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Annita Fjuk
University of Oslo, AnnitaFjuk@emailaddressnotknown

Dirckinck Holmfeld
University of Aalborg, DirckinckHolmfeld@emailaddressnotknown

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Articulation of Actions in Distributed Collaborative Learning

Annita Fjuk* and Lone Dirckinck-Holmfeld**

*Department of Informatics, University of Oslo/Intervett AS
**Department of Communication, University of Aalborg

Abstract

The paper is aimed at exploring how CMC (Computer-Mediated Communication) systems and other factors influence distributed and collaborative learning processes for the purpose of systems design. The paper proposes Anselm Strauss' interactionist theory on action as an analytical framework for understanding the pedagogical and technological conditions of distributed and computer-mediated collaborative learning. The paper presents an overview of experiences based on ten years of practice and research at Aalborg University in Denmark with the analytical framework. The experiences of using this framework show that CMC-based distributed collaborative learning entails additional work for the geographically dispersed learners rather than assisting the construction of knowledge and negotiation of meaning. The computer system cannot, in and by itself, support the collaboratively based processes of learning. Rather, distributed collaborative learning is accounted for by entirely different and far more complex factors grounded in the pedagogical approach to learning.

1. Introduction

Computer-mediated communication (CMC) applications—such as e-mail, computer conferencing systems and recently the World Wide Web—have been considered promising with respect to integrating pedagogical principles from collaborative learning methods into new distributed learning situations where the learners are separated geographically (Mason and Kaye 1989, Harasim 1990, Kaye 1992, Harasim *et al.* 1995). This has been particularly emphasized through the European Commission's declaration of 1996 as being the year of

lifelong learning (European Commission 1994). Lifelong learning is about the practice of adults and adolescents in the interrelations of work and learning. Flexible learning situations with respect to place and time allow adults to get new or further education alongside their work (Peters 1993, Holmberg 1995).

Studies of *computer support for collaborative learning* (CSCL) focus on what new opportunities various computer systems give to collaborative learning (see e.g., Schnase and Cunnius 1995, Koschmann 1996), and are to a minor extent focusing on what new conditions are evolved through computer applications with respect to traditional collaborative learning methods. Others focus on the computer applications' role to support effective two-way communication between learners and between tutor and learners (see e.g., Mason and Kaye, 1989, Kaye 1992), rather than focusing on their roles with respect to collective actions such as joint problem solving and opposed perspectives in negotiations.

There are however, recent and limited insights into what the nature of the collaborative processes in a predominately distributed environment is like. Very little is actually known about the collaborative processes themselves and how the computer applications and other circumstances influence the learning processes. A basic understanding of the nature of distributed collaborative processes is totally decisive with respect to designing qualitatively well distributed learning situations. To obtain a deeper understanding of the nature of distributed collaborative learning, this paper aims at integrating practical experiences and theoretical reflections on collaborative learning processes. The practical experiences rest on *problem-oriented project pedagogy* as a method for collaborative learning. Problem-oriented project pedagogy has been the pedagogical foundation of more than ten years of practice in delivering distributed collaborative learning (supported by computer conferencing) at Aalborg University (AAU) in Denmark. Problem-oriented project pedagogy is of a particular interest since its pedagogical principles are fundamentally based on social interactions and cooperative work, including confrontation and negotiation of individual knowledge and interpretation as well as production of shared documents. Experiences and research at AAU show that this pedagogical method is particularly demanding and problematic in distributed situations—both seen in relation to the learner's benefits with regard to improved understanding of the subject and in relation to the learners' mutual process of developing a shared distributed collaborative environment (Dirckinck-Holmfeld 1990, Georgsen 1995). These experiences constitute the empirical basis for our study, focused through a case study undertaken by the first author. Concepts from articulation work, developed by Anselm Strauss (1985, 1988, Strauss *et al.* 1985), applied within a more comprehensive theory on action and interaction in Strauss (1993), constitute the theoretical approach for the analysis. By applying Strauss' concepts, collaboration is understood as a comprehensive phenomenon concerning the interdependent relations of *who* (the individual learner) is doing *what* (actions, outcome, objective), *where* (the context of actions in terms of time and place, cultural and organizational belongings, etc.) and *how*

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(the process of putting the actions into operation).

The paper takes off with a review of features of development and pedagogical approaches to distributed collaborative learning situations. Then follows a more detailed presentation of collaboration as phenomenon put into focus through concepts of interactionist theory of action. These theoretical concepts are then applied to a rethinking of the collaborative processes taking place in distributed project-oriented learning. The paper closes with a discussion of what we have learned from applying the concepts of this theory of collaborative learning in order to inform designers of computer systems which are to mediate actions in distributed collaborative learning.

2. From Distance Education to Distributed Collaboration

Research into CSCW (Computer Supported Cooperative Work) has stimulated the more recent research field of CSCL (Computer Support for Collaborative Learning) (Koshmann 1994). The overall aim of CSCL is to design collaborative situations so that an active construction of knowledge takes place according to the chosen pedagogical approach.

A general understanding of CSCL is that it departs from a view where the teacher is considered the only resource of knowledge and skills, and where teaching is about 'filling up' the learners with knowledge. Instead, primarily the *social-constructive perspective*—with its roots in the 1930s and Vygotsky's (1978) theories on human development—has received renewed interests and has been adopted. Central to the so-

cial-constructivist perspectives is that collaboration between learners, and between learner and teacher, is seen as being of particular importance in the process of learning.

We present two main approaches to CSCL which are of importance to the empirical basis and problem area. One approach has its roots in distance education. The other has its roots in institution-based collaborative learning situations. Finally, we present problem-oriented project pedagogy and relate it to the overall CSCL approaches.

2.1. Approaches to CSCL

One approach to CSCL—practiced in particular under the conditions of *distance education*—focuses on two-way *communication processes* between distance learners and between distance learners and teachers (Mason and Kaye 1989, Harasim 1990, Kaye 1992). In contrast to traditions centered on *collaborative processes* (see below), which have their theoretical and practical basis in institutional situations, the key concept in distance education has been *flexibility* in terms of *when* to study and *where* to study (Peters 1993, Holmberg 1995, Moore and Kearsley 1996). Distance education as a form has, among other things, been carried along by democratic ideals of people's right and opportunity to take part in advanced education or continuous competence development. In agreement with the basic concept of flexibility, learners have the possibility to participate in educational programs from the places which are most suitable for them—typically home or work place—and at the hours that are most convenient. CMC systems based on asynchronous and textual communica-

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tion, such as computer conferencing systems and recently Internet services like the World Wide Web and e-mail—are regarded promising in this connection as, indeed, they support this flexibility. The pedagogical argument for using CMC systems has moreover—with reference to Vygotsky—been its text-based communication and the learning benefits from writing.

Text-based communication contains certain learning advantages because it offers the learners the possibility to read, reflect, write and revise their arguments and comments before they answer questions or share knowledge with each other (Harasim 1990). Another important argument is the short turnaround times (Holmberg 1995) and socio-emotional factor of possibilities to get easily in touch with peer learners, and not least the better conditions of breaking down the feeling of isolation as a distance learner (Fjuk 1993).

In this approach, the leading principle of learning is based on better conditions for inter-human interactivity in the form of increased and faster two-way communication (O'Malley 1992, Dirckinck-Holmfeld 1995).

Another approach to CSCL has its foundation in theory and practice from institution-based collaborative learning situations. The computer systems in such situations are not solely aimed at supporting communication but serve as a means to mediate mutually dependent activities among the learners. Social-constructivist and cultural-historical perspectives with roots in Neo-Piagetian (Doise and Mugny 1984) and Vygotsky's (Vygotsky 1978) work have often been used as the theoretical foundation of this approach (Bannon 1995, O'Malley,

1995). Vygotsky's concept of the zone of proximal development is regarded as a key concept of how learning takes place. The *zone of proximal development* is:

> the distance between the actual development 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).

The zone, as Vygotsky describes it, is the area between two levels (Mellin-Olsen 1993). The basis for one of the levels is the existing knowledge of the individual related to a phenomenon. The basis for the other, is appropriate yet fully constructed knowledge through problem-solving guided by a more capable peer or a teacher. The proponents of the cultural-historical approaches stress the nature of learning as mediated by artifacts. Computer systems are included in learning processes as tools for thinking and for collaboration between learners (at different schools), and for use in guidance (Crook 1995, Newman 1995). This second approach has its focus on collaborative processes however those which primarily take place at common physical localities. Its starting point is in formal learning processes for children and young people, i.e., school education. (Littleton & Häkkinen forthcomming)

The basis for our analysis comes under a third approach to CSCL, which has its roots in both of the approaches above. It shares areas of study with the first approach to distance education, and the theoretical foundations with the other. As CSCL has not primarily been aimed at distributed learning situations (such as distance education) we have chosen to expand the concept to CSdCL (*Compu-*

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ter Support for distributed Collaborative Learning). The basis of this approach to CSdCL is social-constructivist and cultural historical. But, it also builds on an integration of experiential learning (Kolb 1984, Illeris 1981). The approach relies on a special pedagogical method, which is the institutional profile of Aalborg University, namely *problem-oriented project pedagogy* (Dirckinck-Holmfeld, 1990).

2.2. Problem-Oriented Project Pedagogy

Problem-oriented project pedagogy can to some extent be compared with problem-based learning and case-based learning. The basic principle behind knowledge construction in problem-based learning is solving of pre-defined tasks or problems (Jonassen *et al.* 1993). Problem-oriented project pedagogy is distinguished from such a principle in that problem solving is not the primary condition of active knowledge construction. Critical reflection on a (scientific) problem or a phenomenon in society is the didactic, basic principle. *Critical reflection* and the development of qualifications for formulating problems contribute to problem-oriented project pedagogy arguably being a more demanding form of learning than the approaches focusing on solving a given problem.

According to Illeris (1974), problem orientation does not on its own constitute the foundation of an active process of acquiring knowledge through critical reflection:

> A problem is not a problem in a psychological sense if the person who has to work with it does not experience it as a problem. (p. 83, our translation).

Creativity, engagement and motivation are crucial aspects regarding critical reflection. When the learners themselves define and formulate the problem, they have a conscious ownership of it and are implicitly invited to involvement and motivation. Illeris (1981) refers to this as participant control. Participant control and problem orientation are interdependent and constitute the foundation of knowledge construction.

Collaboration organized in projects constitutes the frame of the didactic principles. The project organization builds on a social-constructivist perspective that underlines the integration of individual construction of knowledge and the learners' joint responsibility of creating a common learning environment. According to constructivist conceptions of learning, the learner constructs knowledge by interpreting perceptual experience in terms of prior knowledge and existing perspectives (Illeris 1974, Jonassen *et al.* 1993). Common understandings among the peer-learners are resulted from confrontations and negotiations of perspective and beliefs. Social negotiations constitute the core of active development of knowledge in that the learner has to internalize the perspectives of the peer learners and alternatively reconsider own knowledge and beliefs. This reconsideration implies inner contradiction that is regarded as the prerequisite for new learning (Illeris 1974, Patterson 1977).

3. Understanding Collaboration in Distributed Environments

We argue that efforts to design computer systems which contribute to the making

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of collaborative communities need a rich grounding in social interaction. Negotiation of meaning, consensus making, co-ordination of tasks and responsibility are all actions that are embedded in *social interactions* which have implications for collaborative knowledge construction.

We propose Anselm Strauss' (1993) interactionist theory on action and articulation work as a theoretical framework for understanding the conditions of social collaboration in a distributed learning environment.

3.1. An interactionist Theory on Action

The fundamental unit of analysis is the interwoven nature of action, interaction and its structural conditions for building social worlds.

> Actions are embedded in interaction—past, present and imagined future. Thus, actions also carry meaning and are located within systems of meanings. Actions may generate further meaning, both with regard to further actions and interactions in which they are embedded (Strauss 1993, p. 24).

A social world is the 'recognizable form of collective action' (Strauss 1993, p. 223) and membership of social worlds is constrained by the limits of effective interaction. Interactional processes (Strauss 1988) thus compromise the structural conditions for articulating individual member's perspectives and knowledge and for influencing the course of actions and interactions.

Negotiation of meaning and collaborative construction of knowledge are particularly related to Strauss« terms of *problematic interactions*:

> Problematic interactions involve 'thought', or when more than one interactant is involved then also 'discussion'.

An important aspect of problematic action can also be 'debate'—disagreement over issues or resolutions (p. 43).

Problematic actions, either taking place in isolation from peers or in the collaborative community, involve reflection on prior knowledge and may in turn present inconsistencies requiring resolution. Examples are: Negotiation of meaning, exploration of opposed alternatives in argumentation, consensus making, etc.

According to Strauss, most interactions are *routinized*:

> Actions and counteractions are expectable; often repeated; governed or guided by rules, regulations, standardized procedures, agreements, or understandings. (p. 43).

Problematic actions cannot take place without the routine actions, the skills and abilities which are usually taken for granted. Routines may be changed and turn into problematic actions caused by contingencies. The routine skills and abilities are integrated into every action as they play into creativity and innovation in face of unexpected contingencies. In time, the actions "flow back into the realm of the routine" (p. 207). By viewing learning as routine interactions this does not in any strong sense imply new resolutions of prior knowledge as their contents are assimilated to existing interpretation. Still, they are needed to keep the underlying activity running.

Both *internal* factors (such as human-to-human relations) and *external* (such as technological, cultural, organizational, physiological, economical factors) are *parts of actions* since they influence and may change the course of actions (Strauss 1993). Following this, we interpret computer applications (such as

e-mail, text-processing programs, painting programs, etc) as external, invisible parts of action.

The concept of interactions have close conceptual relations to the more informal distinction between implicit and explicit articulation of actions (Strauss 1988). Strauss (1993) defines articulation as "the coordination of lines of work" (p. 87) . When people are assigned to interactions, they are making explicit articulation. One actor is assigned to the role of a project leader, and another is in charge of taking minutes, etc. In contrast, the invisible, unforeseen and often problematic actions imply *implicit* articulation. The explicit articulation may thus be connected to the planning and decisions regarding the dimensions of "Who should do what, how, when and where". Implicit articulation is invaluable in order to handle contingencies. Star (1991) points to the unanticipated contingencies and breakdowns as central for articulation work, in order to "get things back 'on track' again in the face of the unexpected" (p. 272).

Following Strauss' interactionist theory on action, developments of collaborative and distributed communities are constrained by social interactions, and the external and internal factors that influence the corresponding course of actions. The theory constitutes a coherent set of abstractions involving an interwoven relationship between actions, actors and computer applications. We interpret this interwoven relationship in terms of the conscious and planned dimensions of "Who should do what, how, when and where".

Hence, we use the dimensions to structure the analysis of social interactions in distributed and collaborative learning communities. The *who*-dimension is related to the learners and their roles with respect to the project as work form and to the principles in problem-oriented project pedagogy. The *what*- dimension is related to the actions which the learners in their capacity of their roles must perform in various phases of the project. The 'where and how' dimensions are related to the interaction between the applied computer applications, and problem-oriented projects. The *where*-dimension represents the context in which the collaboration takes place: In a distributed learning environment, created by the learners by the help of a CMC system. The *how*-dimension is related to the operational functionality of the computer applications to performing problematic and routine actions.

Section 4 structures and discusses the empirical findings by using this interpretation.

3.2. Related Work

Strauss' conceptual framework and particularly his concept of articulation work, have been complemented and evolved by current CSCW work. Schmidt and Bannon (1992) use articulation work as a basis for understanding the complex nature of cooperative work. Simone *et al.* (1995) explore the role of protocols as mechanisms to reduce the complexity and extra work which cooperative work often entails. Close to our work is Fitzpatrick *et al.*'s (1995) which propose Strauss' original interpretation of actions and social worlds to bridge the social and technical dimensions of CSCW. In agreement with the work of the latter authors, we emphasize the strength of using Strauss for understanding the conditions of building collabora-

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tive communities. The analysis resulting form using the framework should clearly inform systems design and development. However, we do not find the interactionist theory sufficient enough for using it as a framework for systems development. In Fjuk & Smørdal (1997) these issues are discussed in detail, and suggest a combination of activity theory (Engeström 1987) and the theory of actions as useful for this purpose.

In contrast to the CSCW research which uses Strauss' concepts, our work has its primary focus on social interaction for the purpose of *learning*. Many collaborative learning methods (including problem-oriented project pedagogy) emphasize social interaction as a *goal* for the learning activity. Collaboration in work situations is to a large extent aimed at production and social interactions become a means to achieve concrete and measurable results. In learning situations, the product (e.g. the final project report) is subordinated to the interactional process in large parts of the collaboration. In fact, the final report is not only concrete product. It constitutes an instrument which mediates the learners' reflections and interpretation as well as their consolidation of knowledge.

The origin of Strauss' theory is work in hospitals. In spite of this background, the theory is useful for understanding the interactional conditions for building collaborative and distributed learning communities. However, in problem oriented project pedagogy, those actions related to the articulation work - and in particular actions related to interactional processes - have an additional aspect. Interactional processes are means of critical reflection and confrontation of perspectives. The meaning of collaboration is

not primarily aimed at a common product, but rather at an active knowledge construction. Therefore the articulation concepts must, in addition, take their starting points in the learning aspect, and the meaning of collaboration related to this. The meaning of the interactional processes in relation to the phases of the project and in relation to the acquisition of knowledge and competences must be in focus and integrated in the analytical frame of "Who should do what, how, when and where".

4. Experiences From Practice

Since the middle 80s, Aalborg University (AAU) has offered computer supported open learning programmes based on the pedagogical and didactic principles of problem-oriented project pedagogy. Untill 1997 , the communicative infrastructure has been based on a text-based and asynchronious group communication system (FirstClass) supplemented by face-to-face seminars on-campus (typically 4-5 weekend seminars per year). The learners who attend the open learning programmes are typically professionals coming from all over Denmark and sometimes also from abroad. Their daily access to the university is maintained through the computer conferencing system, either from home or from work place. The learners' use of the computer conferencing system as well as their participation in face-to-face seminars are built into the learning. It is emphasized that both ways of interaction are nessessary for fulfilling the learning approach. Even though the pedagogical process is carefully contemplated according to the conditions of the asyn-

chronious and text-based system, it seems as though the academic profits derived from active participation in the distributed community have gained from the principles of problem oriented project pedagogy to a lesser extent than what one might have expected (Dirckinck-Holmfeld 1990, Georgsen 1995).

To acquire a deeper understanding of problem oriented distributed collaborative learning, and how the technology and other factors affect it, a case study was carried out during the spring of 1995. One of the methods used in the case study was an explorative experiment.

4.1. The Exploratory Experiment

The participants in the exploratory experiment were a group of teachers with a wide experience of tutoring within distributed collaborative learning situations, and a group of learners belonging to the distance learning program (at AAU), respectively. The group of teachers thus had a considerable knowledge on concrete as well as principal problems connected to computer-mediated problem oriented project pedagy. The learners were first year learners of humanistic informatics. They were novices regarding the subject of humanistic informatics, just as they were novices in relation to problem-oriented projects. In addition, they were novices as far as the use of technology was concerned and also in relation to collaboration in a learning community which is distributed in time and space. The reason why we selected them to take part in the experiment was partly that they, in their project, actually studied their own collaboration processes in a distributed learning environment. Their general problem formulation was: *What*

conditions are needed for exploring each other's understanding in CMC (See Løth & Køhler 1995)? On this ground, they became very consciously aware of how collaboration functions distributedly. Furthermore, as novices, they were interesting for our purpose because novices must very easily be able to point out what they experience as problems. The learners were adults with responsibility for their daily work practice as well as for family and child care.

The experiment was conducted as two group sessions, organized as reflective discussions. To structure the discussions we used so-called rich prictures and dialectical contradictions , inspired by systems development technique Soft Dialectics (Bratteteig & Øgrim 1994). The sessions were videotaped for the purpose of studying the content and the importance of the identified problems and contradictions among the participants.

The two discussion sessions resulted in very complex and rich descriptions of the problems and contradictions regarding computer-mediated and distributed collaboratve learning. In order to organize the findings and the described problems, we found that the interactionst theory on action and the corresponding concept of 'articulation work' might function as a framework for the analysis. Therefore, we structured the analysis according to the *who-*, *what-*, *where-* and *how-*dimensions.

4.2. Who, What, Where and How in CSdCL

The who-dimension concerns the learner's explicit role and her/his responsibility to the collaborative processes in terms of experiences, knowledge and skills.

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The what-dimension concerns the inter-actional processes that compromise the various phases of problem-oriented projects. The where-dimension concerns the situation in which the collaborative learning processes takes place. The how-dimension concerns the operational conditions of the computer applications to performing actions.

Anselm Strauss is a sociologist and has not (as far as we know) integrated technology (such as CSCL tools) in his studies. We find it necessary to integrate computer applications in an anlytical framework in order to understand distributed collaborative processes in a comprehensive view. The what- and how- dimensions particularly concern the intersections between the available computer applications and problem oriented projects. The where-dimension represents the context in which the collaboration takes place, i.e. in a virtual learning environment, created by actors who are separated both geographically and in time. Moreover, the who-, what-, where- and how-dimensions cannot be regarded separately, rather in mutual interactions. However, in the following, we structure the analysis in accordance to each of the dimenions.

4.3. The Who-Dimension

Mutual commitment was identified by the teachers as fundamental for creating a distributed collaborative learning environment. Mutual commitment implies tolerance and trust in relation to the co-actors of the project, their knowledge, and contributions. This also implies a sense of responsibility towards the project as a whole, both on the part of the instructor (the teachers) and among the students. Finally, it implies involvement in relation to the concrete problem and special aim of the projects. In this way, mutual commitment implies continuous articulation work and processes. Mutual commitment is manifested in the following aspects:

- The learner must have the ability to reflect upon the contributions of the peers to make use of them in the collaborative knowledge construction process.
- The learner must have the capacity to negotiate on the basis of his/her *own* interpretations, thoughts and knowledge.
- The learner must be able to cope with and contribute to the solving of personal and social problems.
- The learner must be able to cope with contingencies, and work constructively according to them.

Using Strauss' interpretation of social worlds, mutual commitment is thus dependent on the external and internal conditions for performing problematic and routine actions.

The discussion carried out with the learners indicates that mutual commitment contributes to a contradiction with respect to CSdCL. Mutual commitment, and the embedded interactional processes, implies *extra work* for the learners. In some cases this overshadows the individual perception of belonging to a common learning community. Principally, the learning benefits of collaboration were emphasized by the learners. However, they found it hard to act as a responsible member of the collaborative processes. This influenced and was influenced by the what-, how- and where-dimensions.

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4.4. The What-Dimension

The What-dimension concerns the content and various 'phases' which constitute problem-oriented projects. A problem-oriented project can be devided into the following phases (Dirckinck-Holmfeld 1995): The problem formulation, the research phase, the production phase and the evaluation phase. Here, we are leaving out evaluation. The phases overlap, i.e. one phase is not necessarily ended before the next can be started, just as some phases are carried out more than once during the whole process. However, each phase has special patterns in relation to the interactional process.

In the following, the learners' experiences due to these phases are presented and dicussed.

4.4.1. Problem Formulation Phase

In line with the principles of participants' control and problem orientation, the learners have a joint responsibility of explicitly describing and defining a problem. A joint understanding of the problem constitutes the basic instrument for further actions and collective progress. This phase is thus characterized by social and problematic actions. Ideas must be generated and agreement on key concepts of the project must be reached. In order to make the interactions innovative, good internal and external conditions with respect to the interactional processes are particularly important. This emphasis is manifested by the fact that the learners only rarely know each other at the beginning of their collaboration, and by the fact that they, at this point, do not have a common frame of reference with regard to the problem area.

In addition, the learners must come to an agreement about the roles that they must attend to during the project (chairman, taking minutes, project leader, etc.).

In this early phase of the project, the interactional processes are particularly related to the following collectively and individually oriented actions:

- Explicit articulation of thoughts into presentations for the purpose of communicating them to peers.

- Coordination of the individuals' contributions.

- Negotiations of a joint understanding of the problem.

- Definition and clarification of the aim of the project.

- Reaching agreement about work schedules and plans.

The learners' experiences are expressed in the following quotation:

> We did not make a good job of the ideals of digging deeply into our studies, it only became superficial digging, where we did not succeed in getting to grips with the subject. Maybe this was because our basic knowledge is not certain enough, but also because the mutual challenge did not come off in CMC (...) Then it later appears in the project work that the fact that we have not been able to discuss our way to a conclusion about a common understanding of what it is to challenge each other's understanding creates a lot of problems in the project organization. (Løth & Køhler, 1995, p. 34, our translation).

The lack of sufficient knowledge related to the problem area combined with the operational functionality of the computer applications constitute the main explana-

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tion. The CMC system seemed to constitute a contradiction together with prescribed principles such as joint construction of problem and opposed alternatives in argumentation. This contradiction is further manifested in contradictions *within* the learners' available computer-based applications. The learners' available computer-based applications—the CMC system together with drawing programs, word processing programs, etc.—contradicted the learning benefits associated with articulating thought into drawings, writings, schemes, etc.. A learner's computer applications (e.g., a drawing program) did mediate the individual learner's reflection and thinking. But, because of software incompatibility between the learner's programs, the thoughts manifested in drawings, writings, schemes, etc., did not appear as appropriate means for articulating the learner's argumentation of perspectives and negotiations of meaning (beliefs, perspectives, knowledge, experience, skills, etc). Thus, the use of the computer applications hampered the individually and collectively oriented actions, and also the object of the problem formulation phase. Due to internalization of the properties and behavior of the applications, their use was not conducted automatically. Rather, the use of the computer applications involved thought that stemmed from problems of using them due to breakdowns, or due to unfamiliarity with them. "It was hell!" one of the learners exclaimed during our discussion.

These practical problems had consequences for planning the collective progress since the learners did not manage to develop a joint understanding and definition of the problem. These practi-

cal problems also influenced other phases of the project, since commitment then turned off to be time consuming activities. Actions which are usually routine in traditional forms of collaborative learning, such as coordination of individuals' contributions turned into problems due to unexpected contingencies related to the heterogeneous computer applications of the projects.

4.4.2. The Research Phase

In this phase, relevant literature is obtained, theory is adapted, systems of terminology are drawn up, and empirical data are collected. Awareness on how the work is progressing is particularly important in this phase. However, it is still necessary to negotiate a mutual frame of understanding and to agree about the key concepts to keeping a common course. In contrast to the problem formulation phase, the learners have the possibility of leaning on common frames of reference. Collective actions related to consensus and confrontation are less dominant in this phase. This phase is dominated by collectively oriented and routine interactions related to the following:

- Literature study (books, articles, journals, reports etc.).

- Motivation, support and unification of each other's ideas, interpretations and knowledge.

- Division of labor, delegation and feedback on individual work.

- Demands and feedback from external aspects which the project must relate to (e.g. the case organization or the teacher facilitating the learners' project).

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In the distributed environment, these routine interactions turned into problems due to breakdowns regarding the heterogeneous computer applications and platforms. Another problem was that some individual students often came too far in their own study- and reflection process before the other students were involved or had time to respond. It led the project in different directions and often the other students felt, that they did not have sufficient insight in the special area which was why they could not assess and discuss the contribution of their fellow group member.

4.4.3. The Production Phase

The core of this phase is ideally the processes of writing contributions to a common project report, based on the collected material and the planned actions of the project. Discussion and confrontations on the written contributions may change the planned course of action, and affect the original problem formulation. Through confrontation of individual contributions new understanding is created, which may also affect the original problem formulation. The dominating interactional processes of this phase are related to the following:

- Negotiations on individual ideas, interpretations and knowledge.
- Negotiations on individual contributions to the project.
- Feedback on individual contributions.
- Responsibility and commitment.

The learners in our exploratory experiment claimed that they had gotten too far in their own process of knowledge construction before they received feedback on ideas and thoughts. A major effect of this was a reduced sense of responsibility since it appeared as if there was no one to commit oneself to. The learners only caught a glimpse of the interdependence that this implies. If feedback from peers represented a contradiction to prior knowledge and interpretation, the learners often did not have the capacity to follow it up and to negotiate upon their own thoughts. It was easier to accept negative criticism, even when they did not agree about it, in order to get the work done in time. Negotiation calls for involvement, motivation and time. The learners expressed this in the following way:

> Involvement and motivation require understanding of the subject and time to study unfamiliar knowledge carefully and time to work up this knowledge, partly by oneself and partly by the 'surroundings'. The time it requires is not a question of 'taking' the time, but a question of a development, a process of cognition, where one realizes that one is looking at a part of the world, with a quite new approach. … One must grow so strong in one's knowledge and attitudes that the possibility and foundation of knowledge will arise so that one can negotiate and re-negotiate quite naturally without having to look anything up in the textbook. (Løth & Køhler, 1995, p. 15, our translation).

The lack of surplus energy was a threat against the necessary involvement and feeling of responsibility that the project implies:

> In some cases it is difficult to solve problems and if this happens too often or if we come to a standstill or do not understand each other, then the energy disappears (Løth & Køhler, 1995, p. 41, our translation).

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The project which was the object of our experiment had its distinctive features that separate it from many other CSdCL situations based on problem-oriented collaboration. The project had the general aim of critically reflecting on distributed collaborative learning situations, and of acquiring knowledge on this. This was a particularly motivating factor for collaborating through the computer system. Furthermore, their situation was special since it was their own interactional processes which were the objects of research. In itself, this was a source of personal, latent conflicts as the critical analysis in some situations became critique directed against individual members:

> It appears that actually more often than one would expect one is running the risk of 'smoldering conflicts' which may be of a personal or a scientific nature (Løth & Køhler, 1995, p. 41, our translation).

In some situations, the learners did not trust each other's knowledge, which appeared in discussions connected to the individual learner's contributions to the project. The lack of mutual confidence on each other's knowledge and a lack of will to get acquainted with the others' thoughts became an expression of manipulation. The learners did not have the capacity to carry out the necessary articulation in order to cope with interpersonal problems. The result was that one of the learners broke off with the others in this phase. The learners' conclusion regarding their collaborative learning situation has its background in these problems:

> Openness and tolerance, the will to reflect on others' opinions are far more important in CMC than in an oral discussion (ibid., p. 42, our translation).

The collaborative learning processes were full of conflicts and exacting on the learners and, as such, they have won first-hand experiences with distributed collaborative learning. In accordance with the problem formulation the learners had:

> … recognized that understanding does not prosper in isolation, but from this to be able to challenge each other's understanding there is still a long way to go. (Løth & Køhler, 1995, p. 15, our translation).

In addition, they have recognized that the use of the CMC system in accordance with the didactic principles of problem-oriented project pedagogy is a complicated phenomenon which imposes conditions on the individual learner in respect of conscious and explicit articulation.

4.4.4. The Where-Dimension

The where-dimension concerns the situation in which the collaborative learning processes takes place. The principles of problem-oriented project pedagogy have their roots in situations where both place and time are shared by the learners. Collaborative learning has neither been distance-based nor based on telecommunication technology. Following Strauss' definition of social worlds, membership of distributed and collaborative learning enviroment is constrained by the limits of interactional processes. It is therefore crucial to explore which conditions the distributed environment imposes on those actions found crucial for devloping a common learning environment. The analysis indicates that problematic actions are particularly cumbersome to perform in distributed communities. Moreover, it is necessary to explore to

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which new articulation needs the distributed environments contribute in order to understand the conditions of the new learning environments.

A shared context in terms of time and place contributes to an integration of the learners in a learning community with its infrastructure (the possibility of physically being together both formally and informally), communication facilities (such as face-to-face meetings), technical resources (photo copier, advanced software, advanced computers, scanners, etc.), academic resources (such as informal and formal guidance, technical assistance, library, etc.) and meeting facilities for the project sessions. Parts of the articulation can take place tacitly or implicitly. Implicit articulation takes place through actions which the learners perform in order to be aware of the activities of the others. As Gutwin *et al.* (1995) put it:

> Collaborative learners maintain this awareness by tracking information such as other learners' locations in the shared workspace, their actions, the interaction history, and their intentions. Workspace awareness is necessary for effective collaborative work, but also plays an integral part of how well an environment creates opportunities for collaborative learning. (p. 147)

A shared physical presence and roots in a shared culture will make conscious coordination and adoption of actions possible. In the distributed learning environment, where the learners are physically in different contexts as well as being part-time learners, the learners have far weaker shared cultural roots. Compared to face-to-face situations, it seems that *explicit articulations*—like planning, coordination and meta-communication—

are certainly more fundamental, and there is a greater need for making implicit articulation more explicit.

Additionally, our exploratory experiment indicates that the distributed learning environment implies a sort of *extra* articulation in relation to certain aspects. It is for instance far more laborious to carry on a dialogue about essential open questions in writing than orally. Written communication more easily results in misinterpretations and misunderstandings, and problems of giving feedback on contributions, etc. (Dirckinck-Holmfeld 1990). On the other hand, the CMC systems provide the opportunity to reduce explicit articulation work in relation to other aspects, because the learners of the project can implicitly follow each other's actions through the contributions to the common database.

At AAU's distance education program, the learners are most likely adults who have a job. Those commitments that are made by the distance learner are not only related to peer learners and their collaborative processes. In addition, he or she must attend to his or her commitments to family and the everyday work situation. The interdependence that problem-oriented projects imply may be regarded as demanding with regard to time, and thus active participation with regard to involvement and commitment implies personal articulation processes related to time.

Compared to traditional collaborative learning situations, distributed situations may thus imply a greater need for making implicit articulation more explicit. This is particularly manifested in a need for explicitly articulating responsibility and commitment to various contexts (home, work, and shared learning

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community) as well as more thoroughly articulation in terms of time.

Compared to traditional learning situations, the distributed collaborative learning processes imply *new articulation needs* that in turn require new roles which the learners must fulfill in order to create a collaborative environment. But distributed projects also imply new roles for the teachers. The learners in our exploratory experiment asserted that some of their problems could have been reduced or avoided if the instructors had committed themselves more to the project. This is particularly obvious in situations where the learners have problems with reaching common decisions, and in situations where interpersonal problems became a threat to the cooperative work. At the same time, the role of the teacher becomes more 'distributed' as the learners appear only as names on a screen, and not visiting and 'live' at the teacher's office. The teachers considered this as a threat to their commitment to the learners. Corresponding to the fact that mutual commitment meant a contradiction in the distributed collaboration among the learners, the commitment from the teacher to the learners also implied a contradiction. This contradiction does not necessarily have its origin in the teacher's intentions, but in the readiness of the educational system to allocate resources for the extra articulation work related to the distributed learning situation and to rethink the pedagogical approach to new learning situations.

4.4.5. The How-Dimension

The how-dimension concerns the operational conditions of the computer applications to performing actions. The discussions in the previous sections indicate

problems regarding heterogeneous computer applications. These problems are not necessarily related to the operational conditions of the CMC systems themselves, but to contradictions between the various applied computer applications.

The objective of planned actions is theoretically the same independent of which artifacts are used. The way in which the actions are put into operation and the realization of the actions is to a great extent determined by the conditions that implicitly characterize the applied computer applications. Audio, video, text and 3D images exhibit very different conditions and these conditions strongly influence the outcome of the actions and the participation in distributed environments.

Asynchronous and text-based communication systems are representations or models of social environments perceived as production and exchange of written contributions. The operational functionality of most CMC systems is determined by the conditions set by the written language; presentation and communication of text segments. Thus actions that are performed are controlled by the premises of the written language and the asynchrony of the system.

Earlier experiences from AAU and from the exploratory experiment indicate that such interaction forms seem to harmonize more with the research process than with the problem formulation phase and the production phase. In the problem formulation phase and in the production phases, critical reflection through problematic interactional processes is crucial for learning, just as discussion and 'the better argument' are means for constructing (scientific) knowledge. Text-based and asynchronous communicative

conditions are less appropriate for performing the dynamic and problematic actions. Communicative competence in mastering collaboration in text-based and asynchronous environments as well as skills related to the operational use of the system (Dirckinck-Holmfeld & Nielsen 1992), are essential for utilizing the learning benefits of problematic actions.

5. Final Discussion

The objective of our study has been to examine the nature of distributed and collaborative learning in which certain collective actions constitute the core of knowledge construction. The analysis has been carried out by using Anselm Strauss' theory on action and interaction. Following this theory, development of social worlds is constrained by external and internal conditions for performing collective actions that are embedded in interactional processes. Social worlds may be well defined, like school classes, and they may be loosely defined like a community of World Wide Web users. Moreover, people may be involved in many social worlds simultaneously. Membership in various social worlds have significant meanings on the participants' perspectives and interactional processes.

These features of social worlds are appropriate for the purpose of understanding the conditions of the distance learners' development of collaborative learning communities. Firstly, the learners are adults that have responsibilities for a daily work practice and family representing social worlds which have a significant bearing on their perspectives and

articulation of time. The development of distributed collaborative learning communities are thus constrained by external conditions connected to other social worlds than the learning community. Secondly, the development of collaborative learning communities involves interactional processes to manage the interdependencies which projects entail. It also involves interactional processes to negotiate common understandings and to construct personal knowledge. These interactional processes are constrained by conditions found in the pedagogical approach and the computer applications used. The conditions for interactional processes, the learners and the course of actions mutually shape and evolve one another.

This specific feature of the context of our study, is interpreted in terms of the interdependent relation between 'Who is doing what, how and where'. This approach has given us an opportunity to explore the interwoven conditions that determine the development of a distributed collaborative learning community. The who- and what-dimensions concern the conditions set by problem-oriented project pedagogy, with respect to the learners' role and interactional processes. The where-dimension concerns the conditions set by the context where the collaboration takes place, i.e., a distributed environment where the geographic distances amongst the students are primarily bridged by a CMC system. The how-dimension concerns the conditions the CMC system, and other computer applications, represent for the processes of performing actions.

Our study shows that the learners' commitment to the activities of the peers is fundamental for developing a shared

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learning community within a distributed context. Commitment requires various problematic and routinezed interactions. However, some of these actions seem to be complicated and demanding to perform because of conditions found in an intersection between the what-, where- and how-dimensions. This manifests itself in the following:

Problematic interactions which are often present in processes of negotiating on opposed perspectives in argumentation, ideally require mental and social presence of the learners. This is particularly important in defining a common problem. A joint problem formulation functions as an explicit means for planning the course of work and responsibility. As such, planned and explicit articulation is even more important in distributed collaborative learning contexts than in traditional ones, because the learners have less opportunities to meet physically. Contradictory, collectively oriented interactions, involving both routinezed and problematic actions, become demanding both with respect to time and to communicative competences. The asynchronous and text-based CMC systems are less suitable for performing problematic actions like in-depth discussions, negotiation of opposed alternatives in argumentation, common decisions, idea-generation, etc. They are, however, appropriate means for performing usual routinezed actions such as coordination of documents, literature, ideas and thoughts, etc. Our study clearly shows that these routinezed actions turned into problematic ones caused by contingencies regarding heterogeneous computer platforms and applications. This particular feature strengthen the fact that use of the computer applications involved prob-

lems of using them, rather than being tools for shared reflection and collective growth. Thus, the use of the computer applications hampered the individually and collectively oriented actions that usually are found critical for developing collaborative learning communities and personal knowledge construction. This contributes to the fact that individual involvement and commitment to the interactional processes demanded too considerable time resources.

The use of the analytical framework has given us deeper insights into what the problems of distributed collaborative learning are like.

Firstly, the analysis has contributed to an understanding that the pedagogical ideals themselves may constrain the development of distributed problem-oriented projects. This collaborative learning approach presupposes that mental and social 'distances' must be overcome, and not only the physical one, in order to manage the collective actions that are required. As such, collaboration in a distributed environment requires *new* forms of articulation work and articulation processes that contribute to the fact that the collaboration becomes more demanding than a situation where time and space are shared.

Secondly, the analysis has provided insights into systems design. The computer applications should contribute to performing collectively and individually oriented interactional processes with respect to active knowledge construction. Multimedia technology has by some researchers been suggested as a technological solution to problems corresponding to those we have outlined, because of its wealth of information (see e.g. Kraut *et al.* 1992). Multimedia technology will

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allow a plurality of codes in the interactional processes, which can be integrated, just as 'rich' technology creates the possibilities of direct feedback so that the participants in the project can adjust their contributions "[i]n response to signals of understanding or misunderstanding, questions, or interruptions" (ibid., p. 378). With extension of more powerful net services to the homes of the distance learners and to work places, multimedia applications provide possibilities of adding new interactional modes to distributed collaborative learning situations. This must still be expected to demand extra work in order to mediate the articulation processes through multimedia but it will certainly reduce some of the collaborative problems that have been identified in our analysis.

The World Wide Web constitutes promising solutions for situations where problems of heterogeneity inhibit the deployment of interaction. First of all, the World Wide Web offers a huge potential of integrating external applications across Macintosh, PC and UNIX platforms. Secondly, its usage has low costs and increasing availability from homes and work places. The traditional usage of the World Wide Web has been searching, browsing and retrieving information as well as making information available for others. This approach does not provide sufficient support for learning situations where social negotiation of meaning, joint authoring and project planning are embedded collective actions. Horstman & Bentley (1997) and Bentley *et al.* (1997) have provided useful insights into how World Wide Web can give significant benefits for systems design aimed at developing collaborative tools for heterogeneous environments. The BSCW

(Basic Support for Cooperative Work) system (ibid.) focuses on joint document production, including features for uploading documents, remote editing, version management and group administration. Systems that keep track of documents and awareness; the latter including functions of who has done what at what time (Dourish & Bellotti 1992), are certainly important for project-based learning. Such systems focus on routinezed interactions. Collaborative learning is broader than routinezed work and the interactional processes count for more than efficient workflow (Newman 1996). Systems design directed towards distributed collaborative learning must then focus on the *computational conditions for learning*, in addition to the conditions for document management. Further research and developments, based on our study, are thus aimed at designing computer systems that integrate the World Wide Web with appropriate collaborative learning issues. The aim with such a solution is not to be a collaborative system in its own right, but a means that are sufficient for creating a common learning environment amongst geographically dispersed adult learners.

6. Conclusion

The use of the analytical framework has given us deeper insights into what the problems of distributed collaborative learning are like. Our study of distributed collaborative learning environments shows that the who-, what-, how-, and where-dimensions should be considered mutually in which they determine each other in practice. First of all this makes demands on the pedagogical models to

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be *adapted* to distributed learning situations. This does not mean that the established principles must be rejected, but function as guides with respect to innovative and new thinking in the pedagogical and organizational developments. Moreover, it makes demands on systems designs to be consciously aware of the computational conditions of learning and collaboration. These demands are fundamental to offer and deliver qualitatively good learning situations for adults in the lifelong process of learning alongside work.

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References

Bannon, L., (1995). Issues in Computer Supported Collaborative Learning. In: C. O'Malley, editor. *Computer Supported Collaborative Learning*, pp. 267-281, Springer-Verlag, Berlin.

Bentley, R., T. Horstmann, & J. Trevor, (1997). The World Wide Web as enabling technology for CSCW: The case of BSCW. *The Journal of Collaborative Computing*, 2(3). Kluwer Academic Press.

Bratteteig, T. & L. Øgrim, (1994): Soft Dialectics—Structured Handling of Problem Situations in System Development. In: W. R. J. Baets, editor. *Proceedings of the Second European Conference on Information Systems*, pp. 681-690, Nijenrode University, Breukelen.

Crook, C., (1995). Educational Practice Within Two Local Computer Networks.
In: C. O'Malley, editor. *Computer Supported Collaborative Learning*, pp. 165-182, Springer-Verlag, Berlin.

Dirckinck-Holmfeld, L., (1990). Kommunikation på trods og på tværs. Projektpædagogik og datamatkonferencer i fjernundervisning, Picnic-news no. 9, Aalborg University

Dirckinck-Holmfeld, L., (1995). Project Pedagogy as the Foundation for Computer Supported Collaborative Learning. In: B. Collis & G. Davies, editors. *Innovative adult learning with innovative technologies*. IFIP Transactions A-61, North-Holland.

Dirckinck-Holmfeld, L. & J. Nielsen, (1992). Visual Operational Thinking and Communicative Competence - a prerequisite for bringing multimedia network systems and learners into action. In: R. Aiken, editor. *Education and Society, Information Processing 92*, Vol. II, Elsevier Science Publishers B. V., North Holland

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

Dourish, P. & V. Bellotti, (1992). Awareness and Coordination in Shared Workspaces. In: J. Turner & R. Kraut, editors. *CSCW´92. Sharing perspectives. Proceedings of the Conference on Computer-Supported Cooperative Work*, pp. 107-114. ACM Press.

Engeström, Y., (1987). *Learning by Expanding. An Activity-theoretical approach to developmental research*. Orienta-Konsultit Oy, Helsinki.

European Commission, (1994). Growth, competiveness, employment—The challenge and ways forward into the 21st century (White Paper). Office for Official Publications of the European Communities, Luxembourg.

Fitzpatrick, G., W. J. Tolone & S. M. Kaplan, (1995). Work, Locales and Distributed Social Worlds. In: H. Marmolin, Y. Sundblad & K. Schmidt, editors. *Proceedings of the Fourth European Conference on*

■

Computer-Supported Cooperative Work, pp. 1- 16. Kluwer Academic Publishers. Dordrecht.

Fjuk, A., (1993). The pedagogical and technological challenges in computer-mediated communication in distance education. In: G. Davies & B. Samways, editors. Teleteaching, pp. 249 - 258, IFIP TC3, Elsevier/North-Holland.

Fjuk, A. & O. Smørdal, (1997). The Computer's Incorporated Role in Work. Submitted to Information Technology & People.

Georgsen, M., (1995). Den anden diemension. Computermedieret kommunikation og collaborative learning. Aalborg University, Denmark.

Gutwin, C., G. Stark & S. Greenberg, (1995). Support for Workspace Awareness in Educational Groupware. In: J. L. Schnase & E. L. Cunnius, editors. *Computer Support for Collaborative Learning. Proceedings of CSCL'95.* The First International Conference on Computer Support for Collaborative Learning, pp. 147-156. Lawrence Erlbaum Associates, New York.

Harasim, L. M., editor, (1990). *Online Education. Perspectives on a New Environment*, Praeger Publishers, New York.

Harasim, L., S. R. Hiltz, L. Teles & M. Turoff, (1995). *Learning Networks. A Field Guide to Teaching and Learning Online.* The MIT Press, Cambridge.

Harrison, S. & P. Dourish, (1996). Re-Placing Space: The Roles of Place and Space in Collaborative Systems. *Proceedings of Computer Supported Cooperative Work '96*, pp. 67-75.

Holmberg, Börje, (1995). *Theory and Practice of Distance Education*. 2. ed. Routledge, London.

Horstmann, T. & R. Bentley, (1997). Distributed Authoring on the Web with the BSCW Shared Workspace system. *ACM Standards View*, ACM Press.

Illeris, K., (1974). *Problemorientering og deltagerstyring. Oplæg til en alternativ didaktik.* Munksgaard. København.

Illeris, K., (1981). *Modkvalificeringens pædagogik*. Unge Pædagoger, Denmark.

Jonassen, D., T. Mayes & R. McAleese, (1993). A manifesto for constructive approach to uses of technology in higher education. In: T. M. Duffy, J. Lowyck & D. H. Jonassen, editors. *Designing environments for constructive learning*, pp. 231-247. Springer Verlag, Berlin.

Kaye, A., editor, (1992). *Collaborative Learning Through Computer Conferencing*, The Najaden Papers, Springer Verlag, Berlin.

Kolb, D. A., (1984). *Experiential Learning*, Prentice-Hall, USA

Littleton, K. & Häkkinen, (Forthcomming): Learning together: Understanding the process of computer-based collaborative learning. In: P. Dillenbourg, editor. *Collaborative Learning: Cognitive and Computational Approches*. Elsevier Science / Pergamon

Koshmann, T. D., (1994). Toward a Theory of Computer Support for Collaborative Learning. *The Journal of the Learning Science*, 3(3), pp. 219-225, Lawrence Erlbaum Associates.

Koschmann, T. D., editor, (1996). CSCL: Theory and practice of an emerging paradigm. Lawrence Erlbaum Associates, Publishers. Mahwah, New Jersey.

Løth, S. D. & J. Køhler, (1995): The Conditions for Challenging each other's understanding in CMC (In Danish). Humanistic Informatics, Open Learning, Aalborg University, Denmark.

Mason, R. & A. Kaye, editor, (1989). Mindweave. *Communication, Computers and Distance Education*. Pargamon Press, Oxford.

Mellin-Olsen, S., (1993). *Kunnskapsformidling. Virksomhetsteoretiske perspektiver.* 2. ed. Caspar forlag, Norway.

Moore, M. G & G. Kearsley, editors, (1996). *Distance Education. A Systems View.* Wadsworth Publishing Company.

Newman, D., (1995). Technology's Role in Restructuring for Collaborative Learning.

■

A. Fjuk & L. Dirckinck-Holmfeld 23

In: C. O'Malley, editor. *Computer Supported Collaborative Learning*, pp. 183-199, Springer-Verlag, Berlin.

Newman, D. R., (1996). How can WWW-based groupware better support critical thinking in CSCL? *Proceedings of the ERCIM workshop on CSCW and the Web*, Sankt Augustin, Germany.

O'Malley, C. (1992). Designing Computer Systems to Support Peer Learning. *European Journal of Psychology of Education*, VII(4):339-352.

O'Malley, C., editor, (1995). *Computer Supported Collaborative Learning*, Springer-Verlag, Berlin.

Patterson, H. C., (1977). *Foundations for a Theory of Instruction and Educational Psychology.* Harper & Row. New York.

Peters, O., (1993). Understanding distance education. In: K. Harry, M. John & D. Keegan, editors. *Distance education: New Perspectives*, pp. 10-18. Routledge, London.

Schmidt, K. & L. Bannon, (1992). Taking CSCW Seriously. Supporting Articulation Work. *Computer-Supported Cooperative Work*, 1(2):7-40.

Simone, C., M. Divitini & K. Schmidt, (1995). A notation for malleable and inter-operable coordination mechanisms for CSCW systems. In: N. Comstock, E. Clarence, R. Kling, Mylopoulos & S. Kaplan, editors. *Conference on Organizational Computing Systems*. California.

Schnase, J. L. E. L. Cunnius, editors, (1995). *CSCL 95. Computer Support for Collaborative Learning.* Lawrence Erlbaum Associates Inc., Mahwah, NJ.

Star, S. L., (1991). The sociology of the invisible: The Primacy of Work in the Writings of Anselm Strauss. In: D. R. Maines, editor. *Social organization and social process: Essays in Honor of Anselm Strauss*, pp. 265-283. Aldine De Gruyter, New York.

Strauss, A., (1985). Work and the division of labor. *The Sociological Quarterly*, 26(1):1-19.

Strauss, A., (1988). The articulation of project work: An organizational process. *The Sociological Quarterly*, 29(2):163-178.

Strauss, A., (1993). *Continual Permutations of Actions*. Aldine de Gruyter, New York.

Vygotsky, L., (1978). *Mind in Society: The Development of Higher Psychological Processes.* Harvard University Press, Cambridge

■
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