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INSTRUCTIONAL SUPPORT IN CSCL

Computer-supported collaborative cearning (CSCL) is a recent approach to creating powerful learning and communication environments in combination with collaborative learning ideas and networked technology. Many advanced technical infrastructures for fostering higher-level processes of inquiry-based interaction have been developed (Edelson, Gordin, & Pea, 1999; Scardamalia & Bereiter, 1996). This chapter discusses instructional support in CSCL. First, the basic processes of instructional scaffolding in the context of CSCL are discussed, then relevant instructional models dealing with collaborative learning are presented. The specific focus is to introduce 'basic models' from the cooperative learning tradition to the more recent inquiry models, which are applicable to CSCL. The relationship between instructional support and issues of human learning and the educational setting is also discussed and cases of instructional support in CSCL are presented.

1. INSTRUCTIONAL SCAFFOLDING OF COLLABORATIVE LEARNING

The aim of the first section is to give a theoretical introduction to the essential ideas needed to understand instructional scaffolding in CSCL. The aim is to provide the reader an understanding of the process of collaboration that can be targeted by instructional scaffolding. Instructional scaffolding is conceptualised as assisting learning with minimal support, fading the assistance gradually and increasing the responsibility of the learner her/himself (Hogan & Pressley, 1997). Different aspects of scaffolding are discussed in terms of the scaffolding process of collaboration, cognitive scaffolding and motivational involvement and engagement.

1.1 Scaffolding the process of collaboration

The purpose of CSCL is to scaffold or support students in learning together effectively (the specific methods which can be used in collaborative learning are introduced in Section 2). Collaboration necessitates that participants be engaged in a coordinated effort to solve a problem or perform a task together. This coordinated, synchronous or asynchronous activity is the result of a continued attempt to construct and maintain a shared conception of a problem (Roschelle & Teasley, 1995). The focus on the process of collaboration will be considered as an especially crucial viewpoint in terms of understanding instructional scaffolding in CSCL contexts (see also Chapter 2 by Lipponen, Hakkarainen, & Paavola, this volume). In many of the studies demonstrating positive effects of social interaction for

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individual learning (Light, Littleton, Messer, & Joiner, 1994; Roschelle & Teasley, 1995), collaborative learning has been interpreted as a single learning mechanism. Researchers also tried to control several independent variables, which interacted with one another in a way that made it difficult to establish causal links between the conditions and the effects of collaboration (Dillenbourg, Baker, Blaye, & O'Malley, 1995). In contrast, research trends of collaborative learning have started to focus on particular processes and mechanisms that either support or constrain co-construction of knowledge. Recent research on collaborative learning has also called for more exact use of terminology related to the specific forms of collaboration. Collaborating participants learn if they generate certain collaborative activities, which trigger particular kinds of learning mechanisms. Collaborative learning situations can, for example, provide a natural setting for demanding cognitive activities such as explanation, argumentation, inquiry process or mutual regulation, which, can later trigger collaborative learning mechanisms such as knowledge articulation as well as sharing and distributing cognitive load (Dillenbourg, 1999).

In terms of considering instructional support in CSCL, it is relevant to ask what makes students engage in the kinds of collaborative activities described above, what is the role of instructional support and how the circumstances for potential collaboration can be made more optimal. One way to approach these challenges is to describe the typical problems related to the process of collaboration in CSCL settings. Further on, on the basis of this, necessary prerequisites for successful collaboration can be described. Typical features of collaborative interaction in networked environments are short discussion threads as well as descriptive and surface-level knowledge instead of finding deeper explanations for the phenomena under study (Järvelä & Häkkinen, 2002). It has also proved to be difficult to generalise knowledge approached from multiple perspectives (Schwartz, 1995). One of the most crucial problems related to the process of collaboration is the difficulty in making inquiry questions that would evoke elaborated explanations (Scardamalia & Bereiter, 1996). Below, particular challenges will be related to the reaching of reciprocal understanding, shared values and goals between participants in networked environments (Fischer & Mandl, 2001; Järvelä, & Häkkinen, 2002).

One crucial determinant of successful collaboration is related to the nature of the learning task (Arvaja, Häkkinen, Rasku-Puttonen, & Eteläpelto, 2000). Unlike fact-seeking questions and unambiguous tasks, open-ended and discovery tasks (Cohen, 1994) can promote joint problem solving and reasoning. Tasks that are too obvious and unambiguous do not leave space for questions, negotiations, explanations and arguments. Furthermore, one of the biggest challenges in instructional design and support of CSCL is to provide real group tasks and contexts that stimulate questioning, explaining and other forms of knowledge articulation and demanding collaborative activities.

In the grounding phase of coordinated problem solving, the participators negotiate common goals, which means that they do not only develop shared goals but they also become mutually aware of their shared goals. Building and maintaining common ground means that individuals construct shared understanding, knowledge, beliefs, assumptions and pre-suppositions (Brennan, 1998; Clark & Schaefer, 1989). Although reaching common ground is important for demanding collaborative activities, in instructional design of collaborative learning tasks and scenarios, the possibilities of cognitive diversity should also be taken into account. By utilising cognitive diversity, learning environments can be designed where participants have different perspectives and overlapping areas of expertise, but they also share expertise from different areas (Brown & Campione, 1994).

1.2 Cognitive scaffolding

In cognitive scaffolding of CSCL, we consider the cognitive mechanisms of social and individual aspects of knowledge building (Anderson, Greeno, Reder, & Simon, 2000; Scardamalia & Bereiter, 1996). The examples of mechanisms that promote learning in CSCL, e.g. perspective taking, cognitive conflict and assisted learning will be explained. This section discusses the special mechanisms present in CSCL and how these mechanisms can be supported with pedagogical support.

Recent studies have revealed that in connection with corresponding pedagogical practices, CSCL environments (such as CSILE®/Knowledge Forum®), created by Scardamalia and Bereiter) facilitates higher-level cognitive achievements at school (Hakkarainen, Lipponen, & Järvelä, 2002; Scardamalia, Bereiter, & Lamon 1994). A possible explanation for successful results is an advanced technological infrastructure together with teacher guidance for engaging students in a process of generating their own research questions, setting up and improving their intuitive theories and searching scientific information as well as sharing their cognitive achievements.

Usually the cognitive scaffolding is based on the teacher's aims of teaching effective cognitive strategies or metacognitive skills. The idea of CSCL itself includes certain mechanisms, which sensitise students to the situation where social aspects of scaffolding are present. Such 'social aspects of scaffolding' can be found in considering the conditions for effective social interaction, the process of perspective-taking and socio-cognitive conflict.

Conditions for *effective social interaction* have been analysed by many researchers in different theoretical traditions, for example, human development based on Piagetian and Vygotskian tradition (Newman, Griffin, & Cole, 1989), social psychology (Mead, 1934) and communications (Markova, Graumann, & Foppa, 1995). In social psychology, Mead argued that human capacity to coordinate roles is both the source of a sense of self and the core of social intelligence. Hence, in Mead's sense, without social interaction there could not be a psychological self. Selman (1980) spoke about social perspective taking, which includes developing an understanding of how human points of view are related and coordinated with one another. Similar to this view is Flavell and his colleagues (Flavell, Botkin, Fry, Wright, & Jarvis, 1968), who focus on role taking, characterising social or psychological information from another individual's perspective. These perspectives coalesce in pointing to the importance of social cognition or perspective taking in the building of common spaces or shared worlds between the interactors.

Perspective taking skills are critical to successful human functioning and involvement in everyday social interaction. Global, collaborative and networked technologies can influence student perspective taking and raise interpersonal understanding. The coordination of different perspectives and mutual negotiation produces reasoning on a more general level (Schwartz, 1995). For example, in an asynchronous Web-based university course in pre-service teacher education, students from different countries created cases of problems encountered in schools (Järvelä & Häkkinen, 2002). In such an electronic discussion, perspectives can be shared at the level of superficial information, common interests, or at deeper theoretical or societal levels.

Whilst there is persuasive evidence to suggest that *socio-cognitive conflict* may be a key ingredient in peer facilitation of learning (Doise & Mugny, 1984), other researchers have raised doubts about the role of conflict. For example, the concept of cognitive conflict has been criticised as being vague, ill-defined and hard to be operationalised outside experimental research settings (e.g., Blaye, 1988). Some have also pointed to evidence which suggests that, in certain circumstances, peer interaction can result both in regression as well as development (Tudge, 1989), and that interaction between children at the same level, is actually sometimes the most effective situation (Light, Littleton, Messer, & Joiner, 1994). So, under certain circumstances, collaborative gains may have little to do with decentering through conflict, but may have more to do with the socially mediated processes of conflict resolution such as argumentation or negotiation (Dillenbourg, 1999; see also Chapter 3 by Stahl, this volume).

The area in which an individual's optimum learning can occur is called the zone of proximal development (ZPD). The ZPD is defined as the distance between the child's actual developmental levels as determined by independent problem solving and the higher level of potential development as determined through problem solving under adult guidance and in collaboration with more capable peers (Vygotsky, 1930/1978). Thus, learning is the development of higher-level psychological processes, which occurs first on an external level through social interaction and is later internalised.

Assistance in the zone of proximal development is called scaffolding and is a major component of teaching activity. Scaffolding characterises the social interaction among students and teachers that precede internalisation of the knowledge, skills and dispositions deemed valuable and useful for the learners (Hogan & Pressley, 1997). Wood, Bruner and Ross (1976) describe scaffolding as controlling those elements of the task that are initially beyond the learner's capacity and thus permitting him or her to concentrate upon and complete only those elements that are within the range of competence. In collaborative communities of learners, there are overlapping zones of proximal development (ZPD) and cognitive diversity that guide students to the kinds of areas that they cannot yet manage but that are in their ZPD (Brown & Campione, 1994).

1.3 Motivational scaffolding

A general trend in CSCL has been an aim at turning classrooms of students into communities of learners and learning situations into projects with authentic problems (Brown & Campione, 1994 Cognition and Technology Group at Vanderbilt, 1994). Although the individual students themselves construct and test their own conceptual understanding, the community of learners and the interactions with different cultures of expertise have a notable bearing on the quality of learning (Brown & Campione, 1994). In contrast to traditional school settings, which usually are well prepared, organised and controlled by the teachers, self-organised learning and true student responsibility characterise these new pedagogical cultures.

1.3.1 How CSCL motivates learning

The process of knowledge-seeking inquiry which is a common pedagogical model used in CSCL environments (Koschmann, 1996a; Koschmann, Hall, & Miyake, 2002) starts from cognitive or epistemic goals that arise from the learner's cognitive needs that cannot be achieved by relying on available knowledge. The learner has a close and meaningful cognitive relationship with the learning task, which contributes to the intrinsic quality of motivation (Ames, 1992). An essential aspect of knowledge-seeking inquiry is also the generation of one's own explanations, hypotheses or conjectures (Brown & Campione, 1994; Scardamalia & Bereiter, 1994). Participation in a process of generating one's own explanations fosters a dynamic change of conceptions, produces knowledge that is likely to be connected with the learner's other knowledge, and, thereby, facilitates purposeful problem solving. The learner and the task create a new kind of cognitive relationship. This, to some extent, at least, contradicts the configuration common in traditional classroom settings where information is frequently produced without any guiding questions or personal ambitions.

Another important characteristic of CSCL is the potential it offers for effective social interaction. Some aspects of social interaction bear motivational implications. For example, peers provide models of expertise; observing the progress of other students may increase confidence in one's own ability to succeed (Bandura, 1997; Schunk, 1991). Furthermore, peer models provide a benchmark for students' own self-evaluations, thereby helping them to set proximal or more accurate goals.

In conclusion, it seems important to scaffold students not only on the cognitive level but also on the motivational level. The teacher should try to help students to see the value of the learning task from their personal point of view and, for instance, of its potential applications outside of school context (Brophy, 1999). General level instructions are not enough for a student who has major motivational problems and difficulties in self-regulative learning. Appropriate and realistic guidance towards meaningful sub-goals would help this kind of student to engage in the learning process (Hogan & Pressley, 1997). The instructional design of CSCL, such as inquiry learning, sets new challenges to students' motivation by changing the features of the learning environment. While the students are interpreting these new features they are motivationally constructing them in a different way than in a traditional classroom situation.

1.4 Authenticity used for scaffolding

One of the advantages of using technology is its capacity to create new opportunities for bringing real world problems into the classroom for students to explore and solve. CSCL technology can help to create an active environment in which students not only solve problems, but also find their own problems. The authenticity of the learning situations and tasks is assumed to be an important factor that can facilitate higher order learning (Brown, Collins, & Duguid, 1989). This idea has been particularly stressed in the work of the Cognition and Technology Group at Vanderbilt (1993). Many learning scientists have assumed that information technology can be used to bring real life problems into schools in a form that makes it possible to connect the practical problem solving with the learning of theoretical ideas and general thinking skills.

Anchored instruction (CTGV, 1993) engages the students in the context of a problem-based story. The students have an authentic role while investigating the problem, identifying gaps in their knowledge, searching and analysing the information needed to solve the problem, and developing solutions. This approach to learning is very different from the typical school classrooms in which students spend most of their time learning facts from a lecture or text and doing the problems in the end of the chapter.

Researchers in the CTGV have used video-based problems and computer simulations with CSCL technology that connects classrooms with communities of practitioners in science, mathematics and other fields (Vye, Goldman,Voss, Hmelo, & Williams, 1997). For example, in the Jasper® Woodbery problem solving series (CTGV, 1997), interactive video environments present students with challenges that require them to understand and apply important concepts in mathematics. Students who work in the series have shown gains in mathematical problems solving, communication abilities and attitudes towards mathematics (CTGV, 1997; Hickey 1997). These kinds of learning programs have not been restricted only to science, but problem solving environments have also been developed that help student better understand workplaces, for example in factory simulations students assume roles, such as manager or salesman and learn about the knowledge and skills needed to perform various duties (Achtenhagen, 1993; Lajoie & Lesgold, 1989). Experiments with so called micro-worlds and simulation-based science learning environments (De Jong & Van Joolingen, 1998) have shown that information technology can be used in creating new forms of teacher-student interaction in which the spontaneous activity of the student and the teacher's guidance are in balance. Another way to bring real-world problems into the classroom is by connecting students to working scientists (Cohen, 1997). In many of these student-scientist partnerships, students collect data that are used to understand for exampleglobal issues, involving students from geographically distributed schools who interact though the CSCL technology.

2. COOPERATIVE LEARNING METHODS

This section presents some of the most commonly known and used 'cooperative' (as opposed to collaborative) learning methods. Many of these methods have their roots in times before the constructivist ideas of learning and instruction. They reflect more the ideas typical to behaviourist ideas of that time: many of the methods are very teacher-centred. Learning is seen as mastering the predetermined content, and competition and rewards are used as motivators of student learning. However, the reason to present them in this chapter is their value of structuring instruction and learning. This value has been lost sometimes in recent attempts of non-structuring (non-instructing) learning due to overemphasising constructivist ideas of learning. In addition, many ideas of these methods have been successfully adopted in the field of CSCL (e.g., Dillenbourg, 2002; Miyake, Masukawa, & Shirouzou, 2001).

Research and development on specific applications of cooperative learning methods began in the early 1970s (Slavin, 1990). The need for specific methods of cooperation has, on the one hand, been motivated by accounts of research findings on the advantages of cooperative settings for achievement compared to individualistic settings (Johnson & Johnson, 1990). On the other hand the need has been motivated by findings on disadvantages of not structuring the small group activity, such as diffusion of responsibility and social loafing (Latané, Williams, & Harkin, 1975), destructive conflict (Collins, 1970) and dysfunctional division of labour (Sheingold, Hawkins, & Char, 1984). Next the essential elements of each chosen cooperative learning method is presented. Both socially oriented as well as cognitively oriented methods of cooperative learning are introduced. Finally some critique of cooperative learning methods is presented.

2.1 Socially oriented cooperative learning methods

2.1.1 Student Team Achievement Division (STAD)

An essential feature of STAD (Student Team Achievement Division), developed by Slavin (1980), is that students work together to learn and are responsible for their team-mates' learning as well as their own. The method emphasises the use of team goals and team success, which can be achieved only if all members learn the objectives being taught (Slavin, 1990). STAD has five major components: class presentations, teams, quizzes, individual improvement scores and team recognition. The material to be learned is initially presented to the whole class by the teacher, usually by direct instruction or a lecture-discussion. Teams are composed of four or five students who are carefully selected to represent a cross section of the class in terms of academic performance, sex, race or ethnicity. The major function of the team is to prepare its members to do well on the quizzes. Most often, students quiz each other, correcting misconceptions if team mates make mistakes, working from worksheets that consist of problems or information to be mastered. In addition to peer support for learning, the team provides mutual support and concern that are important for such outcomes as development of interpersonal relationships and acceptance of mainstream students. After team practice, students take individual quizzes. The quizzes assess individual achievement on the material practiced. An individual improvement score is calculated by comparing achievement to a base score, derived from performance on similar quizzes earlier. The idea behind the individual improvement score is to give every student a performance goal that the student can reach, but only if s/he performs better than in the past. This ensures that high, average and low achievers are equally challenged to do their best and have equal opportunities for success. Students then earn points for their teams based on how much their quiz score exceeds their base scores. Teams earn rewards, such as recognition in the newsletter, if their average score exceed a certain criterion. Thus, a teams' success depends on the individual success of all the individual students.

2.1.2 Jigsaw

In Jigsaw, developed by Aronson and colleagues (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978), interdependence among students is promoted by giving each student in a group access to information comprising only one part of the material to be mastered but s/he is evaluated on how well s/he masters the whole material. Thus, each student in a group has one piece of a jigsaw puzzle. The learning task for each student is to obtain information from every piece of the puzzle. The learning material is designed so that every part of the material is comprehensible without reference to the other parts. Team building and communication training activities are taught before grouping the students. In addition, group leaders are assigned and trained to keep the group on task. As in STAD, the composition of the groups is heterogeneous. Each group member reads his or her part of the material. Next, the students from different groups, each having the same material, meet in *expert groups* to discuss and learn their part of the material. After the expert group meeting the students return to their groups and take turns teaching their group mates about their own material. In Jigsaw, students have *individual tests* covering the entire learning material. Thus the incentive structure is individualistic. A group as a whole is not rewarded and thus is not responsible of their members learning, as is the case in STAD.

In the field of CSCL many modifications of the Jigsaw method have been developed and used (e.g., Dillenbourg, 2002; Hoppe & Ploetzner, 1999; Miyake et al., 2001). In these modifications the original Jigsaw's general idea of using expert and home groups has been adapted, for example, by forming groups that each represent a different theme or point of view in relation to other groups (expert groups), and subsequently mixing these groups to form new groups (home groups) in which each student represents a different theme or point of view. Everyone's expertise is needed to accomplish the home groups' task. However, in these modifications, there have been wide variations in instructional procedures, for example, in the complexity of the phases, nature of tasks and criteria of grouping students.

2.1.3 Jigsaw II

Jigsaw II (Slavin, 1980) is an adaptation of the original Jigsaw. The basic idea is the same as in the original Jigsaw, but it differs in three principles. First, all the students have access to all the materials, although they are responsible for one part of it. This provides the possibility of using existing learning materials that are not specially developed into independent units, even though this lessens the interdependence among students. Second, Jigsaw II uses base scores, improvement scores, team scores and individual and team recognition techniques similar to STAD. Third, Jigsaw II does not include team building or communication training. In addition, no group leader is appointed.

2.1.4 Similarities and shortcomings

All of the above described methods use some kind of positive interdependence among the students by systematically applying different reward or task structure principles (Kagan, 1985). In STAD and Jigsaw II, interdependence is created by rewards. The teams cannot be successful unless they take care of every member's success. In the original Jigsaw, interdependence is created by resources. Thus, students are dependent on each other in order to get access to all the material that is needed to succeed in individual evaluation. These include reward and goal (outcome) interdependence as well as resource and role (means) interdependence (Johnson and Johnson, 1990). In their study, Johnson, Johnson and Stanne (1990) examined the impact of positive goal and positive resource interdependence on individual achievement and group productivity. They discovered that the combination of both types of interdependence promoted higher individual achievement and group productivity than did any other conditions. Positive resource interdependence alone, which is the main element in the Jigsaw method, produced the lowest individual and group success.

Another feature that all the above-described methods have in common is individual accountability. Individual accountability is a sense of personal responsibility to the other group members for contributing one's efforts to accomplish the group's goals (Johnson & Johnson, 1990). In STAD and Jigsaw II, individual accountability is structured by having group scores be the sum or average of individual quiz scores. In the original Jigsaw, individual accountability is structured by task specialisation, whereby each student is given a unique responsibility for part of the group task.

The above described methods have been criticised for not paying attention to the specific cognitive activities among the students in the learning groups (O'Donnell, 1999). Even though the importance of group communication skills is taught in the Jigsaw method, there is no specific requirement for students to engage in specific cognitive activities during interaction. Two other cooperative methods, which structure the interaction by requiring students to engage in certain cognitive activities, are described next.

2.2 Cognitively oriented cooperative learning methods

2.2.1 Scripted cooperation

One of the central features of scripted cooperation, developed by O'Donnell, Dansereau, Hall, & Rocklin (1987), is that a script structures the interaction between the participants (usually two people). A script is analogous to a theatre script, where participants are asked to play specified roles (listener and recaller) in a particular order. There are two key assumptions with respect to scripted cooperation. First, in scripted cooperation participants are prompted to use cognitive processing that might not occur routinely. Second, scripted cooperation can limit the occurrence of negative social processes that may hinder effective group functioning. (O'Donnell, 1999).

An example of the use of scripted cooperation is illustrated here with a text-processing task, although the method can be used with a variety of tasks (O'Donnell 1999). Two participants have a shared goal to acquire information from a text. The text is broken into sections and both participants read the first section. The text is put away, and one student takes the role of recaller and the other student the role of listener. The recaller's task is to summarise the section of the material read. The listener's task is to detect errors, identify omissions and seek clarification. Then both of the students together elaborate on the material and make it more memorable. The procedure of reading, recalling, listening and elaborating is repeated for each section of the text. The students alternate the roles of recaller and listener during the procedure. At the end of the text students review the material.

There are many cognitive, metacognitive, social and affective gains of using scripted cooperation (for a detailed review see O'Donnell & Dansereau, 1992). Overt summarisation, error detection, elaboration and review are all activities that aid text processing and comprehension. The role of the listener as an active monitor of cooperation ensures that metacognitive activity is part of the process. The alternation of the roles provides the students an opportunity to model and imitate cognitive and metacognitive strategies. Also the alteration of roles limits unequal participation, typical to unstructured groups (e.g., Cohen, 1994). Affective outcomes such as positive attitudes towards other students have also been reported (O'Donnell, 1999). An example of the usage of scripted cooperation in the field of CSCL is presented in Section 4.3.

2.2.2 Reciprocal teaching

The reciprocal teaching technique, developed by Brown and Palincsar (Brown & Palincsar, 1982; Palincsar & Brown, 1984), is specially developed for understanding and remembering text content. It has many similar features to scripted cooperation, such as using specific cognitive strategies during the discussion and changing the students' roles during the procedure. The main difference in the two methods is that in contrast to scripted cooperation, in the reciprocal teaching model the teacher also has an active role in the group discussion. The basic procedure of the method is as follows. An adult teacher and a group of students take turns leading a discussion of a section of the text that they are jointly attempting to understand. The discussion in the group is free, but four strategic activities must be used routinely: *questioning, clarifying, summarising and predicting* (Brown & Palincsar, 1989).

Reciprocal teaching as a learning method is designed to provide a zone of proximal development. A novice's role in a group is made easier by a teacher's expert scaffolding. Also a group as a whole does a great deal of cognitive work until the novice can take over more responsibility. Because a groups' efforts are externalised, novices can learn from the contributions of those who are more expert than they. The role of the teacher is to model expert behaviour. The teacher makes mature comprehension activities overt, explicit and concrete, when it is her/his turn to be the teacher or when he/she is shaping the teacher role playing by the students.

2.3 Critique of cooperative learning methods

Some of the above described methods have been criticised for being planned to be used in tasks that calls for factual recall, a right answer, rehearsal of basic skills and routine application of procedures and concepts (Cohen, 1994). In these kinds of tasks there is no need for higher-order thinking and high-level interaction. For example, in STAD or Jigsaw II, interaction is limited to arguing about the right answer or procedure, and scripts used in scripted cooperation or reciprocal teaching are considered to impede conceptually oriented interaction (Cohen, 1994). Also the methods have been criticised for using heterogeneous grouping. According to Cohen (1994) heterogeneous grouping with different reward procedures is developed to motivate high-ability students to help low-ability students. This kind of grouping limits the learning opportunities of high-ability students.

However, in practice different cooperative methods have been used in more flexible ways. There is no rule that limits the usage of different methods to well-structured problems and closed questions. They can be used and have been used in ill-structured problems and open-ended questions (e.g., Dillenbourg, 2002; Miyake, Masukawa, & Shirouzu, 2001). In addition, criteria for grouping students can vary considerably. Cognitive diversity, in the form of differences of opinions for example, can be used as a way of assigning students to groups in order to promote high-level interaction (Dillenbourg, 2002). Furthermore, in the field of higher education the ability differences of the students are naturally not as drastic as they can be at the primary or secondary level of education.

The usage of cooperative methods can be seen in using scripts, i.e. "a set of instructions prescribing how students should perform in groups, how they should interact and collaborate and how they should solve the problem." (Dillenbourg, 2002, p. 63), that can be modified according to what kind of interaction, learning or outcome is expected to be achieved. However, from a collaboration point of view, scripting has its risks: it may disturb natural interaction and problem solving processes, increase cognitive load, make collaborative interactions overly didactic and lead to goal-less interactions from the students' point of view. Thus, in order to minimise the risks, the philosophy behind the design rationale should be based on a 'collaborative learning' philosophy (Dillenbourg, 2002).

3. LEARNING AS INQUIRY

3.1 Why models for facilitating learning as inquiry?

This section on learning as an inquiry includes a general framework to conceptualise different pedagogical approaches in CSCL. Discovery and inquiry processes can be described as methods of teaching and learning. Whereas discovery stresses a process whereby learners generate concepts and ideas with little guidance, inquiry stresses the stages where learners systematically become acquainted with scientific rules behind these ideas (Massialas, 1985). In both of these processes a strong activity-participation as well as motivation are needed. One of the basic ideas in these models is that content and process are inseparable components in learning (Bruner, 1960).

When an individual faces a problem, it causes discomfort. In order to move from a state of confusion to a situation characterised by satisfaction, an individual passes through five phases as follows: suggestion, intellectualisation, hypothesis, reasoning, and testing the hypothesis. Various authors have referred to inquiry by using such terms as problem solving, inductive method, critical or reflective thinking, scientific method, or conceptual learning. The essential elements of the process in many studies are those identified and elaborated by Dewey. According to Dewey, "inquiry is active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends." (Dewey, 1933, p. 9).

More recently Scardamalia and Bereiter (1996) have proposed that inquiry can be facilitated by organising a classroom to function as a scientific research community and guiding students to participate in practices of progressive scientific discourse. Analogous to scientific discovery and theory formation, learning is a process of working toward more thorough and complete understanding. It is an engagement in extended processes of question-driven inquiry. Facilitation of inquiry in CSCL requires encouraging students themselves to take on responsibility for cognitive (e.g., questioning, explaining) and metacognitive (e.g., goal-setting, monitoring, and evaluating) aspects of inquiry.

Several recent research projects in the field of CSCL share a common goal of fostering research-like processes of inquiry in education (Brown & Campione, 1994; CTGV, 1994; Lampert, 1995). Inquiry-based learning means that, for example during a course, the students generate and investigate their own research questions dealing with the common topic of the course. During these inquiry lessons, the students share their knowledge about their inquiries. In inquiry-based CSCL this may involve the use of some technological networked learning environment, which provides students equal possibilities to reflect and discuss the problems that emerged during their investigations. A technologically sophisticated collaborative learning environment can provide advanced support for progressive inquiry, and facilitate advancement of a learning community's knowledge through a socially distributed process of inquiry.

3.2 Discovery Learning

Bruner’s (1996) model of Discovery Learning stresses the cultural experiences children have, which encourage them to learn. According to him engaging children in discovery offers them a leap into the part of the world which is unknown to them; a possibility to speculate intelligently on underlying principles or generalisations explaining human interactions or physical phenomena. The first important part of the discovery learning model is that the structure and the form of the knowledge, which is under discovery, can be represented to the learner following three different systems: 1) enactively, that is, by a set of actions like counting real apples together, 2) iconically, that is, by using images of apples which are needed to count, and 3) symbolically, that is, by verbal symbols like 2 + 2 = 4. The normal sequence of instruction for most learners is from enactive through iconic to symbolic representation. This sequence of instruction during discovery is the second main part of Bruner’s model of Discovery Learning, where students are encouraged to develop and refine for themselves heuristic representations. The third essential part of the model is the form and pacing of reinforcement.

Bruner’s model uses the process of reinforcing representations developed by children. Learners discover the concepts and answers trough the heuristic of testing a hypothesis and revising the concepts based on feedback they receive from the test. According to Bruner (1960), the highest state of human learning is achieved when children begin to find out these regularities or irregularities of their physical and social environments themselves.

3.3 Group investigation

Group Investigation (GI) is a general organisation plan where students work in small groups using cooperative inquiry. In practice, students form their own groups of two to six members in which they study the subtopic from the topic being studied by the entire class. The benefit to learning of using the Group Investigation model derives from four basic components the investigation process includes: investigation, interaction, interpretation and intrinsic motivation (Sharan & Sharan, 1992). The main idea in the group investigation is that these components are combined in the authentic investigation process, which includes six separate phases, from choosing the subtopic to break it into individual tasks and carry out the activities necessary to prepare a group report. In the last phases the groups make presentations or displays of their investigations to communicate their findings to the entire class. In order to include assessment of higher-level thinking processes in the investigation, the evaluation by classroom peers and by the instructor of each group’s contribution is seen as an essential phase at the end of the process.

It is argued that Group Investigation gives more autonomy to the students than some other cooperative learning models like STAD. Usually GI has been used more for social domains than for science subjects like mathematics. In particular, it is designed to get the students to think creatively about social studies concepts and learn group self-organisation skills (Sharan & Sharan, 1992).

3.4 Progressive inquiry

The instructional design of progressive inquiry promotes processes of advancing and constructing knowledge, which are characteristic of scientific inquiry. It guides students to generate their own research problems and intuitive theories as well as search for explanatory information (Hakkarainen & Sintonen, 2002). All elements of inquiry are to be shared among the participating students in order to foster their understanding.

A process of inquiry can be divided into different phases, each of which has its own specific objective and function in the process. Accordingly, every phase has a special dimension from the motivational point of view. A starting point of the process of inquiry is *creating context* for a study project in order to help students understand why the issues in question are important and worthwhile to investigate, and to personally commit themselves to solving the problems being investigated. Motivationally, this phase should arouse intrinsic motivation and understanding of the value of learning (Brophy, 1999; Rahikainen, Lallimo, & Hakkarainen, 2001). An essential aspect of inquiry is to *set up questions* or problems that guide the process of inquiry. Questions that arise from the students' own need to understand have a special value. Further, the questions should be in explanation-seeking rather than fact-oriented form in order to direct the process towards deeper understanding (Scardamalia & Bereiter, 1994).

By *creating a working theory* of their own, students can systematically use their background knowledge and make inferences to extend their understanding. This phase enables students to be more involved in the process, because they can feel that they are contributors to the knowledge (Cognition and Technology Group at Vanderbilt, 1993). The phase of *searching and sharing new information* helps students to become aware of their inadequate presuppositions or background information. This phase especially requires students to comment on each other's notes, and encourages collaboration (Dillenbourg, 1999). A critical condition for progress is that students focus on improving their theory by generating and *setting up subordinate questions*. These questions will lead students towards deepening the process of inquiry (Hakkarainen & Sintonen, 2001).

3.5 Problem-based learning (PBL)

Problem-based learning (PBL) was originally developed in medical education in the mid-1950's, but it has been adapted to many other areas, from architecture to education. This learning method can be considered as an example of a collaborative, case-centred, and learner-directed method of instruction, where problem formulating, applying knowledge, self-directed learning, abstracting and reflecting are seen as essential components (Koschmann, Kelson, Feltowich, & Barrows, 1996b). These components arise from constructivist propositions, which can also be seen as instructional principles: all learning activities should be anchored to a larger task or problem, the learner should be engaged in scientific activities which present the same 'type' of cognitive challenges as an authentic learning environment, and the learning environment should support and challenge the learner's thinking (Savery & Duffy, 1996). The learning environment of PBL and a task should be designed in a way that they reflect the complexity of the environment. When conducting inquiry around a task, the learner should be given ownership of the process she or he uses to develop a solution. Teachers still have a role in guiding the process. They ensure, for example, that a particular problem solving or critical thinking methodology will be used or that particular content domains will be 'learned'. As in other collaborative learning methods, PBL students are encouraged to test their ideas against alternative views and within alternative contexts.

There are many strategies for implementing PBL, but usually the general scenario is the same (Barrows, 1986; Savery & Duffy, 1996). The students are divided into groups of four to five, and each group has a facilitator. Then these groups are presented a problem they are supposed to study and solve. Based on the knowledge the students have, they try to generate hypotheses of the problem by discussing with each other. After clarifying the problem, the students engage in self-directed learning to gather information from many different sources. After this individual studying phase, the students meet again in their groups. They evaluate the information they found to gather the essential pieces to solve the problem. This social negotiation of meaning is an important part of the learning process. The students begin to work on the problem and again, reconceptualise their problem to more specific sub problems. At the end of the process usually peer- and self-evaluation is used. This kind of PBL cycle takes some time, for example, in medical education it takes from a week to three weeks to conduct the PBL cycle.

3.6 Project-based learning

Project-based learning can be seen as a way to promote high-level learning by engaging students in real scientific work, learning from doing complex, challenging and authentic projects. To carry out the constructivist theory of learning, the main aim is that students actively construct knowledge by working with and using ideas (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). In a project, students engage in a complex process of inquiry and design, and the result is an artefact, which is based on students' knowledge and can be critiqued and shared. The public display of the artefact can motivate student involvement (Guzdial, 1998). The risk of this kind of projects can be a focus on task-completion. Often in such projects the final artefact is central and not the knowledge that is produced as a result. For example, if students make a poster; there is emphasis on task-completion.

At the same time when students are inquiring into the topic of their project, they are also studying many skills and forms of knowledge which are tacit or deeply embedded within a practice. It is argued that in this model of the collaborative learning methods the projects provide the best opportunity for students to understand these embedded or non-decomposable skills and knowledge (Guzdial, 1998). Usually project-based learning has been used with science subject matters. Especially for project-based science learning, Krajcik, Blumenfeld, Marx and Soloway (1994) proposed some features the learning process should include: 1) a driving question, encompassing worthwhile content, 2) investigations that allow students to ask and refine questions, 3) artefacts that allow students to learn concepts, 4) collaboration among students, teachers, and others in the learning community, and 5) technology that supports student data gathering, analysis, communication and document preparation.

To assist the use of project-based learning in practice, based on several studies Guzdial (1998) has developed a five-stage model for project progression: 1) *initial review*, where a problem is addressed and a solution process is designed, 2) *decomposition*, which includes defining the component of a solution, 3) *composition*, where students begin assembling the solution, 4) *debugging*, which means testing and redefining the artefact, and 5) *final review*, which is an important opportunity for the development of metacognitive skills. In the final stage, students can consider where a process may have failed, where it was successful, and what was finally accomplished. (Guzdial, 1998). However, we often assume that project-enhanced work automatically leads to high-level learning and only seldom describe the barriers to certain types of discourse occurring. Learning from doing complex, challenging and authentic projects requires resourcefulness and planning from the student, expanded mechanisms for collaboration and communication, and support for reflection and assessment (Laffey, Tupper, Musser, & Wedman, 1998). However, there are many difficulties students may encounter while pursuing their project to the result of a self-designed artefact. Students may not be able to recognise the learning goals of the project, or they may simply focus on completing tasks, rather than the process of learning. To orchestrate project-based learning successfully, students need opportunities to reflect on their learning and the purpose of the project. There must also be enough support. Too much support may be overwhelming and not enough can make the task too complex (Guzdial, 1998).

4. CONCRETE DESCRIPTIONS OF CSCL PEDAGOGICAL MODELS AND EXAMPLES OF INSTRUCTIONAL SUPPORT

This section introduces different pedagogical models for CSCL in higher education contexts. The criteria for the models are their contribution to the quality of learning, innovativeness of the pedagogical idea, as well as their relevancy to different educational contexts. Special attention is paid to the practical features of the pedagogical design and instructional support (process scaffolding in Section 4.1 and 4.2, and cognitive scaffolding in Section 4.3), not to the technological environments applied, nor to the research results received.

4.1 SHAPE: sharing perspectives in virtual learning in higher education

Järvelä and Häkkinen and their colleagues have developed a pedagogical model supporting the interactors' perspective sharing in CSCL in higher education. The pedagogical model is based on their previous studies of networked interaction and a case-based model for conferencing on the Web (Järvelä & Häkkinen, 2002; Saarenkunnas, Järvelä, Häkkinen, Kuure, Taalas, & Kunelius, 2000).

An international CSCL course in pre-service teacher education was planned from the point of view of theory-based cases: the students were asked to produce collaboratively two or three short cases on problems they had encountered in different educational contexts, as teachers or students. They were also instructed to comment (e.g., add ideas, ask questions, support, contradict) on the cases written by fellow students, Finnish and American. The Web-work was followed by case summaries the students wrote. In their summaries, they were asked to consider how their understanding of the nature of their initial problem had changed during the Web-discussion. In this project, the students constructed case-based descriptions in areas such as motivation, multicultural education and technology in education, as well as the change these practices impose on traditional teaching and learning practices. Each case could have been either a success story or a description of a problematic teaching scenario based on fieldwork observations of 'theory in action'. For example, students were asked to describe a teacher and/or student(s) in a problematic or instructionally interesting situation observed in the field; leaving all the names and places of the situation anonymous. Different levels of expertise in peer and mentor collaboration were provided during the learning process in order to apprentice student learning. Mentoring was organised by senior students in other countries as well as by in-service teachers and faculty from other universities.

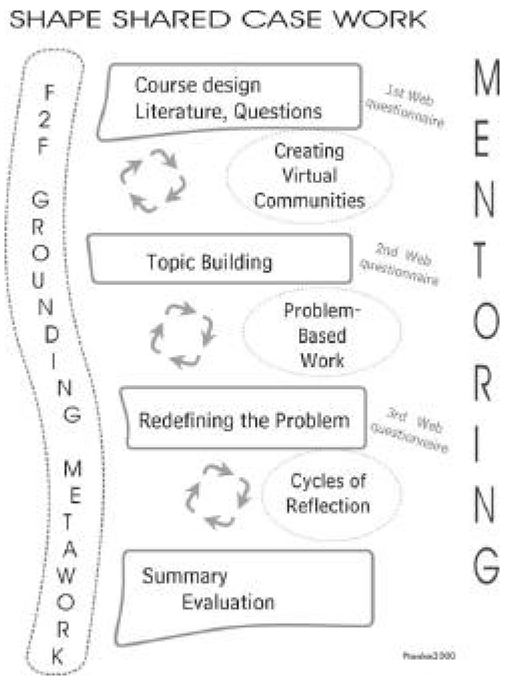

Figure 1. Pedagogical model for SHAPE (Shared Perspectives in Virtual Environments)

In terms of designing pedagogical implications to enhance high-quality virtual interaction, their model emphasises the following principles:

1. Problem-oriented case-work was established. Students had to redefine the original problem as well as to summarise and to reflect in the discussion during the course.
2. Group reflection was promoted by meta-work. The students' awareness of individual and group processes in the virtual community was raised with on-line Web-questionnaires.
3. Awareness of perspective sharing and negotiation of joint goals was supported by participant observation. The role of face-to-face meetings was essential for the grounding process throughout the course.

4.2 Collaborative lesson planning and teaching in a 3D Virtual World

One of the very recent technological applications for enhancing virtual collaboration derives from three-dimensoinal (3D) technology. 3D technology and the ideas related on game technology are not yet commonly used, but the pedagogical ideas and the technology can open future models for learning in higher education contexts. '3D multi-user virtual worlds' provide a shared place where not only content, but people as well, can be brought together to meet, exchange ideas and access a variety of online resources. In a 3D virtual world, the avatar representation provides a physical presence and visual cues (such as facing someone or walking away) that play an important role in interpersonal exchanges. The 3D environment itself becomes an integral part of the experience. Users can visually interact with material that is part of the discussion or learning experience (Jensen, 2001).

Earlier studies have applied 3D virtual environments for collaborative lesson planning and teaching for teachers (Chee & Hooi, 2002; Holmes, Lin, & Brandsford, 2001), for researchers' virtual interaction environments (Corbit & DeVarco, 2002), and spaces for creating the context for a collaborative virtual work space for architects (Wagner, Buscher, Mogensen, & Shapiro, 2001). Holmes, Lin and Brandsford (2001) created an environment for teacher education in science learning. The teachers designed for their virtual laboratory a set of experiments for students to explore. Students had to make valid conclusions about the habitat preferences of cockroaches. The learning space was designed around the virtual classroom and laboratory in order to explore how the physical space might influence discussion, reflections, and interactions with the environment. The participants of their first experiment included teachers from two different countries who used the environment for collaborative lesson planning. These studies show that when collaboratively planning the lessons the teachers did not simply collect, organise, and discuss the material to be taught. When using a 3D environment they can experience the lesson material because it becomes a part of the physical virtual space. The Holmes et al. (2001) study was one of the earliest pilot studies using 3D technology for collaborative learning and it is still difficult to make any further conclusions about the pedagogical ideas. This example shows how rapidly changing technology can give new models for CSCL. The results of their initial studies in the field indicate that virtual learning spaces have great potential to support highly motivating collaborative learning experiences.

4.3 Content schemes and cooperation scripts in desktop videoconferencing

The next case is related to a study that investigates the effects of different types of support for cooperation on the learning outcomes of peer dyads in a video-conferencing scenario (Reiserer, Ertl, & Mandl, 2002). A peer teaching setting was organised where educational psychology students collaborated on a text comprehension task. The learning task was to teach each other the contents of a theoretical text they had read individually in a text acquisition phase. The texts included theories associated with the nature-nurture-debate: one dealing with 'Attribution theory' by Bernard Weiner and the other one with the 'Theory of genotype-environment effects' by Sandra Scarr. Each student took two roles: the explainer-role when explaining his/her theory to the other student and the learner-role when receiving information from the other student. The technology used in the study consisted of a desktop video-conferencing system including audio- and video-connection and a shared screen to support the dyads' knowledge construction and to allow synchronous verbal communication and joint creation of text material. Students' cognitive activities and outcomes of cooperative learning were supported in two ways: with the aid of content schemes and cooperation scripts. The aim of the content scheme was to stress important aspects including concepts and main ideas of the theory, empirical findings, consequences and individual estimations. A text-based content scheme included guiding questions to facilitate collaborative text comprehension. A cooperation script aimed at directing processes of collaborative knowledge construction. The aim of the cooperation script was to direct the learners' interactions during the collaborative learning phase by defining four steps of interaction: 1) explaining the text material (explainer) and asking comprehension questions (learner), 2) typing the information received (learner) and supporting the learner (explainer), 3) generating their own ideas concerning the theory (both individually), and 4) discussing (both together) and writing down the results of the discussion (learner). The results of the study indicate that at its best, peer teaching can help students to actively engage in beneficial learning processes. Peer teaching supports particularly the learners who take the role of the teacher and the explainer.

5. RELATIONSHIP BETWEEN PEDAGOGICAL SUPPORT, CONSTRAINTS OF HUMAN LEARNING AND THE EDUCATIONAL SETTING

Roschelle and Pea (1999) indicated several difficulties for using today's Web as a medium for productive interaction: a) Interactive communication on the Web is very much dependent on text. Thus, it is much easier to passively read and view information than to actively create it; b) Collaborative processes are overemphasised, generalised, and their Web-specific features are not explicated; c) Asynchronous communication is very different from face-to-face communication.

Some of the most important processes in human communication, like creation of mutual understanding or shared values and goals, are hard to reproduce in the Web-environment.

Before the Web or any other collaborative technology there has been a long research tradition in classroom interaction studies. These studies have indicated evidence that the teaching-learning process is a complex social situation containing multiple actors, each interacting with his or her own intentions and interpretations (e.g. Pintrich, Marx, & Boyle, 1993). For example, studies of classroom learning interaction report difficulties in reaching reciprocal understandings even in traditional face-to-face teaching-learning situations (Winne & Marx, 1982). Virtual interaction without immediate social interaction has many challenges to overcome since communicating parties are faced continuously with the task of constructing their common cognitive environment. A great deal of information conveyed by face-to-face interaction is derived from such things as tone of voice, facial expressions and appearance (Krauss & Fussell, 1990). The absence of visual information (e.g., missing facial expressions and nonverbal cues) reduces the richness of the social cues available to the participants, increasing the social distance.

According to researchers in the field of socio-linguistics (Graumann, 1995), the mutual knowledge problem derives from the assumption that to be understood, speakers must formulate their contributions with an awareness of their addressees' knowledge bases. That is, they must develop some idea of what their communication partners know and do not know in order to formulate what they have to say to them. In asynchronous virtual communication the participants need to establish what is mutually known in order that messages can be formulated, and the meaning of messages can be constructed. One could expect the establishment of common ground to be particularly problematic when two or more groups of individuals, who come from different contexts and countries and who have not previously worked together, are electronically brought together to work on a common task.

Research on collaborative learning also calls for reciprocity in social interaction. Nystrand (1986) defined reciprocity as a principle that governs how people share knowledge. It rules their determination of what knowledge they will exchange when they communicate and how they choose to present this knowledge in discourse. Evidently, people acquire knowledge and patterns of reasoning from one another but for some kinds of shared knowledge, individually rooted processes play a central role. Regarding collaborative learning, in the grounding phase of coordinated problem solving, the participants negotiate common goals, which means that they do not only develop shared goals but they also become mutually aware of their shared goals (Guy & Lentini, 1995). The question arises how can we better enable participants to find each other and form collaborative teams around mutual goals, skills, and work processes in technology-based environments. Networked technology used in different learning environments provides a learner a relevant platform for communicating and sharing knowledge. Instead, more advanced technological solutions to support many problematic issues in virtual interaction, such as lack of sense of co-presence or difficulties reaching shared understanding in the distributed teams are still missing (Dourish, 1998; Fischer & Mandl, 2001).

CSCL can be a powerful tool in creating learning communities where students have a chance to collaboratively make representations, develop explanations of the subject studied and analyse knowledge (Scardamalia & Bereiter, 1994). But, it should be noted that students may not benefit from CSCL if they are not accustomed ton the practices of new learning cultures produced by CSCL and inquiry-based activities (Hakkarainen, Järvelä, Lipponen, & Lehtinen, 1998). CSCL practices need to be developed concurrently with pedagogical approaches so that technology, classroom activities and learning culture mutually support each other (Edelson, Gordin, & Pea, 1999).

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