G., & Perkins, D. N. (1998). Individual and social aspects of learning. In P. D. Pearson & A. Iran-Nejad (Eds.), *Review of Research in Education* (Vol. 23, pp. 1-24). Washington, DC: American Educational Research Association.

Savicki, V., Kelley, M., & Lingenfelter, D. (1996a). Gender and group composition in small task groups using computer-mediated communication. *Computers in Human Behavior, 12*(2), 209-224.

Savicki, V., Kelley, M., & Lingenfelter, D. (1996b). Gender, group composition, and task type in small task groups using computer-mediated communication. *Computers in Human Behavior, 12*(4), 549-565.

Savicki, V., Kelley, M., Oesterreich, E. (1998). Effects of instructions on computer-mediated communication in single- or mixed-gender small task groups. *Computers in Human Behavior, 14*(1), 163-180.

Savicki, V., Kelley, M., & Oesterreich, E. (1999). Judgments of gender in computer-mediated communication. *Computers in Human Behavior, 15*(2), 185-194.

Scanlon, E. (2000). How gender influences learners working collaboratively with science simulations. *Learning and Instruction, 10*(6), 463-481.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *Journal of the Learning Sciences, 1*(1), 37-68.

Scardamalia, M., & Bereiter, C. (1992). An architecture for collaborative knowledge building. In E. de Corte, M. C. Linn, H. Mandl, & L. Verschaffel (Eds.), *Computer-based learning environments and problem solving* (pp. 41-67). Berlin/Heidelberg: Springer Verlag.

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

Schellens, T., & Valcke, M.(in press).Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing? *Computers in Human Behavior*

Schneider, B. (2001). Education (primary and secondary) and gender. In N. Smelser & P. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 4239-4243). Oxford: Elsevier.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351-371.

Schwier, R. A., & Balbar, S. (2002). The interplay of content and community in synchronous and asynchronous communications: Virtual communication in a graduate seminar. *Canadian Journal of Learning and Technology, 28*(2), 21-30.

Sfard, A. (1998). On two metaphors for learning and the danger of choosing just one. *Educational Researcher, 27*(2), 4-13.

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

Shuell, T. J. (1996). Teaching and learning in classroom context. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 726-764). New York: Macmillan.

Shuell, T. J. (2001). Learning theories and educational paradigms. In N. Smelser & P. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 8613-8620). Oxford: Elsevier.

Shumar, W., & Renninger, K. A. (2002). On conceptualizing community. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities. Learning and change in cyberspace*. (pp. 1-17). Cambridge: University Press.

Siegel, S. (1956). *Nonparametric statistics for the behavioural sciences*. New York: McGraw-Hill Book Company

Siegler, R. S. (1976). Three aspects of cognitive development. *Cognitive Psychology, 8*(4), 481-520.

Simons, R.-J., Van der Linden, J., & Duffy, T. (2000a). New learning: Three ways to learn in a new balance. In R.-J. Simons, J. Van der Linden & T. Duffy (Eds.), *New Learning* (pp. 1-20). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Simons, R. J., Van der Meijden, H., & Vosniadou, S. (2000b). Recommendations and conclusions, added value of technology, and implementation. In H. Van der Meijden, R. J. Simons, & F. De Jong (Eds.), *Computer supported collaborative learning networks in primary and secondary education. Final report 2017* (pp. 117-127). Nijmegen: Radboud University, The Netherlands.

Slavin, R. E. (1989/1990). Research on cooperative learning: consensus and controversy. *Educational Leadership, 47*(4), 52-54.

Slavin, R. E. (1992). When and why does cooperative learning increase achievement? Theoretical and empirical perspectives. In R. Hertz-Lazarowitz, & N. Miller (Eds.), *Interaction in cooperative groups: A theoretical anatomy of group learning*, (pp. 145-173). Cambridge: University Press.

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

Smeets, E., & Mooij, T. (2001). Pupil-centred learning, ICT, and teacher behaviour: observations in educational practice. *British Journal of Educational Technology* 32, 403-417.

Sottillo, S.M. (2000). Discourse functions and syntactic complexity in synchronous and asynchronous communication. *Language Learning and Technology 4*(1), 82-119.

Stahl, G. (1999). Reflections on Webguide. Seven issues for the next generation of collaborative knowledge-building environments. In C. Hoadley (Ed.), *Proceedings of CSCL '99: The third international conference on computer support for collaborative learning* (pp. 600-610). Mahwah, NJ: Lawrence Erlbaum Associates.

Stahl, G. (2002). *Contributions to a theoretical framework for CSCL.* Paper presented at the CSCL 2002, Colorado 2002.

Straus, S. G. (1996). Getting a clue: The effects of communication media and information distribution on participation and performance in computer-mediated and face-to-face groups. *Small Group Research, 27*(1), 115-142.

Straus, S. G., & McGrath, J. E. (1994). Does the medium matter? The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology, 79*(1), 87-97.

Strijbos, J. W. (2004). *The effect of roles on computer-supported collaborative learning*. Doctoral Dissertation. Open University, Heerlen: The Netherlands.

Strijbos, J. W., & Martens, R. L. (in press). Content analysis: What are they talking about? *Computers & Education.*

Strijbos, J. W., Martens, R. L. & Jochems, W. M. G. (2004). Designing for interaction: Six steps to designing computer-supported group based learning. *Computers & Education, 42(*4), 403-424.

Talamo, A., & Nimievirta, M. (2000). An overview of motivational measurements. In H. Van der Meijden, R. J. Simons, & F. D. Jong (Eds.), *Computer supported collaborative* *learning networks in primary and secondary education. Final Report 2017* (pp. 81-93). Radboud University Nijmegen, The Netherlands.

Torrano Montalvo, F., & Gonzalez Torres, C. (2004). Self-regulated learning: Current and future directions. *Electronic Journal of Research in Educational Psychology, 2*(1), 1-34

Tudge, J. (1989). When collaboration leads to regression: Some negative consequences of socio-cognitive conflict. *European Journal of Social Psychology, 19*(2), 123-138.

Tudge, J. (1992). Processes and consequences of peer collaboration: A Vygotskian analysis. *Child Development, 63*(6), 1364-1379.

Tudge, J., & Rogoff, B. (1989). Peer influences on cognitive development: Piagetian and Vygotskian perspectives. In M. H. Bornstein & J. S. Bruner (Eds.), *Interaction in human development* (pp. 17-40). Hillsdale, NJ: Lawrence Erlbaum Associates.

Underwood, J., & Underwood, G. (1999). Task effects on co-operative and collaborative learning with computers. In K. Littleton & P. Light (Eds.), *Learning with computers: Analysing productive interaction* (pp. 10-23). London: Routledge.

Underwood, G., Jindal, N., & Underwood, J. (1994). Gender differences and effects of co-operation in a computer-based language task. *Educational Research, 36*(1), 63-74.

Underwood, G., McCaffrey, M., & Underwood, J. (1990). Gender differences in a computer-based language task. *Educational Research, 32*(1), 44-49.

Underwood, J., Underwood, G., & Wood, D. (2000). When does gender matter? Interactions during computer-based problem solving. *Learning and Instruction, 10*(5), 447-462.

Van Boxtel, C. (2000). Collaborative concept learning. Collaborative learning task, student interaction, and the learning of physics concepts. Doctoral Dissertation, University of Utrecht, The Netherlands: PrintPartners Ipskamp.

Van Boxtel, C., Van der Linden, J., & Kanselaar, G. (2000a). The use of textbooks as a tool during collaborative physics learning. *Journal of Experimental Education, 69*(1), 57-76.

Van Boxtel, C., Van der Linden, J., & Kanselaar, G. (2000b). Deep processing in a collaborative learning environment. In H. Cowie, & G. Van den Aalsvoort (Eds.), *Social interaction in learning and instruction: The meaning of discourse for the construction of knowledge* (pp. 161-178). Amsterdam: Pergamon.

Van der Linden, J., Erkens, G., Schmidt, H., & Renshaw, P. (2000). Collaborative learning. In R.-J. Simons, J. Van der Linden & T. Duffy (Eds.), *New Learning* (pp. 37-55). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Van der Meij, H. (1990).Question asking: To know that you do not know is not enough. *Journal of Educational Psychology 82*(3), 505-512.

Van der Meij, H., De Vries, B., Boersma, K., Pieters, J., & Wegerif, R. (2005) An examiniation of interactional coherence in email use in elementary school. *Computers in Human Behavior 21*(3), 417-439.

Van der Meijden, H. (2000). Teacher guidance during CSCL. In H. Vander Meijden, R. J. Simons, & F. De Jong (Eds.), *Computer supported collaborative learning networks in primary and secondary education. Final Report 2017* (pp. 137-151). Radboud University Nijmegen, The Netherlands.

Van der Meijden, H., (2002). *Communiceren in Euroland.* [Communicating in Euroland]. *Tijdschrift voor Levende Talen, (3)*1, 34-42.

Van der Meijden, H., & Ligorio, M. B. (2004). Creating new classroom culture via a virtual world: A case study. *European Journal of School Psychology 2*(1-2), 201-218.

Van der Meijden, H., Janssen, J., & Ligorio, M. B., (2002). Edgar Degas: Reconstructing his art in a three-dimensional virtual world. Proceedings of the Conference *'Dealing with diversity' of the International Society for Cultural Research and Activity Theory* (pp.71-72). Amsterdam, The Netherlands.

Van der Meijden H., & Veenman, S. (2005). Face-to-face versus computer-mediated communication in a primary school setting. *Computers in Human Behavior 21*(5), 831-859.
Van der Meijden H., & Veenman, S. (in press). Gender group composition, group size, student ability, and the provision of student elaborations within a computer-supported collaborative learning environment. *Computers in Human Behavior.*
Van Zee, E. H. (2000). Analysis of a student-generated inquiry discussion. *International Journal of Science Education, 22*(2), 115-142.
Veerman, A. L. (2000). *Computer-supported collaborative learning through argumentation.* Doctoral Dissertation, University of Utrecht, The Netherlands.
Veerman, A., & Veldhuis-Diermanse, A.E. (2001). Collaborative learning through computer-mediated communication in academic education. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *Proceedings European perspectives on computer supported collaborative learning* (pp. 625-633). University of Maastricht, The Netherlands
Veerman, A., Andriessen, J. E. B., & Kanselaar, G. (2002). Collaborative argumentation in academic education. *Instructional Science, 30*, 155-186.
Veldhuis-Diermanse, A. E. (2002). *CSCLearning? Participation, learning activities and knowledge construction in computer-supported collaborative learning in higher education*. Doctoral Dissertation, Wageningen University, The Netherlands.
Verba, M., & Winnykamen, F. (1992). Expert-novice interactions: Influence of partner status. *European Journal of Psychology of Education, 7*(1), 61-71).
Vermunt, J. (1992). Leerstijlen en het sturen van leerprocessen in het hoger onderwijs. [Learning styles and the regulation of learning in higher education]. Doctoral Dissertation. University of Tilburg, The Netherlands
Verschaffel, L. (2000). Cognitive effects. In H. Van der Meijden, R. J. Simons, & F. De Jong (Eds.), *Computer supported collaborative learning networks in primary and secondary education. Final report 2017* (pp. 53-57). Radboud University Nijmegen, The Netherlands.
Verschaffel, L., & De Corte, E. (1998). Actief en constructief leren binnen krachtige onderwijsleeromgevingen. In L. Verschaffel, & J. Vermunt (Eds.), *Onderwijskundig Lexicon*, III, (pp. 15-27). Alphen a/d Rijn: Samson.
Verschaffel, L., De Corte, E., Lowyck, J., Dhert, S., & Vandeput, L. (2000). *Supporting Mathematical Problem Solving and Posing in Flemish Upper Elementary School Children by means of Knowledge Forum* (No. TSER project 2017 Computer Supported Collaborative Learning Networks in Primary and Secondary Education). Leuven: University of Leuven, Belgium.
Volman, M., & Van Eck, E. (2001). Gender equity and information technology in education: The second decade. *Review of Educational Research, 71*(4), 613-634.
Von Glaserfeld, E., (1996). Footnotes to "The many faces of constructivism". *Educational Researcher 25*(6),19.
Voogt, J., Almekinders, M., Van den Akker, J., & Moonen, B. (2005). A “blended” in-service arrangement for classroom technology integration: Impacts on teachers and students. *Computers in Human Behavior 21*(3), 523-539.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
Walther, J. B. (1992). Interpersonal effects in computer mediated interaction: A relational perspective. *Communication Research, 19*(1), 52-91.
Webb, N. M. (1984). Sex differences in interaction and achievement in cooperative small groups. *Journal of Educational Psychology, 76*(1), 33-44.
Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research, 13*(1), 21-39.

Webb, N. M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education, 22*(5), 366-389.
Webb, N. M. (1992). Testing a theoretical model of student interaction and learning in small groups. In R. Hertz-Lazarowitz & N. Miller (Eds.), *Interaction in cooperative groups: A theoretical anatomy of group learning* (pp. 102-119). Cambridge: University Press.
Webb, N. M., Ender, P., & Lewis, S. (1986). Problem solving strategies and group learning computer programming. *American Educational Research Journal 23*, 243-261.
Webb, N. M., & Farivar, S. (1994). Promoting helping behavior in Cooperative Small Groups in Middle School Mathematics. *American Educational Research Journal, 31*(2), 369-95
Webb, N. M., & Farivar, S. (1999). Developing productive group interaction in middle school mathematics. In A. O'Donnell & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 117-149). Mahwah, NJ: Lawrence Erlbaum Associates.
Webb, N.M., & Mastergeorge A. (2003) Promoting effective helping behaviour in peer-directed groups. *International Journal of Educational Research 39*, 73-97.
Webb, N. M., & Palincsar, A. S. (1996). Group processes in the classroom. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 841-873). New York: Simon & Schuster MacMillan.
Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology, 87*(3), 406-423.
Webb, N. M., Nemer, K. M., Chizhik, A. W., & Sugrue, B. (1998). Equity issues in collaborative group assessment: Group composition and performance. *American Educational Research Journal, 35*(4), 607-651.
Webb, N., Nemer, K., & Zuniga, S. (2002). Short circuits of superconductors? Effects of group composition on high-achieving students' science assessment performance. *American Educational Research Journal 39*(4), 943-989.
Wegerif, R. (1997). Factors affecting the quality of children's talk at computers. In R.Wegerif & P. Scrimshaw (Eds.). *Computers and talk in the primary classroom*, (pp. 177-186). Clevedon, England: Multilingual Matters Ltd.
Wegerif, R., & Mercer, N. (1997a). A dialogical framework for researching peer talk. In R. Wegerif, & P. Scrimshaw (Eds.), *Computers and talk in the primary classroom* (pp. 49-80). Clevedon, England: Multilingual Matters Ltd.
Wegerif R. & Mercer, N. (1997b). Using computer-based text analysis to integrate qualitative and quantitative methods in research on collaborative learning. *Language and Education 11*(4), 271-286.
Wegerif, R., Mercer, N., & Dawes, L. (1999a). From social interaction to individual reasoning: An empirical investigation of a possible socio-cultural model of cognitive development. *Learning and Instruction, 9*(6), 493-516.
Wegerif, R., Mercer, N., & Dawes, L. (1999b). Children's talk and the development of reasoning in the classroom. *British Educational Research Journal 25*(1), 95-111.
Whitley, B. E. (1997). Gender differences in computer-related attitudes and behavior: A meta-analysis. *Computers in Human Behavior, 13*(1), 1-22.
Wilkinson, I. A. G., & Fung, I. Y. Y. (2002). Small-group composition and peer effects. *International Journal of Educational Research, 37*(5), 425-447.
Winn, W. (1993). *A conceptual basis for educational applications of Virtual Reality.* Human Interface Technology Lab Report No. TR-93-9. [Online April 2004]. Retrieved from: http://www.hitl.washington.edu/publications/r-93-9/.
Wortham, D. W. (1999). Nodal and matrix analyses of communication patters in small groups. In C. Hoadley (Ed.), *Proceedings of CSCL '99. The third international conference on CSCL.* Mahwah, NJ: Lawrence Erlbaum Associates. [Online March 2001]. Retrieved from: http://kn.cilt.org/cscl99/A51/A51.HTM

Zahn, C., Barquero, B, & Schwan, S. (2004). Learning with hyperlinked videos-design criteria and efficient strategies for using audiovisual hypermedia. *Learning and Instruction, 14*(3), 275-291.
Zimmerman, B. J. (2001). Self-regulated learning. In N. Smelser, & P. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 13855-13859). Oxford: Elsevier.

Samenvatting (Summary in Dutch)

Het elaboratiegedrag van leerlingen in een CSCL leeromgeving met synchrone en/of asynchrone communicatie

1. Algemene inleiding

Uitgaande van een constructivistisch perspectief, wordt leren steeds meer gezien als een actief proces waarbij leerlingen hun kennis construeren in interactie met anderen. Samenwerkend leren past in dit perspectief. Onderzoek heeft uitgewezen dat samenwerkend leren een positieve bijdrage levert aan zowel de cognitieve als de sociale ontwikkeling van leerlingen (Cohen, 1994; Dillenbourg, 1999; Johnson & Johnson, 1994; Slavin, 1996). Het invoeren van informatie- en communicatietechnologie (ICT) in het onderwijs heeft nieuwe vormen van samenwerkend leren mogelijk gemaakt waarbij de communicatie tussen leerlingen verloopt via het internet. Leerlingen kunnen gelijktijdig (synchroon) of niet gelijktijdig (asynchroon) vanaf verschillende plaatsen samen leren in een computer ondersteunde leersituatie (computer-supported collaborative learning, afgekort CSCL).

In de drie studies van dit proefschrift ligt de nadruk op het proces van kennisconstructie van leerlingen in verschillende CSCL-omgevingen. De algemene onderzoeksvraag luidt: stimuleert CSCL het proces van kennisconstructie in de vorm van elaboraties? Om deze vraag te kunnen beantwoorden zijn de interacties geanalyseerd van leerlingen die synchroon met elkaar samenwerkten (studie 1), asynchroon met elkaar samenwerkten (studie 2) en van leerlingen die zowel synchroon als asynchroon met elkaar samenwerkten (studie 3).

2. Theoretische achtergronden: computer-supported collaborative learning

Het theoretische kader van dit proefschrift wordt gevormd door een van de perspectieven met betrekking tot leren en ontwikkeling, namelijk het *elaboratie-perspectief*. In het *elaboratie-perspectief* wordt de nadruk gelegd op het cognitieve proces van leerlingen die met elkaar interacteren. Hierbij is elaboratie een belangrijk concept. Dit betreft het geven van gedetailleerde uitleg aan elkaar, bijvoorbeeld door het geven van voorbeelden, argumenten, rechtvaardigingen en toelichtingen. Met dit verbaliseren worden leerlingen deelgenoot van elkaars denkwijzen waardoor reflectie, herstructurering en uitbreiding van kennis mogelijk wordt (King, 1999; Van Boxtel, 2000; Webb & Farivar, 1999). Een van de strategieën om leerlingen het leermateriaal te laten elaboreren is leerlingen het leermateriaal aan elkaar laten uitleggen.

CSCL refereert aan een instructiemethode waarbij studenten samenwerken aan een taak met een gemeenschappelijke doel en waarbij de communicatie tussen de leerlingen verloopt via het internet. Volgens een meta-analyse van Lou, Abrami, en d'Apollonia (2001) leren kinderen meer als ze in kleine groepen aan de computer werken (CSCL) dan wanneer zij individueel werken. Daarnaast stimuleert CSCL taak-gerelateerd gedrag en reflectie (Cohen & Scardamalia, 1998; Hakkarainen, Lipponen, Järvelä, & Niemivirta, 1999), redeneren en argumenteren (Veerman, 2000; Veldhuis-Diermanse, 2002) en het aanleren van complexe natuurkundige concepten (Rochelle, 1992). Bovendien zou CSCL een positieve invloed hebben op de ontwikkeling van metacognitieve vaardigheden (Cohen & Scardamalia, 1998) en motivatie bij de leerlingen (Talamo & Niemivirta, 2000). Bij CSCL kan de communicatie zowel synchroon (gelijktijdig, bijvoorbeeld chat of video-conference) verlopen als asynchroon (bijvoorbeeld e-mail of een discussieforum). Synchrone communicatie, zoals chat, kenmerkt zich door korte bijdragen en veel beurtwisselingen van de deelnemers aan de chat. Er wordt weinig tijd genomen om te reflecteren of nieuwe ideeën uit te werken en op vragen die gesteld worden komt vaak geen antwoord (Veerman & Veldhuis-Diermanse, 2001). Deelnemers worden min of meer gedwongen om snel te reageren om hun aanwezigheid kenbaar te maken door een bijdrage aan de chat. Geen bijdrage betekent voor chatters: afwezigheid van de ander (Van der Meijden, 2002). Bij een chat verdwijnen de bijdragen ook van het beeldscherm. In een asynchroon discussieforum daarentegen, blijft de bijdrage (een "note") van een deelnemer bewaard en is elke bijdrage van een deelnemer zichtbaar in een overzichtelijke boomstructuur. Het grote voordeel van een asynchroon discussieforum boven het gebruik van een chat, is het feit dat deelnemers niet gelijktijdig via de computer met elkaar in verbinding hoeven te staan en niet meteen op elkaar hoeven te reageren. Dat betekent onder andere, dat aan deelnemers tijd gegund wordt om te reflecteren op de eigen bijdragen en die van anderen.

3. Analyse van interacties in een CSCL-omgeving

Voor het analyseren van de interacties van leerlingen in een CSCL-omgeving werd een codeerschema ontwikkeld. Een eerste stap in de ontwikkeling ervan was een literatuurstudie met betrekking tot de inhoudsanalyse van CSCL-interacties. Besloten werd een eigen codeerschema te ontwikkelen op basis van de studie van Henri (1992), aangezien haar methode de basis vormde van manieren om CSCL-interacties te onderzoeken in het afgelopen decennium (Gunawardena, Lowe, & Anderson, 1997; Hara, Bonk, & Angeli, 2000; Lockhorst, 2004; Newman, Webb, & Cochrane, 1995; Veldhuis-Diermanse, 2000). Drie categorieën van Henri (1992) vormden de belangrijkste dimensies voor dit codeerschema, nl. de cognitieve, sociale (affectieve) dimensie en de metacognitieve (regulatieve) dimensie.

De *cognitieve dimensie* heeft betrekking op de wijze waarop de leerlingen het leerproces inhoudelijk uitvoeren. De *affectieve dimensie* heeft betrekking op de wijze waarop de groepsgenoten zich positief of negatief uitlaten over elkaars bijdragen aan de oplossing van het groepsprobleem. De *regulatieve dimensie* heeft betrekking op de metacognitieve uitingen van de leerlingen die gericht zijn op de regulatie van het leerproces (zoals het plannen van de uitvoering van de leertaak of het bewaken van de tijd).

De *cognitieve dimensie* van het codeerschema omvatte 13 categorieën waarvan er drie gericht waren op het stellen van vragen, twee op het antwoord geven, twee op het inbrengen van nieuwe ideeën, twee op het betrekken van eerder besproken onderwerpen in de discussie en vier categorieën waren gericht op het accepteren of verwerpen van elkanders ideeën. De *affectieve dimensie* omvatte één categorie die betrekking had op het proces van samenwerken. De *regulatieve dimensie* telde twee categorieën die betrekking hadden op de uitvoering van de leertaak en het instrueren van de andere leerlingen. Daarnaast werd de categorie "groeten" toegevoegd, waarmee de deelnemers aan de discussie hun aanwezigheid kenbaar maken of afscheid van elkaar nemen. Verbale uitingen die niet in een van deze categorieën konden worden ondergebracht, werden gecodeerd als 'niet-taakgerichte uitingen'. Aldus bestond het codeerschema uit 18 categorieën.

Een verbale uiting kon variëren van één enkel woord tot een uitvoerige monoloog. Segmentering van de verbale uitingen gebeurde op basis van "betekenisvolle eenheden", die werden genomen als eenheid van analyse. Elke betekenisvolle eenheid werd gecodeerd in één van de categorieën van het codeerschema. Om het niveau van elaboratie vast te stellen, werden twee niveaus onderscheiden: *veel elaboratie* en *weinig elaboratie*. Deze indeling was indirect gebaseerd op het werk van Webb, Nemer, Chizhik, en Sugrue (1998). '*Veel elaboratie*' omvatte vijf categorieën uit de cognitieve dimensie, namelijk vragen naar begrip, het geven van uitgebreide uitleg, het inbrengen van een nieuw idee met uitleg, accepteren met uitleg en verwerpen met uitleg. '*Weinig elaboratie*' omvatte de overige acht categorieën uit de cognitieve dimensie.

4. Elaboratiegedrag van leerlingen in een synchrone CSCL-omgeving

Het eerste onderzoek van dit proefschrift had betrekking op het elaboratiegedrag van leerlingen in een synchrone leeromgeving en was het resultaat van samenwerking met het onderzoeksproject "Implementatie van coöperatief leren in het basisonderwijs" (Krol, 2005) aan de Radboud Universiteit te Nijmegen. Ondanks de hoeveelheid literatuur op het terrein van coöperatief leren zijn er weinig studies die zich richten op het verschil tussen interacties in face-to-face versus CSCL situaties.

Dit onderzoek richtte zich op twee vragen: (1) Elaboreren leerlingen die in een face-to-face situatie samenwerken meer of minder als ze in tweetallen aan een rekentaak werken dan tweetallen die in een CSCL-omgeving samenwerken? En (2) Scoren de leerlingen die in een face-to-face situatie samenwerken hoger of lager als ze in tweetallen werken aan een rekentaak dan leerlingen die in een CSCL-omgeving samenwerken?

Aan het onderzoek namen 84 leerlingen deel uit groep acht van negen basisscholen. Bij de aanvang van het onderzoek hadden de betrokken scholen zo goed als geen ervaring met

CL. Er werden twee condities gecreëerd: een face-to-face conditie (de FTF-groep) en een computer-ondersteunde conditie (de CO-groep). In de FTF-groep zaten leerlingen van zeven scholen, waar uit elke klas drie duo's geselecteerd werden (in totaal 21 duo's); in de CO-groep zaten leerlingen van twee scholen, waarvan de hele klas in duo's werd ingedeeld (in totaal 22 duo's). De leerlingen werkten in duo's samen aan een rekentaak. Aan de leerlingen werd uitgelegd hoe ze de taak dienden te maken en hoe de gevonden antwoorden opgeschreven/getypt dienden te worden. De interacties in de FTF-groep werden opgenomen met een videocamera. De CO-duo's werkten synchroon aan de rekentaak in een "private chat-ruimte" via het software-programma Active Worlds (http://www.activeworlds.com/). In de CO-groep werden de chats opgeslagen voor latere analyse. Na beëindigen van de taak, vulde de CO-groep individueel een korte vragenlijst betreffende computervaardigheden in. De rekentaak was gebaseerd op de taak 'rekenen met hefbomen' die door Ros (1994) is ontwikkeld. De rekentaak bestond uit 15 opgaven. Bij de eerste vijf opgaven stond een plaatje van een wip getekend. In het stukje tekst onder het plaatje werd een vraag gesteld. Na overleg moesten de kinderen zelf tekenen of intypen wat zij dachten dat er met de wip zou gebeuren. Nadat de leden van het duo met elkaar overlegd hadden, schreef één van beiden de oplossing op het werkblad (FTF-duo's) of kon elk van hen de oplossing na overleg intypen in het chat-venster (CO-duo's). De maximaal haalbare score was 50 punten.

Tijdens het samenwerken produceerden de duo's in de FTF-groep significant meer uitingen met veel en weinig elaboratie, dan de duo's in de CO-groep. De duo's in de CO-groep produceerden significant meer affectieve en regulatieve uitingen dan de duo's in de FTF-groep. Uit de analyses bleek dat de duo's in de FTF-groep significant hogere scores op de rekentaak behaalden dan de duo's uit de CO-groep. En ze hadden ook vaker de taak binnen de gestelde tijd van 30 minuten af. De duo's met veel computervaardigheden scoorden significant hoger op de rekentaak dan de duo's met weinig computervaardigheden.

Uit de resultaten van dit onderzoek bleek dat de FTF-duo's significant meer elaboratie produceerden, van beide niveaus. In zowel de FTF als de CO conditie was de frequentie van het geven van uitgebreide elaboratie laag. Dit komt overeen met andere studies. Samenwerken houdt niet automatisch een vorm van effectieve interactie in. Leerlingen moeten hierbij zorgvuldig begeleid worden. Onderzoek toont aan dat gerichte training helpt om de leerlingen te leren elkaar uitgebreide uitleg of elaboratie te geven (Fuchs et al., 1999; Webb & Farivar, 1994).

De duo's in de CO conditie gebruikten meer regulatieve uitingen dan de FTF-duo's. in tegenstelling tot de FTF conditie waar de leerlingen naast elkaar werkten aan één werkblad, zagen de leerlingen in de CO conditie elkaar niet, en moesten de taak reguleren via de computer. De CO-duo's gebruikten meer affectieve uitingen dan de FTF-duo's. Studies van Hara, Bonk en Angeli (2000) en De Laat (2002) laten soortgelijke resultaten zien. De FTF-duo's haalden betere resultaten op de rekentaak dan de CO-duo's. Dit komt overeen met onderzoek van Hollingshead, McGrath, en O'Conner (1993) en Straus en McGrath (1994). In de FTF situatie is het blijkbaar makkelijker om de noodzakelijke informatie voor het volbrengen van een bepaalde taak over de brengen dan in een CO situatie.

De resultaten van deze studie laten bovendien zien dat computer- en typvaardigheden een rol spelen bij het uitvoeren van de leertaak. Leerlingen met veel computerervaring kunnen zich geheel concentreren op het inhoudelijk oplossen van de rekenproblemen en hoeven geen aandacht te besteden aan het werken met de computer.

5. Elaboratiegedrag van leerlingen in een asynchrone CSCL-omgeving

Het tweede onderzoek van dit proefschrift had betrekking op het elaboratiegedrag van leerlingen in een asynchrone leeromgeving en was onderdeel van het Europees onderzoeksproject "Computer-supported collaborative learning networks in primary and secondary education" (Van der Meijden, Simons, & De Jong, 2000). In dit tweede onderzoek werden effecten van groepssamenstelling, groepsgrootte, schoolvak en prestatieniveau op het elaboratiegedrag van leerlingen die samenwerken aan een taak met een gemeenschappelijk doel onderzocht.

Uit relevante literatuur is gebleken dat de samenstelling van een groep op basis van geslacht, invloed heeft op het groepsproces. Er zijn verschillen in interacties via de computer tussen jongensgroepen, meisjesgroepen en gemengde groepen (Savicki, Kelly, & Lingenfelder, 1996a,b) op verschillende gebieden, zoals taalgebruik, samenwerking aan het toetsenbord (Underwood, McCaffrey, & Underwood, 1990) en leerprestaties (Light, Littleton, Bale, Joiner, & Messer, 2000). Groepsgrootte kan ook van invloed zijn op het interactiegedrag van de groepsleden. Werken in duo's (zowel in FTF als CO omgevingen) lijkt de voorkeur te genieten boven werken in grotere groepen (Fuchs et al., 2000; Lou et al., 2001; Strijbos, Martens, & Jochems, 2004; Webb, Ender, & Lewis, 1986). De invloed van schoolvakken bij het leren in kleine groepen is eveneens onderzocht. Lou et al. (2001) vonden in hun meta-analyse verschillen in leerresultaten tussen sociale vakken en exacte vakken, ten gunste van de sociale vakken. Onderzoek heeft aangetoond dat het prestatieniveau van de leerlingen eveneens een rol speelt bij de interactie tussen leerlingen die samenwerken aan een gemeenschappelijk doel. Goedpresterende leerlingen zijn in staat tot meer verbale interacties, produceren meer elaboraties en geven meer strategische hulp dan minder goed presterende leerlingen (Fuchs et al., 1996).

Dit tweede onderzoek richtte zich op de volgende vragen: (1) Hoe kan het elaboratie gedrag beschreven worden van leerlingen die in een CSCL-omgeving met elkaar samenwerken aan een taak met een gemeenschappelijk doel? (2) Wat is de kwaliteit van het proces van kennisconstructie bij de deelnemende groepen? (3) Hebben groepssamenstelling op basis van geslacht en groepsgrootte invloed op het elaboratiegedrag? En (4) Hebben schoolvak of prestatieniveau invloed op het elaboratiegedrag?

Aan de studie namen 198 derde en vierdejaars (14-16 jaar) leerlingen deel (116 meisjes en 82 jongens). De klassen kwamen uit de HAVO en VWO-afdeling. De school had geen ervaring met samenwerkend leren met of zonder gebruik van computers. De klassen werden door de leerkrachten verdeeld in groepen, al naar gelang de grootte van de klas en het aantal beschikbare computers. Er werden in totaal 73 groepen gevormd: 36 tweetallen, 22 drietallen en 15 viertallen.

De leerlingen werkten samen aan een taak bij de vakken natuurkunde, biologie en geschiedenis waarbij de leerlingen zelf hun onderzoeksvragen moesten formuleren. De taak werd opgezet met inachtneming van enkele sleutelbegrippen voor samenwerkend leren, namelijk: positieve wederzijdse afhankelijkheid en individuele verantwoordelijkheid (Johnson & Johnson, 1994). De structuur van de taak was voor alle vakken gelijk en bestond uit 6 lessen. De studenten werkten met Web Knowledge Forum (WKF), een asynchroon discussieforum (Scardamalia & Bereiter, 1992). Leerlingen konden hun bijdragen in de vorm van "notes" zetten in een discussieruimte en zij konden reageren op anderen. De bijdragen van de leerlingen waren zichtbaar in een overzichtelijke boomstructuur en konden te allen tijde opgevraagd worden. De bijdragen van de leerlingen werden opgeslagen en later geanalyseerd met behulp van het eerder beschreven codeerschema.

Meer dan de helft van de bijdragen (54.2%) was cognitief van aard. Affectieve en regulatieve bijdragen kwamen veel minder voor, respectievelijk 20.7% en 10.5%. Ongeveer 10% van de bijdragen bestond uit begroetingen en ongeveer 4.5% was niet-taakgericht. Het aantal bijdragen per groep varieerde van 2 tot 61 met een gemiddelde van 2.5 notes per week gedurende de 6 weken van het project. 83.6% van alle groepen heeft tussen de 7 en 30 bijdragen geleverd. Hieruit valt af te leiden dat er sprake was van een brede participatie. De jongens-, meisjes- en gemengde groepen produceerden alle gemiddeld evenveel bijdragen. Er waren wel statistisch significante verschillen met betrekking tot het produceren van uitingen met weinig elaboratie. De gemengde groepen produceerden significant meer uitingen met weinig elaboratie dan meisjesgroepen, die op hun beurt significant meer begroetingen produceerden dan de gemengde groepen. De tweetallen, drietallen en viertallen produceerden alle gemiddeld evenveel bijdragen.. Er waren echter wel statistisch significante verschillen met betrekking tot het niveau van elaboratie en de affectieve en regulatieve bijdragen. De tweetallen produceerden significant meer bijdragen met veel én weinig elaboratie dan de viertallen. De viertallen produceerden significant meer affectieve bijdragen dan de tweetallen en de drietallen. De drietallen produceerden significant meer regulatieve bijdragen dan de tweetallen. Uit de analyses bleek verder dat er geen significante verschillen waren tussen de verschillende schoolvakken met betrekking tot het gemiddeld aantal bijdragen. Er waren echter wel significante verschillen met betrekking het produceren van uitingen met veel én weinig elaboratie, regulatieve bijdragen en begroetingen. De productie van bijdragen met veel én weinig elaboratie was bij de sociale vakken significant hoger dan bij de exacte vakken. De leerlingen in de exacte vakken produceerden significant meer regulatieve bijdragen en meer begroetingen dan de leerlingen in de sociale vakken. Er waren geen significante verschillen tussen de verschillende schooltypen met betrekking tot het gemiddelde aantal bijdragen. Er waren echter wel significante verschillen met betrekking tot het niveau van elaboratie en de affectieve bijdragen, begroetingen en niet-taakgerichte bijdragen. De VWO-leerlingen produceerden significant meer bijdragen met veel én weinig elaboratie en begroetingen. De HAVO-leerlingen produceerden significant meer affectieve bijdragen en niet-taakgerichte bijdragen dan de VWO-leerlingen. VWO-leerlingen stelden meer feitelijke vragen én begripsvragen dan de HAVO-leerlingen.

Uit de resultaten van dit onderzoek - en ander onderzoek - bleek dat de leerlingen taakgericht bezig waren (Guzdial & Turns, 2000; Schellens & Valcke, in press). Het percentage cognitieve bijdragen kwam overeen met resultaten van Lipponen et al. (2002), bij Finse basisschoolkinderen, maar is lager dan de percentages gevonden bij Nederlandse studenten (Veldhuis-Diermanse, 2002) en Vlaamse studenten (Schellens & Valcke, in press). Van het percentage cognitieve bijdragen kon ongeveer 60% gekwalificeerd worden als "uitingen met veel elaboratie". Dit is een hoog percentage in vergelijking met andere studies waarin veel lagere uitkomsten gevonden werden (Fuchs et al., 1999; Webb & Farivar, 1994). Aangezien de leerlingen niet getraind waren in het stellen van vragen zou ons inziens het niveau van elaboratie nog verhoogd kunnen worden na een gerichte training. De resultaten geven aan dat er sprake was van een brede participatie. De meeste groepen produceerden meer dan één bijdrage per week. Hoewel brede en gelijkwaardige participatie gezien wordt als een van de voordelen van CSCL, zijn er verscheidene studies die een ongelijke participatie laten zien (Herring, 1993, 2000) of een zeer lage mate van participatie (Guzdial & Turns, 2000; Lipponen et al., 2002, 2003). Waarschijnlijk heeft de gestructureerdheid van de taak leerlingen gestimuleerd frequent een bijdrage te leveren.

De gemengde groepen produceerden meer uitingen met elaboraties dan de jongens- of meisjesgroepen. Dit is tegengesteld aan onderzoek van Underwood en anderen (1990, 1994), waar gemengde groepen slechter presteerden dan groepen van hetzelfde geslacht. Uit dit onderzoek blijkt dat de interacties van leerlingen beïnvloed worden door het geslacht van de leerlingen met wie zij samenwerken. We hadden verwacht dat de tweetallen meer bijdragen zouden leveren, aangezien zij minder leden in hun groep hadden en deze communicatie gedragen werd door twee groepsleden (Fuchs et al., 2000; Strijbos et al., 2004). De tweetallen gaven wél statistisch significant meer uitingen met veel én met weinig elaboratie dan de viertallen. Dit komt overeen met een meta-analyse van Lou et al. (2001). Grotere groepen produceren meer affectieve en regulatieve bijdragen. Blijkbaar moesten de drie- en viertallen meer inspanningen verrichten om het uitvoeren van de taak te coördineren (De Jong et al., 2005). Hoewel de structuur van de taak in alle vakken gelijk was, is het onderwerp van de taak blijkbaar van grote invloed op de interacties van leerlingen (Cohen, 1994; Webb & Farivar, 1994), evenals het prestatieniveau. In onderzoek van Fuchs et al. (1996) en King (1989) werd eerder een relatie aangetoond tussen leerprestaties en het elaboratiegedrag van leerlingen in een FTF collaboratieve setting. Het huidige onderzoek toont deze relatie aan in een CSCL-omgeving.

6. Elaboratiegedrag van leerlingen in een drie-dimensionale leeromgeving met synchrone en asynchrone communicatie

Het derde onderzoek van dit proefschrift had betrekking op het elaboratiegedrag van leerlingen in een driedimensionale (3D) leeromgeving met synchrone en asynchrone communicatievormen. Deze studie maakte onderdeel uit van een Europees onderzoeksproject (het "Euroland" project) naar internationale samenwerkingsprocessen in een 3D virtuele leeromgeving. In deze studie werd het elaboratiegedrag onderzocht van Nederlandse en Italiaanse leerlingen van middelbare en basisscholen die met elkaar samenwerkten.

In dit onderzoek werd gebruik gemaakt van driedimensionale Virtual Reality software, Active Worlds (AW) (http//:www.activeworlds.com), een op het internet gebaseerde driedimensionale wereld. Het beste is zulk een wereld voor te stellen als een landschap met verschillende objecten, gebouwen, wegen en bomen, waar een persoon, in de vorm van een geanimeerd poppetje, een "Avatar[4]", kan rondlopen en kan communiceren met anderen. Er kan ingelogd worden als bewoner (citizen) met bouwrechten of als bezoeker (visitor), zonder bouwrechten. De leeromgeving in het AW-programma heeft drie eigenschappen die van belang kunnen zijn voor het onderwijs. Dat is (1) de aantrekkelijke interface, met bewegingsmogelijkheden in drie dimensies; (2) de vorm van communicatie, gebruikers kunnen de representatie van elkaar zien en zo met elkaar communiceren en ook non-verbale informatie uitwisselen; en (3) de mogelijkheid om 3D-objecten te bouwen. In dit project werden verschillende leeractiviteiten naast elkaar gebruikt (blended learning). Er waren activiteiten in de klas, buiten de klas en online in de 3D leeromgeving, met zowel synchrone als asynchrone communicatie.

In dit derde onderzoek werd de vraag gesteld of het zinvol is een asynchroon discussieforum toe te voegen aan een driedimensionale virtuele wereld met synchrone communicatie. De volgende onderzoeksvragen werden geformuleerd: 1) Hoe kunnen de synchrone en asynchrone interacties van leerlingen die samenwerken in een 3D virtuele wereld beschreven worden in termen van cognitieve, affectieve en regulatieve interacties en wat is de kwaliteit van het proces van kennisconstructie? 2) Bestaan er verschillen tussen de synchrone en asynchrone interacties en 3) Heeft het toevoegen van een asynchroon discussieforum een meerwaarde voor de leeromgeving?

In 1999 werd gestart met een project om internationale samenwerking tot stand te brengen via computers. Gezien het internationale karakter kreeg dit project de naam "Euroland". In Euroland participeerden ongeveer 42 leerlingen van zeven verschillende

[4] Het woord Avatar werd in India gebruikt voor een god die in verschillende gedaantes kon reïncarneren. Op het internet wordt de avater gebruikt als de belichaming van de gebruiker.

scholen, drie Nederlandse en vier Italiaanse (zowel bovenbouw basisschool als onderbouw voortgezet onderwijs). Er waren één of twee docenten per school bij betrokken en vier onderzoekers, van de universiteiten van Nijmegen, Rome en Salerno.

Er werden wekelijkse virtuele bijeenkomsten gehouden, waar de deelnemers synchroon met elkaar overlegden door middel van een chat. Op deze virtuele bijeenkomsten waren niet steeds alle deelnemers aanwezig, maar altijd wel een van de onderzoekers voor didactische en technische ondersteuning. Daarnaast hadden deelnemers de mogelijkheid asynchroon met elkaar te communiceren via het discussieforum WKF, dat in AW geïntegreerd werd. Het project liep van oktober 1999 tot mei 2000. Aan het begin van het project werd een lege wereld aangeboden. In de eerste bijeenkomst werd door een aantal leerlingen, docenten en onderzoekers gebrainstormd over de inhoud van het project. De taak was open: de bouw en inrichting van enkele “culturele huizen”. Om samenwerking te bereiken en communicatie te bevorderen, werd een vorm van wederzijdse afhankelijkheid gecreëerd: de Nederlandse kinderen moesten de Italiaanse huizen bouwen en inrichten, en andersom. Ongeveer 80 uur synchrone communicatie werd opgeslagen, evenals alle bijdragen van leerlingen in WKF. Van de in totaal 44 synchrone virtuele bijeenkomsten werden 9 “chat sessies” en 9 “views” met in totaal 99 bijdragen van het asynchrone discussieforum inhoudelijk geanalyseerd aan de hand van het eerder vermelde codeerschema .

Voor wat betreft *de synchrone chat* bleek dat bijna 36.5% van de bijdragen cognitief van aard was met 28% regulatieve bijdragen en bijna 16% affectieve bijdragen. Het percentage begroetingen lag op 18% en dat van niet-taakgerichte interacties op 1.5%. Van de cognitieve bijdragen bleek 11.2% bijdragen te zijn met veel elaboratie en 88.2% met weinig elaboratie. In het *asynchroon discussieforum* was 56% van de bijdragen cognitief van aard, 9% regulatief en 7% affectief van aard. Het percentage begroetingen lag op 28% en er waren geen niet-taakgerichte interacties. Van de cognitieve bijdragen bleek 57% interacties te zijn met veel elaboratie en 43% met weinig elaboratie. Uit de analyses bleek dat er statistisch significante verschillen waren tussen de synchrone en asynchrone bijdragen met betrekking tot bijdragen met weinig elaboratie, ten gunste van de asynchrone communicatievorm, de verschillen waren echter niet significant met betrekking tot de bijdragen met veel elaboratie. In de synchrone chat werden meer affectieve en regulatieve bijdragen en begroetingen geproduceerd dan in het asynchroon discussieforum. Om na te gaan of het toevoegen van een asynchrone discussievorm meerwaarde had voor de activiteiten in de leeromgeving, werd een kwalitatieve analyse uitgevoerd met betrekking tot de referenties in de chat naar het discussieforum en omgekeerd, van het discussieforum naar de chat. Uit deze analyse bleek dat er een wisselwerking was tussen de synchrone chat en het asynchrone discussieforum.

Het percentage cognitieve bijdragen in de synchrone chat was laag, lager dan in de andere studie van dit proefschrift. Een van de verklaringen daarvoor zou kunnen zijn dat directe synchrone communicatie via chat, niet geschikt is voor taaluitingen met een hoge mate van elaboratie. Leerlingen zijn meer bezig met het typen van een antwoord dan met de inhoud van dat antwoord (Wegerif, 1997). De uitingen in het asynchrone discussieforum waren hoofdzakelijk uitingen met een hoge mate van elaboratie. Het forum werd gebruikt voor het stellen van complexe vragen, waarop veel complexe antwoorden kwamen, soms van meerdere leerlingen.

In de synchrone chat kwamen veel meer regulatieve bijdragen voor dan in het asynchroon discussieforum, met name het geven van instructies aan de ander over het gebruik van het programma. Het grote aantal affectieve bijdragen en begroetingen is waarschijnlijk te danken aan de duur van dit onderzoek. Leerlingen begonnen elkaar beter te leren kennen en interesse in elkaar te krijgen. In het asynchroon discussieforum begon en eindigde vrijwel elke bijdrage met een begroeting, waarschijnlijk omdat de leerlingen niet wisten wanneer hun bijdrage gelezen zou worden en door wie. Deze resultaten geven aan dat het asynchrone discussieforum een zinvolle aanvulling vormde op de synchrone chat. De synchrone chats hebben met name een sociale functie. Het uitwisselen van taakgerichte informatie vindt voornamelijk plaats via het asynchrone discussie forum. Wellicht is het zo dat de asynchrone communicatie gestimuleerd wordt door de synchrone communicatie en daardoor effectiever kan verlopen.

7. Conclusies en discussie

Vanwege de grote verschillen tussen de drie studies, bijvoorbeeld in leeftijd van de leerlingen, type school, type taak, kan slechts een globale vergelijking gemaakt worden. Uit de resultaten van deze drie studies kan geconcludeerd worden dat de CSCL-omgevingen de mogelijkheid bieden om een proces van kennisconstructie op gang te brengen. Op de eerste plaats biedt een CSCL-omgeving leerlingen de mogelijkheid om informatie uit te wisselen, vragen te stellen en uitleg te geven. Ten tweede kan een CSCL-omgeving een opslagruimte voor informatie bieden en als zodanig voor leerlingen de mogelijkheid om in een later stadium weer informatie op te vragen. In de derde plaats biedt een CSCL-omgeving de mogelijkheid om de buitenwereld in de klas te halen (Lockhorst, 2004).

In alle studies werd een substantieel aantal cognitieve bijdragen geproduceerd. De leerlingen waren over het algemeen zeer taakgericht aan het werk en werden weinig afgeleid. Onze resultaten geven aan dat een asynchrone leeromgeving een goede omgeving is voor het grondig leren van inhouden. Maar als sociale interactie met anderen het belangrijkste leerdoel is, dan is een synchrone chat meer geschikt dan een asynchroon communicatiemedium. Onze resultaten geven verder aan dat leerlingen beter in tweetallen kunnen samenwerken in een CSCL-omgeving dan in grotere groepen. Ook de samenstelling van de groep, zowel met betrekking tot geslacht als prestatieniveau van de leerlingen heeft invloed op de interacties van leerlingen bij CSCL. In het algemeen kan gesteld worden dat bij het uitvoeren van een taak in een CSCL-omgeving, de leerlingen meer aandacht moeten besteden aan de regulatie van de taak. Hoe groter de groep waarin leerlingen samen werken, des te meer regulatieactiviteiten er ontplooid moeten worden (Strijbos, 2004). In alle studies kwamen weinig affectieve interacties tot stand. In de eerste studie werden nauwelijks affectieve bijdragen geobserveerd. Het percentage affectieve bijdragen lijkt af te hangen van de duur van de taak. Leerlingen moeten elkaar eerst een beetje beter kennen om zich affectief te uiten (Gillies & Ashman, 1998; Van der Meij et al., 2005). Ook het percentage begroetingen lijkt met de duur van de taak samen te hangen. De leerlingen die in een CSCL omgeving samenwerkten aan een taak, waren zelden of nooit afgeleid en bijna altijd taakgericht bezig. Dat mag als een positief resultaat opgevat worden. Zowel FTF- als CSCL-omgevingen lijken de leerlingen te motiveren bij de taak te blijven (Jonassen & Kwonn, 2001; Slavin 1995).

Het niveau van elaboratie in deze studies was niet erg hoog. Betekent dat nu dat we moeten stoppen om CSCL in te voeren in de onderwijspraktijk? Gezien het eerder beschrevene in de discussieparagrafen bij de afzonderlijke discussies, moet het antwoord hierop ontkennend zijn. Wel moet getracht worden enkele verbeteringen aan te brengen om het niveau van elaboratie te verhogen, bijvoorbeeld door het trainen van discussievaardigheden. Daarnaast zou ook de docent een grotere inbreng moeten hebben. Met name de participatie van de docent in de online discussie is van belang, evenals het geven van feedback en het stimuleren van de leerlingen om andere leerlingen van feedback te voorzien. Meer aandacht zou ook besteed moeten worden aan de structuur van de collaboratieve taak en de eisen die aan de leerlingen gesteld worden bij het uitvoeren van de taak.

Op dit moment wordt CSCL hoofdzakelijk gebruikt in het hoger onderwijs. De resultaten van deze onderzoeken geven aan dat CSCL ook toegepast kan worden op de basisschool en in het voortgezet onderwijs. Evenals andere onderwijsinnovaties, zou samenwerkend leren zeer zorgvuldig geïmplementeerd dienen te worden op school (Joyce & Showers, 1995), met een trainingstraject voor leerkrachten en een beleid vanuit het management op lange termijn voor het stimuleren van samenwerkend leren bij leerkrachten.

APPENDICES

Appendix A: Balance beam task
Study 1

Rekentaak

Tijd: ______

Computer Nummer:__________

School:

Samen een rekentaak maken via de computer!

Deze rekentaak bestaat uit 15 opgaven. Het is de bedoeling dat jullie de opgaven *samen* maken. **Je werkt samen met iemand op een andere computer. Je weet niet wie dat is. Het is de bedoeling dat jullie dat ook niet weten!!** Jullie overleggen met elkaar via de computer. Jullie mogen niet op de opgaven blaadjes schrijven, gebruik daar de computer voor. Je mag niet met iemand praten in het computerlokaal, want het kan degene zijn met wie je samenwerkt!! Jullie moeten doen alsof jullie op 2 verschillende scholen zitten en elkaar niet kennen. We gaan kijken of deze rekentaak via de computer gedaan kan worden.

De rekentaak bestaat uit 15 opgaven. Voor het maken van deze taak hebben jullie een uur. Probeer in deze tijd zoveel mogelijk af te hebben. Het is niet erg als jullie in deze tijd niet alles af hebben.

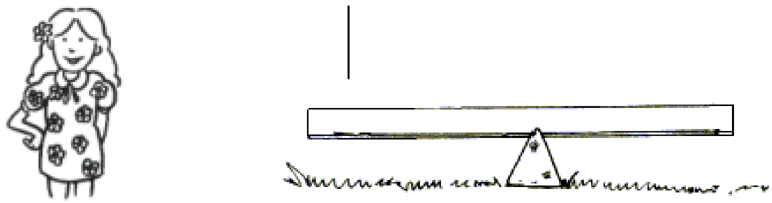
Lees bij elke opgave de instructie goed door. Als jullie een opgave niet goed begrijpen, vraag het dan niet aan de testleider, maar typ je vraag in op de computer. Probeer er *samen* uit te komen.

Op elke bladzijde staat steeds wanneer je de volgende bladzijde van de stapel mag pakken. Volg deze aanwijzingen goed op.

Succes ermee!

Jullie mogen nu bladzijde twee van de stapel pakken.

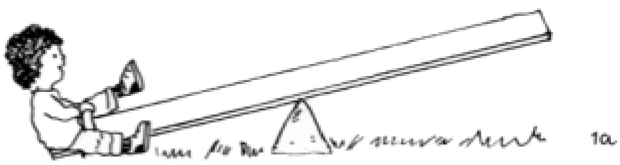
Opgave 1



Hierboven zie je een wip. Naast de wip staat een kind. Stel dat het kind op het linker uiteinde van de wip gaat zitten, wat zal er dan gebeuren? Overleg met z'n tweeën hierover via de computer. *Zijn jullie het samen eens geworden?* Ja? Beschrijf dan wat er volgens jullie met de wip zal gebeuren. Als jullie daarmee klaar zijn, mogen jullie bladzijde drie van de stapel pakken.

(Volgende pagina)--

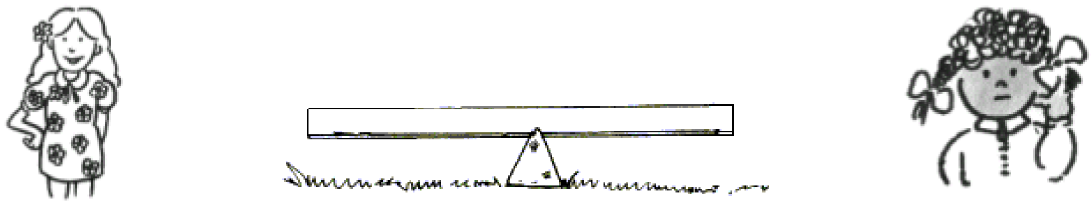
Antwoord opgave 1



Als het kind op een uiteinde van de wip gaat zitten, zal dat uiteinde van de wip naar beneden gaan, omdat dat het zwaarste is geworden. De kant van de wip met het meeste gewicht erop gaat naar beneden.

Hadden jullie dit goed? Overleg met z'n tweeën via de computer of je dit allebei begrijpt. Als jullie het allebei begrijpen, mogen jullie bladzijde vier van de stapel pakken.

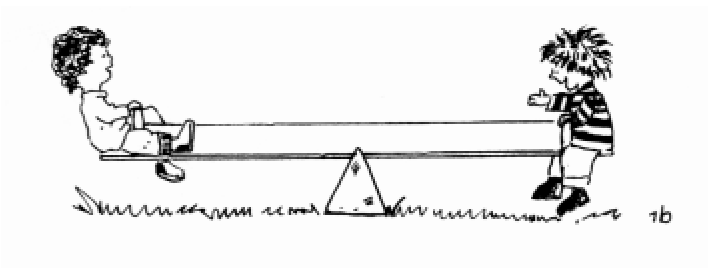
Opgave 2



Net als bij de eerste opgave zie je hierboven weer een wip. Nu staan er aan allebei de uiteinden van de wip een kind. De kinderen zijn even zwaar. Stel dat op allebei de uiteinden van de wip een kind gaat zitten, wat zal er dan gebeuren? Overleg met z'n tweeën hierover via de computer. *Zijn jullie het samen eens geworden?* Ja? Beschrijf dan wat er volgens jullie zal gebeuren. Als jullie hiermee klaar zijn, mogen jullie bladzijde vijf van de stapel pakken.

(Volgende pagina)---

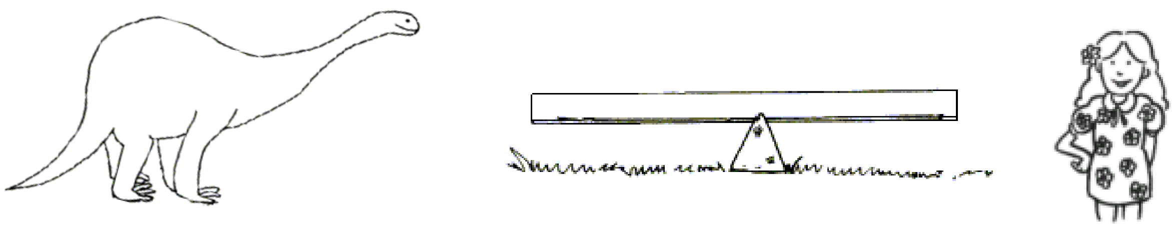
Antwoord opgave 2



Als twee kinderen die even zwaar zijn op de wip gaan zitten, dan blijft de wip in evenwicht. Aan beide kanten van de wip is dan evenveel gewicht.

Hadden jullie dit goed? Overleg met z'n tweeën via de computer of je dit allebei begrijpt. Als jullie het allebei begrijpen, mogen jullie bladzijde zes van de stapel pakken.

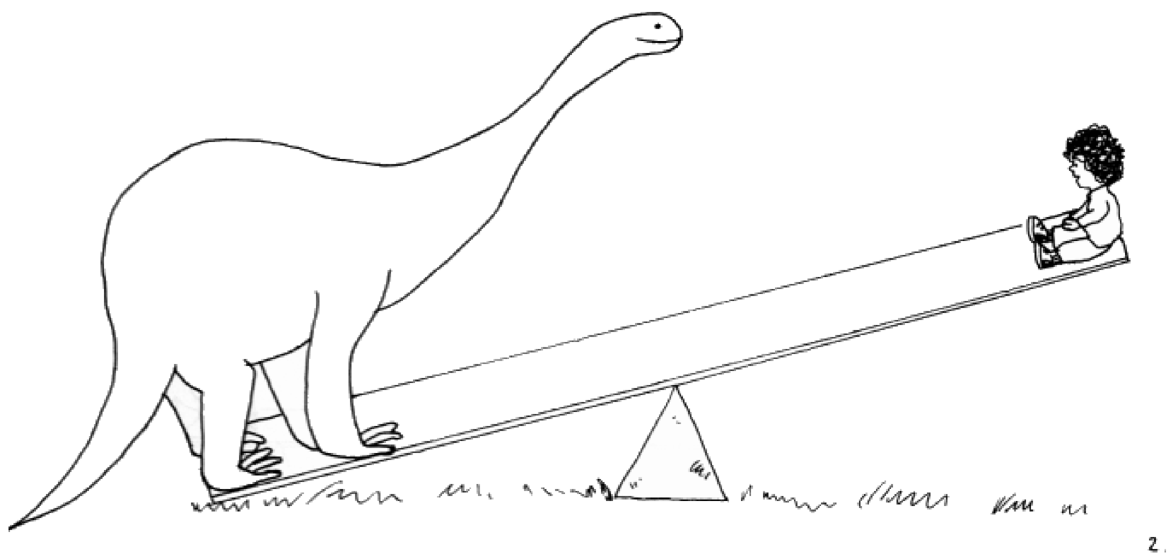
Opgave 3



Ook nu zie je weer een wip. Nu staat aan de linkerkant van de wip een dinosaurus en aan de rechterkant van de wip een kind. Stel dat de dinosaurus op de linkerkant van de wip gaat zitten, en het kind aan de rechterkant, wat zal er dan gebeuren? Overleg met z'n tweeën hierover. *Zijn jullie het samen eens geworden?* Ja? Beschrijf dan wat er volgens jullie zal gebeuren met de wip. Als jullie daarmee klaar zijn, mogen jullie bladzijde zeven van de stapel pakken.

(Volgende pagina)--

Antwoord opgave 3



De dinosaurus is veel zwaarder dan het kind. Net als bij opgave 1 heeft de linkerkant van de wip het meeste gewicht, dus zal deze kant van de wip naar beneden gaan.

Hadden jullie dit goed? Overleg met z'n tweeën via de computer of je dit allebei begrijpt. Als jullie het allebei begrijpen, mogen jullie bladzijde acht van de stapel pakken.

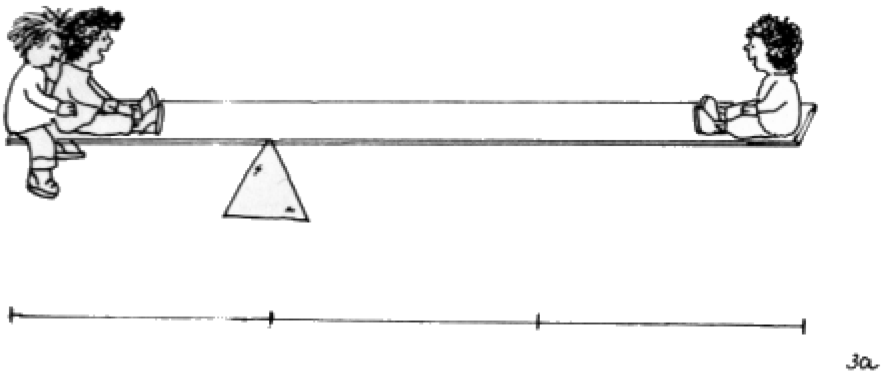
Opgave 4

De wip die jullie hierboven zien is anders dan de vorige drie wippen. Het steunpunt van de wip staat nu niet in het midden, maar meer naar links. Het gedeelte rechts van het steunpunt is nu *twee keer zo lang* als het gedeelte links van het steunpunt.

Aan de linkerkant van de wip staan twee kinderen en aan de rechterkant van de wip staat één kind. Stel dat de twee kinderen op de korte linkerkant gaan zitten, en dat het andere kind op de langere rechterkant gaat zitten, wat zal er dan gebeuren? Overleg met z'n tweeën hierover. *Zijn jullie het samen eens geworden?* Ja? Beschrijf dan wat er volgens jullie zal gebeuren op dit blad. Als jullie daarmee klaar zijn, mogen jullie bladzijde negen van de stapel pakken.

(Volgende pagina)---

Antwoord opgave 4



Als het steunpunt van de wip niet in het midden van de wip staat, is aan de lange kant van de wip altijd *minder* gewicht nodig om de wip in evenwicht te krijgen. In dit geval is de lange kant van de wip twee keer zo lang als de korte kant. Er is dan twee keer zo *weinig* gewicht nodig om de wip in evenwicht te brengen. Op de korte kant zitten twee kinderen. Aan de lange kant is twee keer zo weinig gewicht nodig, dus hoeft daar maar één kind op te zitten om de wip in evenwicht te brengen. In dit geval is de wip dus in evenwicht.

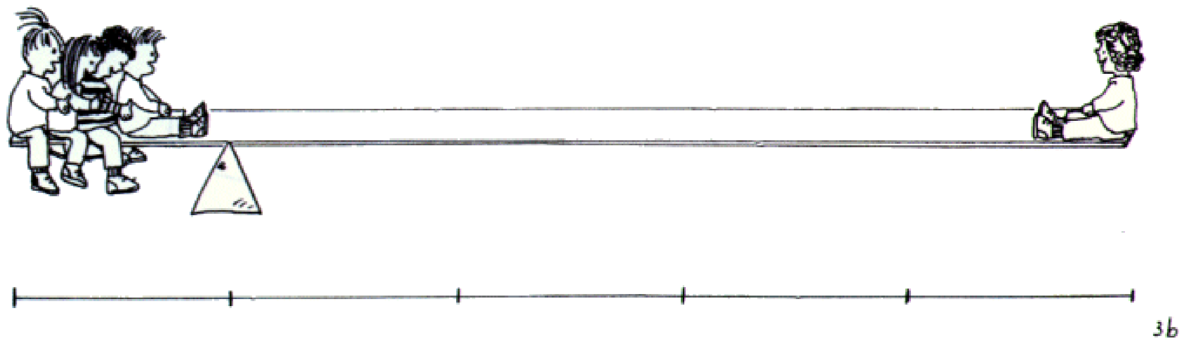
Hadden jullie dit goed? Overleg met z'n tweeën via de computer of je dit allebei begrijpt. Als jullie het allebei begrijpen, mogen jullie bladzijde tien van de stapel pakken.

Opgave 5

Ook bij deze wip zit het steunpunt niet in het midden. De lange rechterkant is vier keer zo lang als de korte linkerkant. Aan de linkerkant van de wip staan vier kinderen en aan de rechterkant staat één kind. Stel dat de vier kinderen op de linkerkant van de wip gaan zitten en het ene kind op de rechterkant van de wip, wat zal er dan gebeuren? Overleg met z'n tweeën via de computer hierover. *Zijn jullie het samen eens geworden?* Ja? Beschrijf dan wat er volgens jullie zal gebeuren op dit blad. Als jullie daarmee klaar zijn, mogen jullie bladzijde elf van de stapel pakken.

(Volgende pagina)---

Antwoord opgave 5



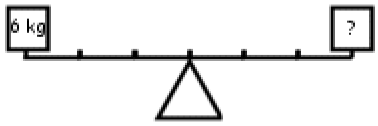
Aan de lange kant van de wip is dus altijd minder gewicht nodig om de wip in evenwicht te brengen. De lange kant van de wip is in dit geval vier keer zo lang als de korte kant van de wip. Het gewicht op de lange kant is in dit geval ook vier keer zo klein, want er zit maar één kind in plaats van vier kinderen. De wip is in dit geval dus in evenwicht.

Hadden jullie dit goed? Overleg met z'n tweeën via de computer of je dit allebei begrijpt. Als jullie het allebei begrijpen, mogen jullie bladzijde twaalf, dertien en veertien van de stapel pakken.

Opgave 6 tot en met 15

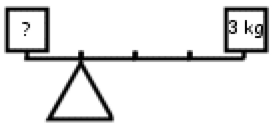
Bij de vorige vijf opgaven hebben jullie gezien hoe een wip werkt. Het is de bedoeling dat jullie nu gaan proberen om de volgende tien sommen samen op te lossen. Het is de bedoeling dat jullie bij elke som overleggen via de computer over het antwoord. *Pas als je het allebei eens bent met het antwoord en ook allebei het antwoord begrijpt, geef je allebei het antwoord*. Daarna gaan jullie verder met de volgende vraag. Als jullie alle vragen af hebben, laat je de computer gewoon aan staan. Verder niets doen. Jullie antwoorden zullen nagekeken worden en jullie krijgen er samen één cijfer voor.

6. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.



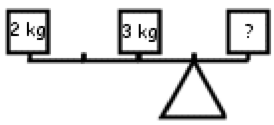
- Antwoord: ____ kilogram

7. Hoeveel kilogram moet er op het linker-uiteinde van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.



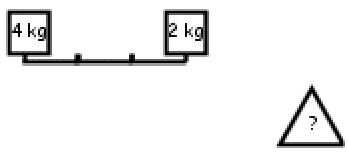
- Antwoord: ____ kilogram

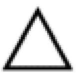
8. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.



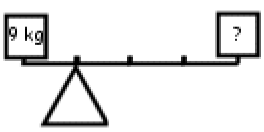
- Antwoord: ___ kilogram

9. Waar moet het steunpunt van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.

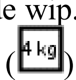


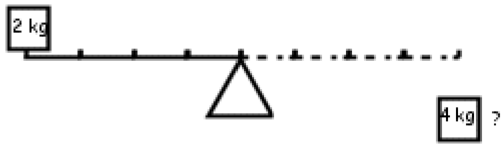
- Waar komt het steunpunt  onder de wip te staan?
- Antwoord: bij letter____

10. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.



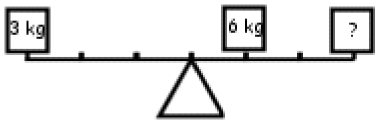
- Antwoord: ___ kilogram

11. Kijk naar de wip. Waar zou het blokje met 4 kilogram () moeten staan, zó dat er evenwicht is? Overleg via de computer over het antwoord.



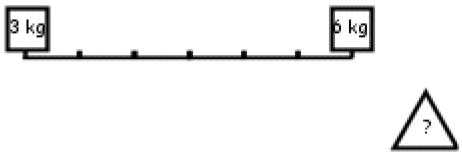
- Antwoord: bij letter____

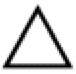
12. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen? Overleg via de computer over het antwoord.



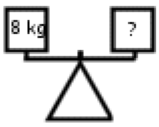
- Antwoord: ___ kilogram

13. Waar moet het steunpunt van de wip komen om evenwicht te krijgen?



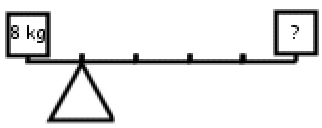
- Teken het steunpunt  onder de wip.
- Antwoord: bij letter____

14. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen?



- Antwoord: __ kilogram

15. Hoeveel kilogram moet er op het rechter-uiteinde van de wip komen om evenwicht te krijgen?



- Antwoord: ___ kilogram

Appendix B: Questionnaire: Student's perception on collaboration
Study 1

School: Naam:

Wat vond je van de rekentaak die je met de computer hebt gedaan?

Uitleg:	
1 = helemaal mee oneens	4 = mee eens
2 = mee oneens	5 = helemaal mee eens
3 = niet mee oneens en niet mee eens	

1. Ik vond de taak leuk	1	2	3	4	5
2. We konden het makkelijk eens worden over hoe we de taak op zouden lossen	1	2	3	4	5
3. We hebben fijn samengewerkt	1	2	3	4	5
4. Ik begreep de bedoeling van de taak	1	2	3	4	5
5. We hebben naar elkaars ideeën gekeken tijdens het werken aan de taak	1	2	3	4	5
6. We hebben samen bedacht hoe we de taak zouden oplossen	1	2	3	4	5
7. Ik vond de taak moeilijk	1	2	3	4	5
8. Ik wil nog wel een keer zo'n taak met de computer maken	1	2	3	4	5
9. We hebben elkaar goed geholpen tijdens het oplossen van de taak	1	2	3	4	5
10. We hebben allebei even veel moeite gedaan om de taak op te lossen	1	2	3	4	5
11. Ik vond dat de taak te veel opgaven had	1	2	3	4	5
12 Tijdens het samenwerken zijn we vergeten de tijd in de gaten te houden	1	2	3	4	5
13. We hebben het uiteindelijke antwoord pas opgeschreven als we het er samen over eens waren	1	2	3	4	5
14. Ik vond dat we te weinig tijd hadden om de taak af te krijgen	1	2	3	4	5

15. Ik vind het samen bedenken van antwoorden erg leuk	1	2	3	4	5
16. Ik leer meer als ik met iemand samenwerk dan wanneer ik het alleen zou doen	1	2	3	4	5

Bedankt voor je medewerking!!!!

Appendix C:Questionnaire: Student's computer skills
Study 1

Wat doe je met de computer?

Naam:

1. Hoe vaak zit je achter een computer? (kruis 1 hokje aan)
   - ? nooit
   - ? minder dan 1 x per week
   - ? een paar keer per week
   - ? iedere dag

2. Waar zit je het meest achter de computer? (kruis 1 hokje aan)
   - ? op school
   - ? thuis
   - ? ergens anders

3. Als je achter de computer zit, wat doe je dan meestal? (je mag meerdere hokjes aankruisen)
   - ? spelletjes
   - ? huiswerk
   - ? tekst verwerken (bijvoorbeeld met "word")
   - ? internetten
   - ? e-mailen
   - ? chatten
   - ? anders, namelijk…………..

4. Als je een stukje tekst moet typen op de computer, gaat dat
   - ? heel snel
   - ? best snel
   - ? langzaam

5. Als je een stukje tekst moet typen op de computer, dan typ je met

? één vinger
   - ? twee vingers
   - ? meer dan twee vingers
   - ? tien vingers

6. Als je een spelletje speelt op de computer, welk spelletje is dat meestal?
(Je mag meer dan 1 spel invullen)

7. Zit je op type- les? (of heb je een type-diploma?)

? ja
? nee

Appendix D: Guidelines for lessons on natural science and social science
Study 2: natural science

Groupware-project: Gezondheid, wat een zorg!

Docent:
Klas: HAVO 4 (HA42)
Vak: Biologie

Opdracht 1
Deze opdracht wordt in de klas gedaan.

De leerlingen lezen een tekst. Na de tekst volgen er vier vragen over gezondheidszorg.
De leerlingen gaan na wat ze er zelf al van weten (samenwerking/taakverdeling).
Daarna worden de vier vragen (onderwerpen) verdeeld.

Opdracht 2
Deze opdracht kan (gedeeltelijk) buiten de les worden gedaan.

De leerlingen formuleren individueel vragen over wat ze nog meer willen weten over het onderwerp en gaan op zoek naar antwoorden.

Opdracht 3
Deze opdracht wordt in de les gedaan.

De leerlingen maken kennis met Web Knowledge Forum.
Ze maken achter de note van de klas een note met hun groepje.
Daarachter maken ze individueel een note over hun eigen onderwerp.
De eerste note daarachter wordt een note met wat ze zelf al wisten over het onderwerp.
Opm. opdracht 2 en 3 kunnen in omgekeerde volgorde: De helft van de klas werkt aan opdracht 2, de helft aan opdracht 3. De les daarna worden de rollen omgedraaid.

Opdracht 4
De opdracht wordt gedeeltelijk binnen de les gedaan.
De leerlingen die niet aan een computer terecht kunnen werken aan andere opdrachten.

De leerlingen zetten hun vragen en antwoorden in de workspace.
Ze maken ook een note met hun eigen mening.

Opdracht 5
Deze opdracht wordt gedeeltelijk binnen de les gedaan.
De leerlingen die niet aan een computer terecht kunnen werken aan andere opdrachten.

De leerlingen reageren op de notes met “mijn mening”van andere leerlingen die bezig zijn geweest met hetzelfde onderwerp.Verder kunnen ze ook in een speciale note hun mening geven over de opdracht en deze manier van werken.

Leestekst

Zorgen voor je gezondheid is belangrijk. Daar kun je zelf ook veel aan doen: letten op wat je eet; letten op hygiëne; zorgen voor voldoende lichaamsbeweging en ontspanning naast je studie of werk.

Toch kan het mis gaan. Je krijgt griep of breekt een arm. Sommigen komen in aanraking met drugs en kunnen misschien niet meer zonder. Je kunt zelf ook zoveel gaan tobben dat je er ziek van wordt. Heel kleine kinderen kunnen n iet zelf voor hun gezondheid zorgen. Ze kunnen zelfs niet goed aangeven wat er aan mankeert als er iets mis is. Ze zijn afhankelijk van anderen.

Ook heeft niet iedereen van nature een goede gezondheid en een sterk gestel. Er zijn mensen die moeten leven met een handicap als gevolg van een aangeboren afwijking of een ongeluk. En als we oud worden gaat het met onze gezondheid meestal ook minder goed.

Kortom, gezondheidszorg is inderdaad een hele zorg. Maar voor wie eigenlijk? Alleen voor wie het betreft, of is het meer een zorg voor ons gezamenlijk, voor de maatschappij? En hoe regelen we dat allemaal? Hoe zorgen we ervoor dat de kans op ziekte, gebreken en ongelukken zo klein mogelijk blijft? Wat doen we als er hulp nodig is waar mensen zelf niet (meer) voor kunnen zorgen?

Opdracht 1

Deze opdracht doe je samen in de les (je werkt in groepjes van vier).

De leestekst eindigt met een aantal vragen. Om een antwoord op dit soort vragen te vinden gaan jullie een onderzoekje doen. We beperken het tot de volgende onderwerpen:

1. Hoe is de gezondheidszorg geregeld voor heel kleine kinderen (0 tot 4 jaar)?
2. Hoe is de gezondheidszorg geregeld voor bejaarden?
3. Hoe is de gezondheidszorg geregeld voor gehandicapten?
4. Hoe is de gezondheidszorg geregeld voor alcohol- of drugsverslaafden?

1. Ga samen met de andere leerlingen in jouw groepje eens na wat jullie al over deze onderwerpen weten. Zorg er voor dat alle onderwerpen aan de beurt komen. Verdeel het werk als volgt:
   1 leerling zorgt dat iedereen aan het gesprek meedoet.
   1 leerling let er op dat alle onderwerpen voldoende aan bod komen.
   1 leerling noteert kort wat jullie al weten over onderwerp 1 en 2.
   1 leerling noteert kort wat jullie al weten over onderwerp 3 en 4.

   Schrijf meteen goed leesbaar (niet eerst in klad!).
   Wanneer je klaar bent lever je het blaadje in. Jullie docent zorgt dat het vier keer gekopieerd wordt. Daarna krijgt ieder een afdruk.

2. Verdeel nu de vier onderwerpen over de vier leerlingen van jullie groepje.

Opdracht 2

Deze opdracht kan buiten de les worden gedaan (individueel).

1. Bij de vorige opdracht heeft iedereen een onderwerp gekregen. Bedenk bij jouw onderwerp wat je er nog meer van zou willen weten. Formuleer tenminste drie vragen waar je het antwoord nog niet op weet.

2. Ga daarna op zoek naar de antwoorden. Je kunt daarvoor verschillende bronnen gebruiken (boeken, tijdschriften, CD-ROM, Internet, organisaties of instellingen in de buurt).

Opdracht 3

Er wordt eerst een korte uitleg en demonstratie gegeven van het programma Web Knowledge Forum

•

Web Knowledge Forum is een programma op Internet. Het is een ***database*** waar allerlei informatie kan worden ondergebracht. Dat moet wel op een overzichtelijke manier gebeuren. Voor jullie klas en dit project is ruimte gereserveerd. We noemen dat onze ***workspace***. Alle bijdragen in de workspace worden ***notes*** genoemd.

N.B. Het programma is alleen toegankelijk voor personen die daar zijn aangemeld en die een inlognaam en wachtwoord hebben gekregen. Voor jullie is dat in orde gemaakt. Je krijgt jouw inlognaam en wachtwoord van je docent.

De groep aanmelden

Er moet nu eerst een note voor jullie groepje worden gemaakt.
Die moet achter de note van jullie cluster komen die al in de workspace staat.
In principe kan een van de leden van het groepje dit uitvoeren.

1. Een van de leden van het groepje logt in.
2. Zoek daarna de note voor jullie cluster op en klik daarop.
3. Klik op ‘Build-On’ (links op het scherm).
4. Typ bij ‘Title’ **Groep 1** (of Groep 2 enz.).
5. Klik op de knop ‘Co-Authors’.
6. Selecteer nu de andere leden van het groepje (met Ctrl + klikken op de juiste namen).
7. Klik op ‘Add Authors’.
8. Klik op ‘Close Add Authors’.
9. Terug bij de note klik je op ‘Contribute’.
10. Klik tenslotte op ‘Selected View’ (links in beeld) en kijk of alles klopt. (Als dat niet zo is moet je het nog in orde maken).

De deelnemers aanmelden

Achter de note van de groep moeten de notes van de deelnemers van dat groepje komen te staan. Dat moet iedereen zelf in orde maken.

1. Log in met je eigen gebruikersnaam en wachtwoord.

2. Zoek de note van jullie groepje op en klik op die note.
3. Klik op ‘Build On’.
4. Typ bij ‘Title’ jouw onderwerp (Bijvoorbeeld: Gezondheidszorg voor gehandicapten).
5. Klik op ‘Contribute’.

De note met ‘Wat we er al van wisten’

Daarna kun je de note maken met wat jullie al over het onderwerp wisten.

1. Klik op ‘Build On’.
2. Typ bij ‘Title’ **Wat we er al van wisten**
3. Typ in het tekstvak wat jullie hierover hebben opgeschreven.
4. Klik op ‘Contribute’.

Opdracht 4

Deze opdracht kan (gedeeltelijk) buiten de les gedaan worden (individueel).

1. Breng de vragen en de antwoorden daarop onder in de workspace (zie schema). De vragen zijn notes achter jouw onderwerp (build-on), de antwoorden zijn notes achter de vragen (build-on).

2. Daarna maak je achter het onderwerp nog een note met als titel ‘Mijn mening’. Daarin kun je vertellen of de gezondheidszorg voor wat betreft jouw onderwerp volgens jou goed geregeld is. Wat wel, wat niet? Vertel er ook bij waarom je dat vindt. Je kunt ook ideeën opschrijven over hoe het anders zou kunnen.

Opdracht 5

Deze opdracht kan (gedeeltelijk) buiten de les gedaan worden (individueel).

1. Kijk bij andere leerlingen die hetzelfde onderwerp hadden als jij wat zij hebben opgeschreven bij ‘Mijn mening’.

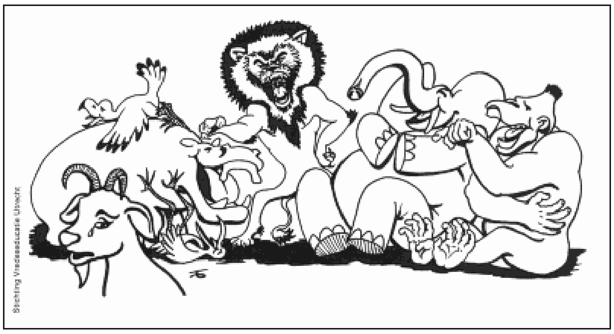
2. Zoek tenminste twee leerlingen waar je het in grote lijnen mee eens bent en maak een note achter die met hun mening, waarin je dat meedeelt.

3. Zoek ook tenminste twee leerlingen waar je het niet (helemaal) mee eens bent. Maak een note achter die met hun mening en schrijf daarin waarom je het er niet mee eens bent.

Er is door de docent ook een note gemaakt met de titel ‘Evaluatie’.

4. Maak achter deze note een note, waarin je vertelt wat je vond van deze opdracht en de manier waarop we dat deden met een workspace op Internet.

Appendix D: Guidelines for lessons on natural science and social science
Study 2: social science



Groupwareproject Geschiedenis Klas GY3a en AT3a

Racisme, discriminatie en vooroordelen

In de afgelopen weken zijn jullie bezig geweest met dictaturen, fascisme en de gevolgen daarvan. Jullie gaan het thema fascisme, en zaken die ermee te maken hebben, zoals bijvoorbeeld racisme, discriminatie en vooroordelen, wat verder uitdiepen. Jullie gaan daarbij in groepen werken aan verschillende onderwerpen. We werken met het programma Web Knowledge Forum.

Les 1. Inleiding samenstelling groepen

We gaan eerst een testje doen. Hoe tolerant ben je zelf. Daarna word je aan een medeleerling gekoppeld. Samen met andere koppels gaan jullie werken aan een van de volgende 5 onderwerpen.

1. **Wettelijke bepalingen**
   Welke wettelijke bepalingen gelden in Nederland t.a.v. racisme en discriminatie, (grondwet, wetboek van strafrecht, leerlingenstatuut). Regels bij sollicitatie, woningtoewijzing, asielbeleid. Zijn er tegenstrijdigheden in regels.

2. **Racistische organisaties en organisaties die daartegen strijden**
   Racistische organisaties, antiracistische organisaties, programma's of doelstellingen, inzet van middelen

   Een voorbeeld:
   Stichting Vredeseducatie. Adres: http://www.xs4all.nl/~vrede/ Zij hebben bijvoorbeeld de tolerantietest gemaakt.

3. **Programma's van politieke partijen**
   Vergelijking programma's van politieke partijen, verschillen asielbeleid, zijn er programma's die in de richting van discriminatie duiden

Een voorbeeld:
Extreemrechtse fusie Nationale Partij opgericht
Op 10 juni 1998 zag een nieuwe extreemrechtse partij het licht: de Nationale Partij Nederland (NPN). Met deze partij probeert een groep gerenommeerde rechts-extremisten, racisten en fascisten de extreemrechtse partijpolitiek nieuw leven in te blazen.

4. **Concrete gevallen**
Concrete gevallen uit de dagelijkse praktijk: school, dorp, Nederland, achterliggende oorzaken
Een voorbeeld:
Uit : de Muurkrant, 1997, 's Hertogenbosch
Een racistisch uitspatting aan het Hugo Vriesthof. Ferme taal van bestuurders en verantwoordelijken. Een hete nazomer in Den Bosch, waar vooroordelen, maar vooral ook slap bestuurlijk handelen aan ten grondslag liggen en waar problemen en racisme met een deken van lieve woorden worden bedekt….. "Wij discrimineren niet, maar ze maken er hier een getto van. Al dat buitenlands eten stinkt. Teveel criminaliteit. Er moeten er niet teveel komen. En dus bekliederen een aantal bewonersvan het hof in de Gestelse buurt een woning die is toegewezen aan een Somalisch gezin, hangen spandoeken op met vol = vol en blokkeren de doorgang voor de woningkandidaten om de toegewezen woning te bekijken.

5. **Slachtoffers**
Slachtoffers van racisme, discriminatie en vooroordelen, ervaringen, trauma's, hulpverlening.

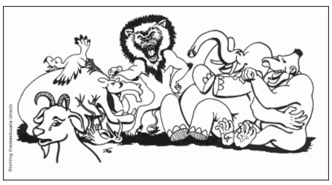
Er zijn meerdere koppels die aan hetzelfde onderwerp werken. Je kunt hen dus altijd vragen stellen of reageren op hun notes in Knowledge Forum. Alle koppels van hetzelfde onderwerp gaan met elkaar samen "brainstormen" over hun onderwerp. Wat weet je er van? Schrijf dit op want dit moet je de volgende les invoeren in Knowledge Forum. Huiswerk: per koppel: Formuleer 3 vragen over zaken waarvan je nog niet voldoende weet, of waarvan je meer zou willen weten. Bijvoorbeeld: Hoe zijn de regels bij woningtoewijzing of wat doet nou iemand die slachtoffer is geworden van discriminatie?

Les 2 Werken met Knowledge Forum

Als je met Knowledge Forum gaat werken, zie je deze onderwerpen al in een view staan. Hier in het voorbeeld: klas GY3a

Geschiedenis GY3A Views

Please select a view:
(Aah!) Moppentrommel *(2)*
(Anti) racistische organisaties *(0)*
Concrete gevallen *(0)*
Politieke partijen *(0)*
Slachtoffers *(0)*
Wettelijke bepalingen *(0)*



AAH!!! MOPPENTROMMEL

Je ziet meteen een interessante view: de Moppentrommel. Daarin kun je alle moppen zetten die bij dit onderwerp horen , discriminerende moppen, moppen met een vooroordeel etc. Je kunt dus moppen die je kent, of die je hoort in deze view zetten. Je kunt daar ook weer op reageren. Wel hebben we afgesproken dat moppen die niet door de beugel kunnen, verwijderd zullen worden. Ook seksistische moppen zullen verwijderd worden.

“Belgenmop”
Twee Belgen hebben fietsen gehuurd en zijn een ritje aan het maken.
Opeens stapt een van de Belgen af, en hij laat uit beide banden lucht lopen.
"Wat doe je nou?" vraagt de ene Belg.
Zegt de ander: "Ja, mijn zadel zit een beetje te hoog."

Per koppel voer je in de view van je eigen onderwerp in wat je er al van wist. Je voert ook je 3 vragen in. Probeer daarbij in de titel al aan te geven waar de vraag over gaat. Bijvoorbeeld: Titel: “vraag over woningtoewijzing”
Kijk bij andere koppels wat die er van weten, kijk naar hun vragen, reageer daar op. Misschien weet je wel het antwoord op een van hun vragen. Zorg ervoor dat je goed kijkt waar je je note op bouwt (“build on”)
Dan ga je op zoek naar de antwoorden van je eigen vragen. Materialen daarbij: boeken, interviews, Internet.

Huiswerk:

Op zoek gaan naar antwoorden op de eigen vragen

Les 3 Knowledge Forum

Voer de gevonden antwoorden in. Dat doe je meteen in de vraag. Dus je zoekt je vraag op, zoekt naar “edit note” en vul je antwoord daar in. Maak een note “eigen mening” over de gevonden stof.

Les 4 Knowledge Forum

Maak van note “eigen mening” over de gevonden stof, als je dat nog niet gedaan hebt in les 3
Geef reacties op de meningen van andere koppels. (build-on)

Huiswerk les 5

Maak per koppel een samenvatting van de informatie die alle koppels bij elkaar hebben gebracht over dit onderwerp
Voer dat in in Knowledge Forum.

Les 6 Evaluatie

Toets en evaluatie (mondeling) van deze manier van werken.

Appendix E: How to work with Web Knowledge Forum?
Study 2

Oefenen met Web Knowledge Forum

Vooraf

Web Knowledge Forum (verder afgekort als KF) is een computerprogramma met een centrale database die in ons geval op een server in Wageningen staat. Er kan veel informatie in worden opgeslagen, die daarna op verschillende manieren kan worden geraadpleegd. De database is meestal verdeeld in een aantal hoofdonderdelen, de **views**. Je moet altijd eerst voor een view kiezen voor je in de database kunt gaan werken. De onderdelen van de views heten **notes.** Als gebruiker kun je nieuwe notes aanmaken of eerder door jouw aangemaakte notes wijzigen. Dat laatste heet **editen**.

Inloggen

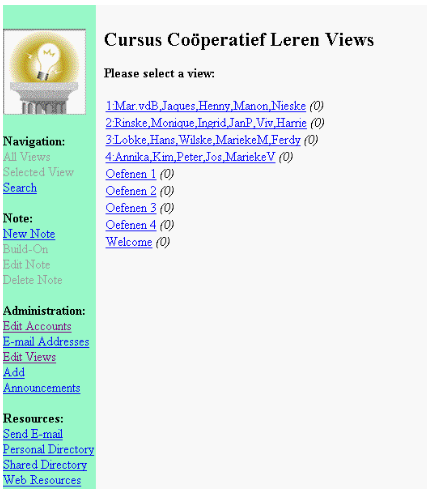
Je kunt alleen toegang tot de database krijgen wanneer je in die database bent ingevoerd als gebruiker. Je hebt daar dan een **account**. Allereerst moet je inloggen. Je komt in de oefendatabase door het adres http://pluk.wau.nl/oefen.html

in te toetsen, als je verbonden bent met het Internet.
Je login name is de eerste letter van je voornaam, dan een punt, dan je achternaam voluit. Geen hoofdletters.

Voorbeeld:
Loginname: h.vandermeijden
Password: h.vandermeijden

Verander het password als je wilt. Dan kan niemand inloggen onder jouw naam. Dit kan door te klikken op ***Change Password*** (te vinden links onder in de groene kolom). Mocht dit niet lukken, dan stuur mij per mail je password, dan doe ik het voor je.(H.vandermeijden@ped.kun.nl)

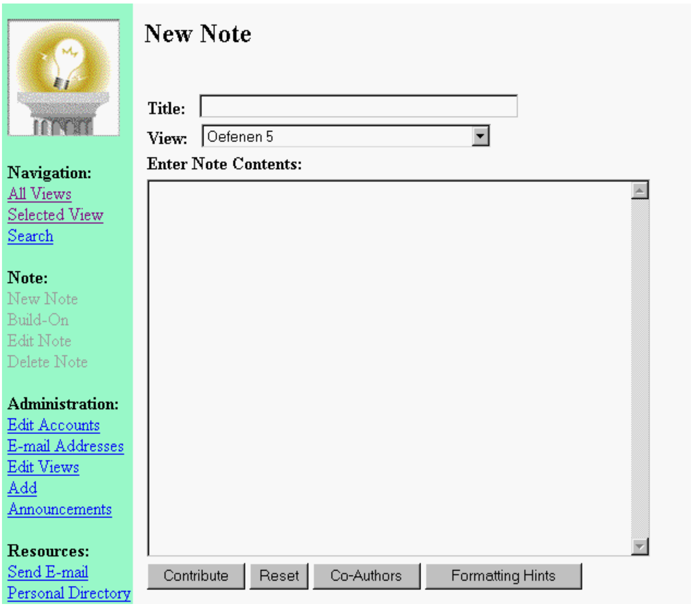
Het venster van KF is verdeeld in twee delen:
Via het linker deel (groen gekleurd) kun je opdrachten doorgegeven.
In het rechter deel (wit) zie je de views en de notes staan. In dit deel kun je ook nieuwe notes invoeren of eerder ingevoerde notes wijzigen.



Om de database overzichtelijk te houden is het belangrijk dat de notes op de goede plaats komen te staan. Dat bereik je door notes achter andere notes te plaatsen waar ze bij horen. We noemen dat **Build On**.

Een New Note maken

1. Log in op de database met je inlognaam en wachtwoord.
2. Klik op de view ***Oefenen (dan je groepsnummer)***
3. Geef de opdracht ***New Note*** (links in het groene deel).
   Het witte deel van het venster wordt nu je invoerscherm.
4. Klik in het tekstvak rechts van ***Title***.
5. Typ een korte omschrijving van het onderwerp waar je aan werkt (nu als voorbeeld: *coöperatief versus collaboratief)* Klik nu in het grote tekstvak onder ***Enter Note Content***.
6. Typ een stukje tekst (nu als voorbeeld: *verschillen tussen coöperatief en collaboratief*)
7. Scroll nu naar beneden (met de schuifbalk rechts in beeld).
   Je ziet dan onder het tekstvak vier knoppen. Die hebben de volgende betekenis:
   (lees dit stukje nu zonder het meteen uit te proberen)



- Contribute (om de note op te slaan in de database op de server).
- **Reset** (om titel en inhoud van de note weer te maken zoals bij het openen voor de bewerking).
- **Co-Authors** (om andere gebruikers medeauteur te maken zodat zij ook de note kunnen wijzigen).
- **Formatting Hints** (hiermee roep je een hulpvenster op met tips over hoe je tekst kunt centreren, vet of schuingedrukt kunt maken enz.)

8. Ga via de opdracht ***Selected View*** terug naar het overzicht.

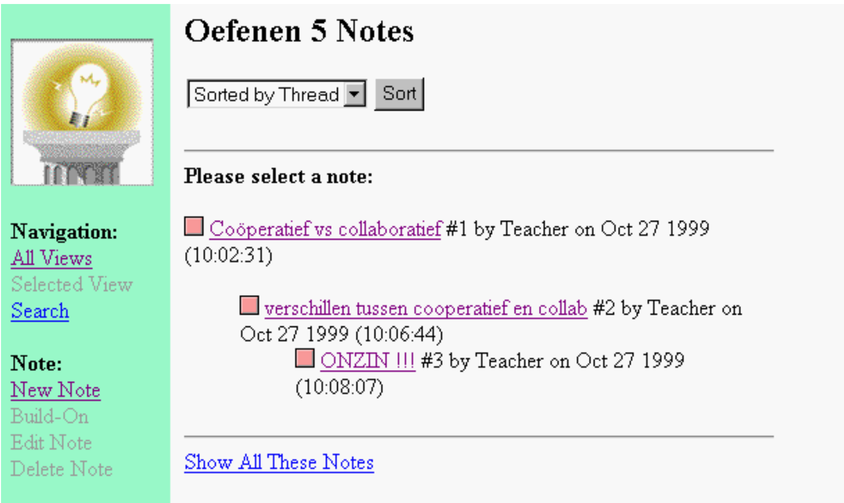
Een Build On Note maken

Let op: Wanneer de volgende note achter de eerste moet komen, moet je altijd eerst die eerste note openen!

1. Klik op de titel van je eerste note.
2. Geef nu de opdracht ***Build-On*** (links in het groene deel).
3. Voer op dezelfde manier als bij je eerste note de titel in.
   Het is belangrijk dat later jijzelf en anderen weten waar jouw note over gaat. Probeer dat in de titel tot uitdrukking te laten komen. Probeer de titel in steekwoorden te zetten. Bij een vraag een " ? " Verzin een titel, met een kort commentaar. Voer daarna de inhoud van de note in.
4. Voeg je andere groepsgenoten toe als co-authors.
5. Klik op de knop ***Contribute*** (onder het tekstvak) om de note op te slaan.
6. Ga via de opdracht ***Selected View*** terug naar het overzicht.

Nog meer notes

Je weet nu hoe je notes invoert. Bij volgende notes is het opnieuw belangrijk dat je er voor zorgt dat ze op de goede plaats komen te staan. In het overzicht zie je de view Oefenen 5. Open die view. Je krijgt dan het volgende te zien



Wanneer een volgende note **op hetzelfde niveau** moet komen als de build on note over de *verschillen tussen coöperatief en collaboratief,* moet je eerst klikken op de note *coöperatief versus collaboratief.* Wanneer een volgende note **achter** de note over moet komen met een vraag of commentaar op de note *verschillen tussen coöperatief en collaboratief* moet je eerst klikken op de note *verschillen tussen coöperatief en collaboratief.*

Open nu weer je oefenview. Daar zijn ondertussen misschien al een paar notes ingekomen.

1. Maak nu een note op hetzelfde niveau als de note *verschillen tussen coöperatief en collaboratief*
2. Maak nog een note achter deze note.

Notes editen

Wanneer je een note achteraf wilt bijwerken, klik je eerst op die note. Daarna geef je de

opdracht ***Edit Note***. Je kunt nu de wijzigingen aanbrengen. Daarna sla je de note weer op met de knop ***Contribute***.
Wanneer bij een note meerdere auteurs zijn opgegeven, kunnen die allemaal de note editen, als dat niet het geval is, kan alleen de auteur de note editen.
Probeer nu eens om een van de notes die je gemaakt hebt te editen.

Notes verwijderen

Je kunt door jou gemaakte notes ook weer verwijderen.
Je klikt dan eerst op die note en daarna geef je de opdracht ***Delete Note***.
NB: Alleen de auteur(s) en de “teachers” kunnen een note verwijderen.

Een referentie note maken

Als je wilt refereren aan een bepaalde note, dan kun je dat doen door het nummer van deze note in te toetsen onder aan de te maken note, en op insert te klikken. De note waaraan gerefereerd wordt, komt dan als link in de note te staan, zodat lezers deze meteen op kunnen vragen.

Dit was het oefengedeelte

veel succes!

Appendix F: List of selected chats
Study 3

chats euroland

	date	pages	participants	content	language
01	12-1	12	DS IS T	building a roof	English
02	12-1	11		use of colors	beginning Italian/rest English
03	12-1	11	DS T	use of colors	English
04	13-1	4	DS T	house of architecture	English
05	19-1	9	DS IS IT T	problems with loggin in	Italian (4 pages English)
06	19-1	8	IS T V(Japan)	working of AW	English (a lot of whisper)
07	20-1	11	DS T V(Italian)	building content	English (7 pages with DS)
08	20-1	3	IS T	tutoring IS	Italian
09	21-1	5	IS T	tutoring IS	Italian
10	21-1	3	T	researchers meeting	Italian
11	24-1	3	T V	conversation with V	English
12	26-1	8	DS IS IT T	talking about pasta	Italian and English
13	26-1	16	DS T V	working of AW	Italian and English
14	27-1	14	IS T V(Japan)	explaining the project to a visitor	Italian (2 pages with DS)
15	27-1	16	T	researcher meeting	Italian
16	2-2	7	IS T	showing the "building"world	Italian
17	2-2	14	IS T	Bari students connected	Italian
18	8-2	15	DS IS T	Bari students connected	Italian (7 pages English)
19	9-2	9	IS T	visiting another world	Italian
20	9-2	13	IS T	server problems	Italian
21	15-2	13	DS IS T	exchanging cultural information	Italian (7 pages English)
22	16-2	12	IS T	Milan building	Italian
23	16-2	14	IS T	Milan and Rome building	Italian
24	18-2	3	DS T	guided tour	English
25	18-2	9	T	teacher meeting	English
26	21-2	11	DS IS T	dutch children asking	Italian, English, Dutch
27	23-2	15	DS IS T	up-loading pictures and sounds	English
28	23-2	9	IS IT T	virus problems	Italian
29	29-2	8	DS IS T	discussing the travel agency	Italian (2 pages Dutch)
30	29-2	11	IS T	discussing materials	Italian
31	4-4	5	T	teacher meeting	Italian
32	4-4	8	DS IS T	exchanging cultural information	Italian and English (4 both)
33	5-4	3	IS T	prize for treasure hunt	Italian
34	5-4	7	DS DT T	reaction to Dutch teacher	English
35	11-4	12	DS T	discussion with DT Venus exhibition	English
36	12-4	11	DS T	connection Amsterdam students	English
37	12-4	15	DS T	visit venus exhibition	English
38	13-4	17	DT IT T	teacher meeting	English
39	14-4	3	DS DT T	talking about Knowledge Forum	English
40	18-4	7	DT T	teacher meeting	English
41	19-4	12	DT IT T	teacher meeting	English
42	19-4	17	DS IS T	bridges and map	English
43	19-4	12	DS DT T	treasure hunt	English
44	29-4	4	T V	visitors in AW	Italian

DS = Dutch student, DT = Dutch teacher, IS = Italian student, IT = Italian teacher, T = tutor, V = visitor

Curriculum vitae (in Dutch)

Henny van der Meijden is in 1955 in Boxtel geboren. Zij behaalde het diploma Gymnasium ß in 1973 aan het Jacob Roelandslyceum in Boxtel. In 1985 behaalde zij het doctoraal diploma Vrije Lettteren (vakdidactiek) aan de Radboud Universiteit Nijmegen. Zij werkte binnen deze Universiteit bij verschillende afdelingen bij de Faculteit |Letteren en Sociale Wetenschappen.

Van 1998-2000 was zij betrokken bij een internationaal onderzoek naar computer supported collaborative learning. Van 2001-2004 was zij een van de onderzoekers van een NWO-aandachtsgebied naar regulatie van leerlingen binnen verschillende electronische leeromgevingen. Voor haar promotie verrichte zij onderzoek naar het elaboratiegedrag van leerlingen (zowel van basisscholen als van het voortgezet onderwijs) die samenwerkten via het internet.

Momenteel is zij als docent werkzaam binnen de opleiding onderwijskunde van de Radboud Universiteit Nijmgen, zowel in het bachelor als masterprogramma, met als specialisaties leren en instructie (ict en leren, leren in sociale contexten) en verzorgt zij trainingen op het gebied van het opzetten en rapporteren van onderwijskundig onderzoek.

Naast haar werk op de universiteit consulteert zij scholen bij het implementeren van samenwerkend leren met en zonder computers.