Collaborative learning and CSCW: research perspectives for interworked educational environments

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Abstract
Collaborative learning has a long research history in education. In this paper this history is briefly sketched, highlighting its main orientations and insights in classroom settings, in classroom settings where a computer is present, and in networked and internetworked learning environments. Developing parallel to the educational research focus on collaborative learning, the research field of computer-supported cooperative learning has also emerged. A brief history of this field is also given, sketching its main orientations and insights relative to group cooperation, both face-to-face and in distributed environments. A comparative analysis of these two research streams is developed, suggesting contributions that each could make to the other, relative to insights and methodologies. A consideration of the need for synergy in the two research communities is presented, with examples of some research activity in which cooperative learning and CSCW are both represented.

Keywords: Cooperative learning; Collaborative learning; CSCW; Distributed; Groupware; Internetworked; Research issues and perspectives

1. INTRODUCTION

... the social science of collaboration is in its infancy. We currently do not have a deep understanding of the factors that enable people to work together effectively when they are physically proximate or remote... A deep understanding of this sort will probably only come after we acquire much more experience than we have now in building and studying systems designed for collaboration and coordination.

(Pea & Gomez, 1992, p. 100)

The purpose of this paper is to contribute to the development of this deeper understanding. We will do so by looking at two different streams of research and insight, that coming classroom-based educational research and that coming originally from the field of organizational and management theory and finding its expression now in the study of computer-supported cooperative work (CSCW). We will argue that each of these streams is generating insights and research agendas which are highly complementary to the other. Through their syntheses or at least synergy we will suggest a framework and research agenda for internetworked group collaboration in an educational context and consider the methodologies, technologies, and testbeds which could serve to address the agenda. We focus

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particularly on the design of computer instrumentation as a concretization of insights from both streams. We end with a plea for this type of synergy, which as of yet is little occurring.

2. COOPERATIVE LEARNING AS A FOCUS IN EDUCATIONAL RESEARCH

Cooperative learning has been defined as "instructional strategies which depend on the interaction of a small group of learners as a central feature of classroom learning tasks" (Dodd, 1990, p. 344); "a form of classroom organization in which students work in small groups to help one another learn academic material" (Slavin, 1987, p. 1). A small group is "a collection of interacting persons with some degree of reciprocal influence over each other" (Schmuck & Schmuck, 1988, p. 20). These definitions, typical of the domain, give a first emphasis to what the teacher does (instructional strategies, classroom organization) and situate the concept of cooperative learning in the classroom, under the teacher's instigation and management.

2.1 Research Prior to Cooperative Learning Situations Involving Computers

Cooperative learning as thus conceptualized has been researched extensively since the 1920s. At least four major centres of research have been productive and influential in the domain since the early 1970s (The Johns Hopkins University, the University of Minnesota, the University of California at Santa Cruz, and the University of Tel Aviv). Research was extensive enough by 1981 to generate a sample of 122 studies with characteristics appropriate for meta-analysis (Johnson et al., 1981). This study was (and is) widely cited, in that it concluded that all forms of cooperative learning were more effective than individualistic or competitive learning and further that cooperation without intergroup competition was more effective than cooperation with intergroup competition.

Methodological criticisms

However, this analysis and its sweeping conclusions quickly came under the methodological criticism that often follows meta-analytic analyses: the study was accused of ignoring pertinent interactions among critical variables; of basing itself upon often marginally valid dependent variables (i.e. achievement measured in terms of block stacking or performance on game-like measures such as golf or mazes or card playing); for including very brief and artificial experiments; and for potentially critical differences in the conditions under which cooperative groups worked compared to comparison groups (Cotton & Cook, 1982; Slavin, 1984). Studies appearing at the same time reached less-clear conclusions than the 1981 Johnston et al., analyses, leading Slavin in 1987 to perform a new meta-analysis in which best-evidence synthesis was used as the methodology (a procedure in which quantitative meta-analytic techniques are applied to studies passing a priori standards relative to methodological characteristics and constructual genericness (Becker, 1987). In addition, Slavin's 1987 study included as an analysis variable the method of cooperative learning involved.

Emphasis on method employed by the teacher

Dozens of distinct cooperative learning methods had appeared in the educational research literature by the mid 1980s (see, for example, Kanga, 1985); seven were selected by Slavin as most widely used. All of these seven were characterized by students being organized by the teacher into heterogeneous groups of about four members with the task of helping one another learn. While a group goal was present, individual accountability was also stressed. Variation within the methods was present relative to stress on equal opportunity for success, team competition, task specialization per group member, and adaptation of instruction to individual needs.
The 68 studies which were finally included in Slavin's (1987) analysis reinforced Johnson et al.'s earlier 1981 conclusion, that overall the effects of cooperative learning were positive (49 of the 68 comparisons favored the cooperative learning group to the comparative group). However, the analysis also established the importance of the method used by the teacher to organize the cooperative learning experience. In particular, "cooperative learning can be an effective means of increasing student achievement, but only if group goals and individual accountability are incorporated in the cooperative methods" (Slavin, 1987, p. 21; see also Slavin, 1990).

Other researchers have further studied the influence of the teacher's implementation of a cooperative-learning strategy as a critical variable on subsequent student achievement. Webb (1985), for example, found that group activities structured by the teacher to include the giving and receiving of explanations resulted in significant achievement gains compared to groups where such teacher structuring did not occur. Joyce and Weil (1986) characterized successful cooperative learning as requiring the teacher serving as a counselor, consultant, critic, and the one who engineers the discrepant event which motivates the group activity.

Johnson and Johnson (1984) also emphasized the role of the teacher in cooperative learning, to (a) clearly identify the activity's objective to the group members; (b) determine how the groups will be constructed relative to size, ability-level mix, time for interaction, group-member roles, and physical and logistical aspects of organization of the group-work setting; (c) appropriately explain the task and cooperative goal structure to the students; (d) monitor group effectiveness and intervene to provide content or group process-oriented assistance; and (e) evaluate group achievement and how well the group members collaborated with one another. Johnson and Johnson also stressed criteria relative to the group members as being essential to the success of cooperative learning: positive interdependence relative to goals, task, resources, roles, and rewards; face-to-face verbal and non-verbal interactions; acceptance of individual accountability; and appropriate command of interpersonal and small-group skills. For the latter, the teacher again is critical, in that the teacher's role is "to teach the group members the limitations and boundaries of the group, acceptable social skills, goal setting, and the skill to analyze progress of the group." (Dodg, 1990, p. 348)

Preliminary consensus
Thus educational research appears to have reached a certain level of consensus about cooperative learning, at least in traditional classroom settings. Clear in this consensus is that the process is complex and requires considerable skill and effort on the part of the instructional leader and the participants to execute effectively.

2.2 Cooperative Learning with Non-networked Classroom Computers
Parallel to this on-going research focus on classroom cooperative learning, the 1980s also of course saw the broadscale development of educational research relating to the effects of microcomputers in the classroom. Studies began to appear investigating the inclusion of a microcomputer into the instructional-materials mix in cooperative learning situations. Some of this early investigation was done by researchers already focused on the cooperative-learning paradigm, but other studies were done by persons with more of a focus on the computer aspects of the research than on the cooperative-learning dynamic.

Importance of individual characteristics of the learners
Webb and, Johnson and Johnson are among those who made a productive transition from their earlier work on cooperative learning into the investigation of cooperative classroom learning
environments when a computer is a central instructional resource. Webb, in a series of studies (see for example, Webb, 1984; Webb, Ender, & Lewis, 1986) examined students working in small groups while they learned programming. She in particular studied the relationship of the students' cognitive styles and abilities to their behaviours while engaged in cooperative activities as well as their performance outcomes relative to programming skills. Her results were generally supportive of cooperative learning but included the insight that not only the cooperative group processes were involved in subsequent results, but also student characteristics, including their preferred cognitive styles, gender, and previous experiences with computers and the subject matter under consideration.

Johnson and Johnson also continued their cooperative-learning research by extending it to the investigation of the comparable effects of competitive, cooperative, and individualistic learning experiences when computer use is integrated into the various experiences. They found that "computer-assisted cooperative learning promoted greater quantity and quality of daily achievement, more successful problem solving, and her performance on factual recognition, application, and problem-solving test items than did computer-assisted competitive and individualistic learning" (Johnson & Johnson, 1984, p. 15). They also extended their previous work by noting a particular trait-treatment interaction that had not previously been highlighted in the (non-computer related) cooperative learning research - the finding that "the combination of cooperative learning and computer-assisted instruction had especially positive impacts on female students' attitudes toward computers, whereas the combination of competition and computer-assisted instruction had an especially negative impact on female students' achievement, achievement motivation, confidence in their ability to work with computers, attitudes toward computers, and attitudes toward the subject area being studied" (p. 15). This observation (and also findings of Webb's relative to gender and cooperative learning) contributed to a shift in focus in many research studies relating to cooperative learning in the 1980s - a focus more toward the gender-difference/computer dynamic than the cooperative learning perspective. However, as they had previously done with non-computer strategies, Johnson and Johnson continued to focus on suggestions for the teacher relative to the organization of the cooperative learning experiences but now where the computer is a central educational resource (see, for example, Johnson & Johnson, 1988, pp. 15-18, for instructions on how to organize computer-based instruction for cooperative learning groups in the classroom).

Small groups and ATI

The work of Webb and Johnson and Johnson demonstrates what appears to be the major shift in orientation in educational research relating to cooperative learning when computers were added to the investigative domain in the 1980s; a shift away from a major focus on the teacher-organized methodology of the cooperative activities (as had been the primary organizer in Slavin's 1987 meta-analysis) toward a focus on trait-treatment interactions in students' computer-use activities in cooperative situations. Schlecter, for example, (1991) conducted an analysis in 1991 of 55 published studies involving 'small group/cooperative learning' and instructional uses of computers. [While the enlargement of the domain to include 'small group' as well as cooperative learning is problematic (as noted by Rysavy & Sales, 1991, just because students are organized into a group does not mean that conditions earlier cited as fundamental to cooperative learning, such as individual accountability and a clear sense of group goals have been met), this enlargement is typical of much of the research regarding cooperative learning and computers evolving since the mid-1980s.]

Schlecter found in his analysis that student-ability level was involved in the effectiveness of the learning activities ('heterogeneous ability grouping helped the performance of lower ability students
without any negative effects on the higher ability students”, p. 14); in general, that students’ preferences for and abilities to benefit from small group and individualized computer-based learning were influenced by various student characteristics, including their social skills; and that task demands “could foster or impede cooperative learning” (p. 23). Relative to performance achievement, he found no consistent effects for either small-group or individualized use of computers in the 55 studies. Schlecker concludes his analysis by noting:

“Educators should also realize that small group CBT has not been demonstrated to be more instructionally effective than individualized CBT. This ‘non-finding’ could reflect ATIs in students’ abilities to benefit from small group or individualized CBT. For example, extroverts or learning disabled students might benefit more from small group CBT than individualized CBT, while the reverse might be the case for introverts or highly gifted students. Such possible ATI effects for small group CBT have largely been ignored by the research community.” (p. 23)

**Other social and theoretical insights**

A number of other insights have begun to emerge out of the more recent educational research relating to cooperative learning and computer use is that of the significance of the social interchange among the learners as they work cooperatively. The quality as well as the quantity of learner interactions has been found to be an important variable (Webb, 1988); as has group composition not only relative to ability level but to gender/ability level interaction (Dalton, 1990). Also important is the more explicit embedding of cooperative learning in Piagetian and Vygotskian learning theory, in order to ground peer interaction in a theoretical framework for cognitive growth (see, for example, Anderson et al., 1993; Doise & Mugny, 1984; Erut & Hoyles, 1988). Doise and Mugny, for example, apply the concept of group cognition from socio-cognitive developmental theory to support the necessity of children working in groups “to facilitate the breakdown of individual/egocentric understanding without being presented with a didactically induced (for a teacher or leader) demand for an answer” (Erut & Hoyles, 1988, p. 3). Thus, in the context of the new stimulus of classroom computer use, additional orientations and perspectives are receiving emphasis in the more recent educational research relating to cooperative learning than was notable in the earlier research in this domain.

**2.3 Educational Research and (Inter)networked Cooperative Learning**

Meanwhile, another application area for cooperative learning and computers has begun to emerge, with new infusions of insights, applications, and emphases. This is the area of distributed collaboration made possible by telecommunications technology. In this situation, the participants in a cooperative learning group will not be interacting face-to-face with one another, and may not even know each other personally. Rather than being in a single classroom, they may be spread out throughout a school, region, country, or internationally. They may be interacting at the same time (synchronously) or at delayed times (asynchronously). The ‘teacher’ may be far-removed from the group, both personally and in terms of group organization and coordination. How is this new application area for educational research evolving and what are some of its new perspectives, in comparison with research relating to cooperative learning in non-computer and standalone-computer classrooms?

**Cooperation mediated by classroom networks**

Newman and colleagues (1989) did early work in this area through the Earth Lab Project, which was based on “established classroom practices of cooperative groups” (p. 151) and utilizing LAN technology and specially developed software to facilitate the communal
development of a common database and other cooperative learning activities in which the students were involved. One of the goals of the project was "to let the children use computers the way scientists do" (p. 153), an example of the socially oriented results emerging in current networked cooperative learning activities. Another important insight of the EarthLab Project was the value of coordinated rather than redundant investigations among the different groups of students, so that each group makes a unique contribution to a communal product which Newman and his colleagues describe as "a new level of meaning as well as a greater level of complexity to classroom activities which are not found in standard approaches to cooperative learning" (p. 163). If indeed there are conceptually new aspects of cooperative learning may be questioned with Newman et al's sorts of cooperative activities, but certainly more technical complexity is present in the combination and sharing of collected data than had been the case in early 1980s' cooperative learning activities.

CMC and cooperative learning activities
While Newman and his colleagues studied LAN-mediated cooperative activities, another area of research has developed from classroom learning projects involving computer-mediated communication (CMC) and cooperative activities involving participants physically unknown to one another and at a distance from one another. The work of Riel (see, for example, 1983; 1990) is representative of this stream of educational research. Building upon cooperative learning principles, Riel notes similarities and differences in cooperative learning activities taking place within classrooms with those taking place across classrooms via electronic networks (1990). In the 'Learning Circle Model' which she describes and investigates, the teacher remains a central factor is activity organization and execution (for example, see Riel & Levin, 1990). The internetworking aspects allow broadening of scale and the additional dimension of cooperative learning between classroom groups as well as within them. In her work and that of her colleagues, Riel has documented changes in students' reading, writing, science and problem-solving skills when working cooperatively through networks with students in distant locations (for example, in Cohen & Riel, 1989) and also in students' self-esteem (Riel, 1990).

The teacher as collaborator
However, Riel and others in the cooperative learning/CMC stream of educational research are emphasizing more than a broadening of scale in internetworked cooperative learning, they are also focusing on the teacher as a member of the cooperative team, not just its coordinator. The parallel learning and professional growth that takes place as teachers interact with each other and with other educational professionals via internetworking is emerging as an important dimension of cooperative learning activities, in the internetworked environments of the 1990s.

The multi-aspect LabNet Project (Ruopp et al., 1993, is an example of this sort of system-oriented approach to cooperative learning. The LabNet Project is a teacher-support project developed by TERC (Technical Education Research Center) in Cambridge, Massachusetts, and funded by the National Science Foundation. The Project began in 1989 and finished in 1992. During that time, 562 secondary-school teachers of physics from 37 states, Puerto Rico, and American Samoa were involved in project activities. The activities were based on three premises: the value of the use of projects to enhance students' science learning, that a community of practice should be developed among teachers of physical science to stimulate their professional growth and to overcome their professional isolation, and that new technologies should be used to support both the implementation of the student projects and the development of a community of practice among the teachers in the project.
Telecommunications-supported communication supported both the student and teacher cooperative activities. Results were related more to broadscale change than to student pre- and post-test measures. Among the results of the project are the thus the following:

- The community of practice, with TERC staff serving as catalyst, created the opportunities for teachers to take leadership roles...the leadership role was experienced as personal growth and produced a greater commitment to the community of practice.
- Teachers' leadership roles in the community of practice tended to respond well to local needs...This kind of grass-roots activism is one successful outcome of the community of practice. (Ruoff et al., p. 142)

**Facilitating a community of practice**

This orientation toward results in terms of teacher facilitation are occurring in a number of current research studies relating to internetworked cooperative learning (see also, for example, Stapleton et al., 1992; and Willis, 1991 for an application to higher education professionals) and is related to another focus of internetworked collaboration - the social focus of increasing individual involvement in public issues. As early as 1983 John Seeley Brown was investigating this aspect of the computer as a communication device. He concludes an analysis of this aspect by saying:

"We must also recognize the critical role of the computer as a device capable communicating the products of creative efforts along with the process that underlies their creation. The computer as a communication facilitator not only permits the wide dissemination of knowledge and the development of supporting subcultures, but also provides the opportunity to engineer the sociological element of learning environments-a topic that deserves some serious research." (Brown, 1985, p. 199)

**Emphases on theoretically grounded instrumentation and methodology**

This shift in research focus is bringing with it at least three new emphases in educational research. One of these is the call for more detailed study of the social and psychological aspects of groups as they work both face-to-face and electronically (Pea & Gomez, 1992; Willis, 1991). Another is a focus on the design of the instrumentation through which the learner interacts with not only his or her own computer but also with the unseen learning partners and their communally accessible resources in internetworked collaborative learning settings (Dede, 1990; Bijkerkemberg et al., 1992). A third is a coupling of metacognitively-oriented learning theory with innovative software design in order to develop and test new sorts of networked learning environments for cooperative learning activities. A number of examples of this latter category will now be discussed.

**Examples of theoretically ground instrumentation**

Among the more-recent examples of theoretically grounded innovative software to facilitate networked cooperative learning activities can be cited the projects of Rada et al., (1993); of Clement et al., (1992); and in particular, the CSILE research of Scardamalia & Bereiter (1991; 1992) and their colleagues (Scardamalia et al., 1989). All of these share the aspect of being hypermedia systems, grounded in cognitive learning theory. Rada and his colleagues have designed a series of multi-user hypermedia systems to support cooperative learning activities among various groups of university students. The systems were developed with a hypermedia tool called the MUCH (Many Using and Creating Hypermedia) system and the research results reported were those from on-going formative evaluation of the innovative materials
being developed by the tool and surveying tool users, students and faculty, with their impressions of the value of the MUCH-based learning experiences.

Clement, Vieville, and Vilers (1992) base their design of a collective system for five networked computers on constructivist and interactionist perspectives where learners, using a hypertext system, "build together an integrated vision of an analyzed situation i.e. the need to offer to the learners a work space where they will share their representation and/or solutions of the problem and then decide in favour of the optimal solution, selected as a correct one by everybody" (p. 152). They further note "speaking about cooperative learning does not mean leaving the learners alone in front of the task/problem" but requires external guidance, mediation, and scaffolding. Their ways of organizing this in their system, called CoCoNut, are referenced theoretically to Bruner (see, Bruner, 1965, for the classic work) and Vygotsky (1978). The experiences so far with the prototype CoCoNut system have been fraught with many technical difficulties, but have convinced the researchers that "the role of the human mediator is essential for the construction of shared knowledge and social cognition, even with the shared workspace made possible by networking." (p. 159)

CSILE, which stands for Computer-Supported Intentional Learning Environments, is a networked hypermedia system allowing students to create a communal database of information in various media. All information in the database is available to all students, and they can retrieve, link, add to, and comment upon each other's work. The CSILE conceptualization and its software environment have been evolving over a period of years and are based on the idea of procedural facilitation, an approach:

"...to providing learners with temporary supports while they are trying to adopt more complex (cognitive) strategies. These supports include turning normally covert processes into overt procedures; reducing potentially infinite sets of choices to limited, developmentally appropriate sets; providing aids to memory; and structuring procedures so as to make it easier to escape from habitual patterns. A cardinal principle is that these supports should be designed so that when they are withdrawn the learner is carrying out the mature process independently." (Scardamalia et al., 1989, p. 54)

The design principles underlying procedural facilitation as mediated by the CSILE system are carefully described and emphasize shared responsibility and "students gaining higher-level executive control of their learning processes" (p. 65). Experiences with the CSILE system in classroom situations are underway and are yielding productive and promising results (Scardamalia & Bereiter, 1991).

Two orientations

Thus we see two different types of orientation emerging in the current research related to cooperative learning facilitated by (inter)networked learning environments; one characterized by sophisticated cognitive learning theory, the other by a vision of expanded professional activity and interaction among both students and teachers. Both require for their execution sophisticated new technological tools. Knowledge about such tools is only slowly evolving in educational research. In contrast, such knowledge is much-further developed in the domain area of CSCW (computer-supported cooperative work). However, among all the educational research cited so far in this paper, little acknowledgement of the CSCW domain can be found (Dede, 1990, and Pea & Gomez, 1992, are notable exceptions. The Pea and Gomez study will be elaborated later in this paper). What is this domain? What are key findings emerging from it that could inform the current educational research in networked cooperative learning environments?
3. THE EVOLUTION OF CSCW TO ITS CURRENT RESEARCH FOCUS

3.1 Cooperative Work as a Focus in Organizational Theory Research

The current research area called CSCW (computer-supported cooperative work) was only given a name in the late 1980s but is the product of the long evolution of research in a number of domains, "including, but not limited to, organizational theory, management science, information systems, computer science, industrial engineering, cognitive psychology, social psychology, ergonomics, linguistics, communication studies, sociology, and even anthropology" (Banton et al., 1988, p. 188). For space reasons here, only a brief overview will be given of this evolution, from the general framework of organization theory. Only a few classic references will be given; general sources such as Luthans (1985) are available in the organizational theory literature to support the following summary.

From task specialization to decision support

Organizational theory had its beginnings in the late nineteenth century, largely through the pioneer work of Taylor (1911) who was the first to consider the production line of the factory in terms of scientific principles for its management. (Henry Ford applied Taylor's ideas to the automobile assembly line, leading to an emphasis on efficiency and task specialization and a de-emphasis on human and social aspects). Taylor's work remained the classic source for organizational theory for more than two decades.

Two parallel trends, however, began to emerge over time. In one, the Frenchman Henri Fayol translated Taylor's ideas relative to the scientific organization of the production floor to the management level, laying the foundations for management theory and introducing a more human-oriented dimension to analysis (for a later translation of Fayol, see 1963). In the other, a gradual reorientation took place toward a more human-relations oriented approach to organizational theory (thus following Fayol rather than Taylor). By the 1930s psychologists and sociologists became contributors to organizational theory, emphasizing the study of managers' behaviours, how they cooperate and take decisions. The methodology of organizational theory gradually became that of the social scientists, predominantly interviews and observations. But evaluation procedures and a theoretical basis for this approach to organizational theory did not clearly emerge. What did emerge was an orientation in the field toward the idea of self-improvement, emphasizing the importance of the individual in management.

However, by the end of the 1930s, stimulated by the development of the field of applied mathematics and the continual need by management for better support, a new phase of organizational theory and practice emerged. This phase took the decision as its focus and worked from the assumption that if managers know how to make good decisions, good results will follow. The evolution that had before occurred away from production-line orientations toward human considerations now found its operationalism in the idea of an algorithmic, mathematical approach to decision making. By the 1940s, highly influenced by the needs of the military, 'operations research' focused on the use of high-speed calculations to support timely and accurate decision making. This approach of necessity was multidisciplinary, involving mathematicians, information systems scientists, technical experts, and, still, human-behaviour specialists.

By the end of the 1950s the decision-oriented focus in organizational theory was modified again, this time through the influence of the newly developing 'system theory', in which the idea of social and technical interactivity began to be articulated. Systems analysis began, aiming at the integration of technical and social perspectives within work environments.
Through the 1960s the complexity of the task of improvement within complex work environments became increasingly obvious, and the methodologies available through both the operational research and system-theoretical approach were not capable of dealing with the multivariable complexity.

**Information technology**

The development of computing brought new possibilities and perspectives. Management needs and information technology (in the form of programming) and human behaviour perspectives combined in the new application of management information systems (MIS), based on the assumption that people will make better decisions if they have access to large amounts of data, well organized in databases which can be processed by high-speed computing to reflect various management models.

MIS stimulated much research in the 1970s but gradually, again, frustration set up, based on the realization that much of human behaviour is (somewhat) unpredictable and that only limited decision-making processes can be formalized for machine simulation. Simon and Newell, in their classic work (1972), elaborated the position that it is wrong to attempt to prescribe human behaviour, that the successful manager does not make decisions in an algorithmic or model-based manner, but instead uses a vastly complex set of experiences in a flexible way, making rapid compromises. Optimal solutions are not the goal, but support for individual needs in decision making is critical. A reorientation from MIS to DSS (decision support systems) emerged, structured, rapidly accessible data as a resource for the decision maker to use as he or she best sees fit became the key concept (Turban (1990) is a basic source). DSSs became key foci in organizational theory research in the 1970s and early 1980s.

**Information technology and support of the cooperating group**

But evolution continued. Gradually the awareness developed that the individual does not often take a decision in isolation, but as part of a group and that the management of group decision making is a critical need. Thus gradually, in the 1980s, group decision-support systems (GDSSs) began to emerge. But for groups to come to a decision, their members must be able to communicate with one another, a more and more complex task as groups often consisted of colleagues working at different locations. Group communication support systems (GCSSs) began to emerge. The concept of groups working together and working cooperatively developed strongly in the organizational theory research during the 1980s.

McLeod (1992) performed a meta-analysis of experimental studies published in the 1980s that focused on the relationship between electronic group support systems (GSS) use and group process and outcomes. She included both GDSSs and GCSSs with both physically dispersed groups and face-to-face groups. All 42 studies in her analysis used electronic communication channels, involved comparisons with groups not using electronic support, stressed the input of all group members to the group work, had software that mediated the task work of the group, and involved an empirical comparison of the DSS group with a non-DSS group yielding data appropriate for meta-analysis techniques. Her sources for the meta-analysis included journals such as MIS Quarterly, Management Science, Communications of the ACM, Academy of Management Journal, Journal of Management Information Systems, Information and Decision Technology, Decision Support Systems, Organization Behavior and Human Decision Processes, Human-Computer Interaction, Human Factors, Small Group Research, and the Journal of Applied Psychology, among others, and proceedings from various Computer-Supported Cooperative Work conferences and other such sources.
Her findings included the following: that GSSs are associated with statistically significant ($p < 0.05$) increases in task focus within groups, with increases in participation equality, with increased time to task completion, and with improved decision quality when compared to groups not using GSSs. No difference was found relative to individual group members' satisfaction and confidence with the task process used by their groups. She concludes, after an analysis of the limitations in her base studies and in the meta-analysis procedures, and after including a qualitative synthesis of some additional studies, that "although the results of the current analysis suggest that GSS improves decision quality, we should question whether it improves overall performance" (1992, p. 275). She calls for more research relative to the task of task most appropriate to GSSs, to the interaction between leadership and GSS use, to the ways in which GSS can affect process over time in a group, and for more attention to the balance between task and socio-emotional behaviours in subsequent research (p. 277). What she does not mention is anything to do with learning and the fact that participants within a group are in fact learning from each other and for their own improvement.

The emergence of CSCW
It is in this stream of development that CSCW has emerged. (The term was first used in 1984, to label a series of conferences sponsored by the ACM, Association for Computing Machinery, to examine how people work in groups and how technology can support them.) CSCW adds the focus on 'cooperation' relative to what a group is doing, and brings with it from early work the accumulation of insights relating to decision-support tools and theory, management-information systems, and group-oriented DSSs and CSSs, and human considerations as well as considerations relating to efficiency, systems, computer science, information systems and sociology. Notably missing in this list, as also was the case with the studies in McLeod's meta-analysis, is any mention of the considerable research base from education relating to cooperative learning and small-group dynamics, as well as the more focused research relating to cooperative activities in computer and internetworked environments.

3.2 Research Foci in CSCW
The multidisciplinary CSCW researchers have been highly productive in the years since 1984. Certain major foci can be identified in their research. Among these are (a) enabling persons to have the benefits of meeting face-to-face without actually being in the same place, (b) supporting cooperative work by providing participants with a shared information space and resources that they can communally use, and (c) facilitating group coordination and communication through increasing sophisticated software tools and environments. Cutting across all of these are certain key issues: How do groups work and how can they work more productively? What is computer-supported cooperative work, both practically and conceptually? What is groupware and what are its important functionalities and design issues? Some examples of the research base can give a flavour of this work.

Studying group processes
Studying groups with and without electronic support has been an important part of the CSCW research. Typical of such research is that of Kraut, Gallegher, and Egido (1988) who studied the nature of collaboration among 50 pairs of professions who had worked together on some sort of long-distance collaboration, generally the writing of a jointly authored paper. They identified two dimensions of the collaborative activity engaged in by the pairs, a dimension relating to the stages of the task (initiation, execution, presentation) and a dimension relating to task or relationship focuses during each of these stages. Through their detailed examination of the factors that facilitated or hindered collaboration within this two-dimensional domain they articulated an analysis of what sorts of technological support would be most helpful at
different periods in the distributed collaborative process. They concluded that, "the challenge we see for information technology developers is to create tools that not only facilitate task completion but also support productive personal relations." (p. 764) They give the opinion that "the main technologies that have been developed so far to support group work focus primarily on task completion, and we believe, have been largely unsuccessful precisely because of this." (p. 764)

Similarly, Tang (1989) observed teams of designers working in ordinary workspace (thus face-to-face) conditions. Through his detailed analysis, he identified two general dimensions of the process of teamwork, one relating to function (store information, express ideas, mediate interaction) and one relating to actions (list, draw, gesture). He then argued that electronic environments to support distributed groups must allow colleagues to achieve each of the nine function-action combinations as naturally as if they were working face-to-face if effective distance cooperative work is to occur.

Nunamaker, Dennis, Valacich, Vogel, and George (1991) took a different focus in their study of groups. They considered group size; group proximity; main group activities (idea generation, idea organization, prioritisation); and important sources of group process gains and losses, such as gains related to synergy and stimulation and losses related to 15 categories of disfunctionalities, such as failure to remember the contributions of others, domination of some members over others, or incomplete understanding of the task resulting in superficial discussions (p. 356). Through their analysis, they also developed a two-dimensional view of group interaction tools, where one dimension lists 13 types of tools (for example, group outliner and group questionnaire) and the other indicates if process or task is the major focus of the application of the tool.

As one more example, Heeren and Collis (1993) have also made an analysis of group cooperative activity, and concluded that three parallel sets of processes are occurring, processes related to the content-oriented focus of the group in a given problem situation, but also processes related to the management of the group as coordinated body, and processes related to the maintenance of the social well being and harmony of the group. Each set of processes requires different sorts of skills for its management in the group context, as well as different sorts of tools.

Those who take the group as their focus tend, in general, in CSCW work, to look to electronic support to compensate for face-to-face group interaction as much as possible when collaborators are physically separate from one another. McLellan & Knapier (1993) talk about 'virtual collaboration' in this context, and Lef and Giordano (1993) state explicitly that "the goal of CSCW design is supporting the group is to both model and simulate as nearly as possible the face-to-face situation... through the promotion of interaction and maximizing the exchange of interpersonal information in situ." (p. 210) They further note that an "aggregate of individuals is not a group" in that groups in the CSCW framework are "people who are interdependent upon one another to satisfy one or more of their needs, and who achieve or expect to achieve satisfactions from their association, developed feelings of mutual attraction and hence become a group". (pp. 211-212)

Analyses such as these, a rich collection of insights about group cooperative work is developing from the CSCW research community that is serving as the framework for decisions about the sorts of electronic support that is useful for supporting such cooperative work, in the workplace or at a distance.
Studying the nature of collaboration
A second ongoing line of research in CSCW is related to the first, but focuses more specifically on the nature of cooperation itself. As was the case when small-groups started to be clustered along with cooperative groups in the educational research, a number of CSCW researchers caution the field not to assume that shared workspaces or group communication are necessarily supporting cooperative work. A number of researchers make a further distinction between concepts such as teamwork and collaboration. Schrage (1991) for example is emphatic about this distinction:
"Collaboration is the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously processed or could have come to on their own. Collaboration creates a shared meaning about a process, a product, or an event." (p. 25)

Schrage further describes the collaborative process as being comprised of two elements: conceptual and technical collaboration, with the conceptual collaboration the primary aspect. He believes that "all collaborations rely on a shared space" (p. 25) and that "collaborative tools should enhance the visual nature of communication, but also require a new type of literacy." (p. 26) His articulation of collaboration has parallels with the ideas of social constructivism and shared meaning present in the CSILE work in the educational context and also suggest connections with Vygotskian ideas relative to social interaction.

However, Schrage's emphasis on a particular construct for collaboration is not necessarily shared by other researchers in the CSCW community. The term 'cooperative' is more typically used than collaborative, and many different nuances in definition can be found. Kling (1991), for example says the "CSCW may be seen as a conjunction of certain kinds of technologies, certain kinds of users (usually small self-directed professional teams), and a worldview that emphasizes convivial work relations." (p. 83) Collaboration is defined by Goodman and Abel (1986) as "people sharing information of some form and thus effecting changes in the thinking and actions of the people involved in the process." (p. 4) After comparing a number of such definitions, Bannon & Schmidt (1991) conclude that "the term 'cooperative' is the general and neutral designation of multiple persons working together to produce a product or service. It does not imply specific forms of interaction or organization such as comradely feelings, equality of status, formation of a distinct group identity etc." (p.7)

From such widely varying possibilities, it is clear that the definition of 'cooperative' is pertinent, not only in terms of the theory and motivations surrounding CSCW, but also in terms of the choice of tools and expectations of use of CSCW environments.

Technical support of CSCW
While CSCW researchers may not agree on what they mean by a group or what sorts of expectations they have for the process or outcome of 'cooperative' activity, they are in more agreement as to the nature of the electronic tools that can be part of the CSCW environment. The design and integration of such tool collections is a third major theme in CSCW research. The tools, often collectively called groupware (although "there is no rigid dividing line between systems that are considered groupware and those that are not", Ellis, Gibbs, & Rein, 1991, p. 25) can be organized according to a 'time-space taxonomy' identifying four categories of applications (same time/same place, same time/different places, different time/same place, and different time/different places), or can be organized in an 'application-level' taxonomy, including message systems, multiuser editors, procedure processing/work flows systems, calendar system, shared filing systems, document co-authoring systems, screen sharing
systems, group decision support systems and electronic meeting rooms, computer conferencing environments, intelligent agents, team development and management tools, and coordination systems (Ellis, Gibbs, & Rein, pp. 26-29; Wilson, 1991).

**Groupware**
Groupware products are becoming more and more complex, theoretically and functionally. Greenberg *et al.* (1992) describe four interrelated systems that constitute their GroupSketch communal work surface. Gibbs (1989) describe LIZA ('an extensible groupware toolkit') as an object-oriented collection of tools and 'events of interest'. 'Media spaces' (1993) under investigation at the Xerox PARC Research Laboratories involve "electronic settings in which groups of people can work together, even when they are not resident in the same place or time. In a media space, people can create real-time visual and acoustic environments that span physically separate areas... Support for cooperative work is not complete without considering all aspects of the work group process... the need for informal interaction, spontaneous conversations, and even general awareness of people and events at other sites." (pp. 29, 31) Thus media spaces involve video, audio, and computer conferencing environments.

**The 'Great Divide'**
But, despite the increasing conceptual and technical sophistication of the CSCW research, a sense of frustration is appearing in the CSCW literature. A 'great divide' based on the divide between social and technological focuses for CSCW is coming to be seen as a critical problem in the CSCW research (this was the theme of an international workshop Social Science Research, Technical Systems and Cooperative Work, held in Paris in March 1993 and bringing together by invitation productive CSCW researchers from many countries). The consensus of this workshop was that such a divide is a real problem in the CSCW research and underlying this is the lack of a true theoretical framework for CSCW (see, for example, Kuutti, 1993). Bodker and Christiansen consider the task of "messing with... the prospects of a theoretical framework for CSCW" (1993, p. 99), make "an attempt to bridge the great divide" (p. 108), and conclude:

"Maybe we are not ready: to try to merge humanities into technical thinking or vice versa. But by working on an overall theoretical conceptualization in interplay with concrete interpretations addressing as well technical as social issues in [CSCW] design we see possibilities to fill the gap between social analysis of present work situations and design of future and technically richer settings... to move our thinking in the direction of a theory of CSCW." (p. 109)

4. **RESEARCH ON COOPERATIVE LEARNING AND RESEARCH IN CSCW**

The great divide that the CSCW researchers discussed at the Paris Workshop also appears to exist between the educational research community investigating cooperative learning (particularly in internetworked environments) and the CSCW research community in either its social or technically oriented streams. Almost no cross-referencing of research from the two camps occurs, almost no cross-mingling of papers at each others' conferences (for example, a 1992 search of the ERIC data base of abstracts of educational research found 19,715 citations relating to 'cooperation' or 'collaboration' but only 2 relating to 'CSCW'; also see Collis, 1993, for verification of this lack of cross fertilization from a comparison of content from conference proceedings). It is the final goal of this paper, therefore, to make a contribution to such a bridge. Major contributions that each group's research methodologies and findings
could make to the needs of the other group will be suggested; common issues under investigation by both groups (but using different vocabularies) will be identified; and finally, a research agenda will be put forward which could capitalize on a synergy of the educational research and CSCW communities.

4.1 Major Contributions of Educational and CSCW Research
The analysis so far in this paper cannot claim to be an exhaustive one, either from the educational side or the CSCW side. However, from it and other sources (see, for example, Greenberg, 1991; Sharan, 1990) it appears justifiable to make some comparisons between main streams of development and contribution in the research domains. We suggest the following as an interpretation of main research orientations (Figure 1), limiting ourselves to focuses already discussed in the paper and presenting the points in an approximate chronological order relative to their appearance and emphasis in the literature:

Similarities and differences
From the chronological synthesis in Figure 1 we can see many points of generic isomorphism in the two streams of research development. Both involve groups functioning in the context of particular tasks or in the sorts of activities that facilitate task solution. Both show a recognition on the importance of effective communication for collaborative group work, and for structured contexts and environments in which the work can occur. Both show an early focus on the importance of the leader (teacher, manager) but also the individual within the group. Both evolved toward the support of distributed collaborators, and both have moved toward the design and examination of sophisticated electronic environments to support and mediate group cooperative work and learning among distributed groups.

Both each stream has had its distinct context and motivation, and these have led to different emphases within the research, emphases which may be less dominant or only implicit or even lacking in the research of the other stream. Our impression of these differences includes the following (for convenience the cooperative-learning focus within the educational stream is designated by CL and the pre-CSCW work is included in what is designated as CSCW) is given in Figure 2. We also give an opinion as to when the research orientations of one of the streams could make a useful contribution to that of the other stream, and when the orientations may be more appropriately different.

Areas of common concern
Figure 2 suggests areas of relative strengths in the CL and CSCW communities that could be of benefit each other's work. It is also interesting to consider some problem areas that both the CL and CSCW may well spend more time considering. These include the lack of good definitions relative to critical aspects of their research, namely, what is meant by a 'group' and what is meant by 'cooperative' or 'collaborative' work and learning. Also, each stream is grappling with appropriate methodologies for research and for meaningful measures of effectiveness. Finally, each stream is still working on a small-scale, controlled level; real-world, large-scale implementation of current research findings have not been empirically or 'market-place' tested given the costs and difficulties of technically supporting and implementing the types of interaction currently under investigation by the research in real practice. Thus each stream is facing the risk of distancing itself from the mainstream of the field in which it based for its relevance.
<table>
<thead>
<tr>
<th>Educational Research:</th>
<th>CSCW Research (Background: Organizational Theory)</th>
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<tbody>
<tr>
<td>• Benefits of cooperative learning relative to individual learning</td>
<td>• Focus on task specialization and efficiency</td>
</tr>
<tr>
<td>• Importance of methodology employed by teacher in structuring and guidance of cooperative activities</td>
<td>• Importance of managers’ behaviours, how they cooperate and make decisions in practice</td>
</tr>
<tr>
<td>• Influence of teacher</td>
<td>• Usefulness of social science methodologies (interviews and observations)</td>
</tr>
<tr>
<td>• Importance of structuring of group activities, of shared goals within the group, of individual accountability within the group</td>
<td>• Emphasis on self-improvement</td>
</tr>
<tr>
<td>• Importance of characteristics of verbal interaction among group members</td>
<td>• Focus on decision making as a logical activity that can be externally supported by technological tools</td>
</tr>
<tr>
<td>• Need for interpersonal skills</td>
<td>• Importance of analyzing the system in which decision making takes place</td>
</tr>
<tr>
<td>• Interaction between various personal characteristics (cognitive style, ability, gender, self-confidence, etc) on results of collaboration</td>
<td>• Application of information systems and movement toward technically supported decision support systems</td>
</tr>
<tr>
<td>• Theoretical frameworks based on socio/developmental and constructivist learning theories</td>
<td>• Development of group decision support systems</td>
</tr>
<tr>
<td>• Benefits of developing a community of practice for teachers; multilayer aspects of distributed communities of cooperative learners</td>
<td>• Importance of communication in group work on complex tasks; development of technologically supported GCSS</td>
</tr>
<tr>
<td>• Emerging interest in the electronic instrumentation to support cooperative educational activities; instrumentation typically grounded in a cognitive and constructivist learning theory</td>
<td>• Study of the group in terms of its content-oriented, organizational, and social aspects and simulation of face-to-face group work through technological support of distributed groups</td>
</tr>
<tr>
<td>• Metacognitive development, affective outcomes, and professional facilitation are dominant focuses of cooperative learning research</td>
<td>• Multidisciplinary development of electronic tools for distributed communication and sharing of resources</td>
</tr>
<tr>
<td></td>
<td>• Facilitating flexible, efficient 'virtual working groups' as they cooperate independent of time and distance is dominant focus of CSCW research</td>
</tr>
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Figure 1. Overview of dominant focuses and insights from educational research on cooperative learning and CSCW research
Comparison of Research Focuses in CL and CSCW

**CL Research Particularly Useful to CSCW:**
- Focus on importance of the teacher (leader)
- Focus on the impact of personal characteristics of individual group members (in particular, cognitive style, personality, ability level, gender) on group participation and group results
- Focus on importance of structure in the cooperative task
- Focus on metacognitive outcomes
- Embedding of research within theoretical frameworks (socio-developmental theories, cognitive psychology, constructivism)
- Design of technological support instrumentation based on theoretical frameworks relative to learning theory

**CSCW Research Particularly Useful to CL:**
- Focus on detailed analysis of different aspects of group activities and performance (face-to-face or distributed)
- Focus on the process of group cooperative work
- Focus on the tools and resources useful to support group cooperative work (face-to-face or distributed)
- Focus on decision support, mediated by efficient access to effectively organized information systems
- Focus on tools to support group communication and coordination
- Focus on adults working on real-world problems
- Research based on multidisciplinary partnerships with the benefits of combinations of resources and insights

**Aspects of CL Research Limiting Applicability to CSCW:**
- Research still carried out in classrooms, where subjects participate in contrived activities for which they are not directly motivated and for which they are not personally accountable
- Outcome measures are theoretically of interest but often their abstractness limits their meaningfulness in the business and professional settings in which CSCW finds its main application and support base
- Instrumentation often remains at the prototype level, not usable outside of the research setting in which it is (over a long period of time) being used as a research tool

**Aspects of CSCW Limiting Applicability to CL:**
- High cost and sophistication of electronic environments makes them only affordable in business and organizational settings
- Lack of conceptualization of cooperative work as involving learning, but instead a focus on facilitation of process, may lead to an emphasis on performance possibilities rather than on reflection of meaningfulness of the possibilities. Thus the contributions of the more reflective educational research community may not be considered relevant or useful to the more process-oriented CSCW community.

Figure 2. Cross-contribution potential for CL and CSCW research
In order to confront these problems, and their own limitations, it seems important that cooperation and collaboration become more established between the CL and CSCW research streams themselves (both streams accept the importance of such synergy as a construct within the framework of their own frames of reference, so logically the value of such synergy between themselves should also be evident). Some considerations for this synergy, and promising examples of its occurrence are the focus of the next, and last, section of this paper.

4.2 Toward Synergy and Cooperative Research Agendas

Figure 2 suggests areas of cross-fertilization for CL and CSCW research. It also suggests orientations which hinder this cross-fertilization. In this section we look at a sample of acknowledgements from each of the streams relating to the need for collaboration, or at least, acknowledgements of some of its own deficiencies. Also, some examples of synergistic research are described. The section, and the paper, end with a suggestion for collaborative projects involving both CL and CSCW researchers.

**Calls for expansion and collaboration from educators**

Dede (1990) has presented a particularly strong theoretical argument for "incorporating ideas from cooperative learning and computer supported cooperative work" (p. 247) through the application of improving the delivery of distance learning. He describes this focus as 'technology-mediated interactive learning' (TMIL) and notes that:

"Successful distance instruction depends on more than classroom management strategies, knowledge of subject matter, pedagogical expertise, and the ability to use the technology. Creating an intellectually and emotionally attractive 'telepresence' and building 'virtual communities' of learners are also vital." (p. 253)

For these virtual communities to emerge, Dede argues that the mediation of communication is vital, as are tools for aiding teamwork in cooperative problem solving, for reducing information overload in groups communications, and to enhance interaction within the group. He notes that CSCW research has a strong contribution in these areas and that "ideas powerful in improving occupational productivity may also enhance effectiveness in educational settings" (p. 255). He also predicts that groupware, the instrumentation of CSCW will, "within a decade . . . be influential in shaping the cognitive, affective, and normative quality of working life, thereby determining the attributes educators will be asked to instil in students." (p. 255)

Dede goes on to specify in more detail some of the contributions from CSCW that can be of value to TMIL. He describes the WYSIWIS interface ("what you see is what I see") as embodying a critical principle, that all members of the interactive learning group can see and manipulate the same information at the same time. He notes other important functions to include the capacity to save the dynamic contents of each participant's windows "storing not only the final product of a group session, but also the detailed ideas and changes each individual evolved during the session." (p. 256) He notes that hypertext capabilities are a frequent feature of CSCW software and argues the importance of being able to use these capabilities to "reveal and conceal complexity as the group builds an elaborate mental model." (p. 258) He then describes very CSCW research settings in which these and other tools are being used to study how such shared instrumentation can enhance group problem solving in both face-to-face and distributed contexts. Dede concludes with the recommendation (to his educational research readers) of some CSCW literature and notes that "ideas from CSCW should be very valuable in helping distance learning developers not 'reinvent the wheel' in adopting new functionalities." (p. 262)
Pea and Gomez (1992) provide another powerful argument for synergy among the educational research and the CSCW communities. They discuss the educational potential of 'interactive multimedia environments' (IMT) and in particular on telecommunications-centered distributed multimedia learning environments (DMLEs). They believe that such environments will be "central to the achievement of a learning society that can meet the demands of education and training during the next century. These theories have communication at the center, and they are based on interactive models of learner and teacher engagement in inquiry around activities such as design and real problem solving, rather than the dominant didactic model of the teacher as a delivery agent of knowledge through curriculum materials. Education and training concerns, we argue are thus squarely in the telecommunications business." (p. 75)

They go on to argue that this evolution will transform teachers and learners into coworkers and that more and more informal learning and informal learning settings will occur, noting that "the research base in informal learning settings outside schools is highly impoverished by comparison to new theory and empirical work in learning that is school-based." (p. 75) They see learning as a "lifelong process integral to becoming a member of different 'communities of practice' and sustaining such membership" (p. 78) and they proceed to give a thoughtful and educationally grounded picture of what sort of environments and interactions will not to occur for this evolving model of education to function. Many of these sorts of environments are beginning to exist and be used in practice, but in companies rather than educational institutions. Pea and Gomez fear that the typical 15-year 'trickle-down lag' between new technologies being developed for the defense, industrial, and commercial sections should not allowed to occur with IMT in that the social costs are too high if DMLEs are not concurrently developed. Educators cannot operate in isolation in that the infrastructure needed for DMLEs is too broad and complex and expensive to attempt to develop for educational research purposes. "IMT for DMLE is a technically class of applications" which cannot evolve out of the "classic model of a software industry creating applications for customers." (p. 100) Pea and Gomez see collaboration thus as necessary for the educational research community, but also argue that DMLEs "can serve as the leading edge to spur fundamental developments in the sciences that support computing and communication" (p. 100); thus of benefit for society as a whole.

Calls for expansion from the CSCW community
Called for expansion of their domains research framework are also beginning to emerge from the CSCW community. Bannon (1993) for example, notes that the CSCW community must recognize the members of cooperative groups are often heterogeneous in essential characteristics and that more attention should be given to user modelling in groupware design. Rogers (1993) calls for new paradigms of 'distributed cognition' to infuse CSCW research. Normal (1991) also notes the importance of incorporating more cognitive and social scientists in CSCW research, so that 'collaboration first, computing second' becomes more characteristic of CSCW activity. None of these CSCW researchers go quite so far, however, as to term 'learning' and 'educational researchers' in their pleas for more multi-disciplinary partnerships, although the areas in which they acknowledge CSCW research is comparatively weak are areas being significantly addressed by a number of educational research such as the CSILE group, and Pea and Gomez and their colleagues.

Cross-boundary research
Fortunately, some cross-boundary research is occurring, where the CSCW and CL traditions are being explicitly represented. The DELTA-ECOLE Project, funded by the European
Community, is one such example (Eijkelenburg et al., 1992). In this project, a diverse group of scientists from both the educational and CSCW communities are working jointly on the investigation of technological possibilities for TML (telecommunication-mediated interactive learning). The DELTA-JITOL Project, also funded by the European Community, is another example of collaboration including educational researchers, in this case on the technological and organizational support of open learning environments which learners can access when they wish, for the type of learning support that they need at that particular time (thus, 'Just-In-Time' Open Learning; see Goodyear & Steeple, 1992).

Other, smaller-scale projects are also showing this synergy. Heeren, for example, is investigating 'telecooperation support tools' from both educational and CSCW perspectives (Heeren & Collis, 1993). Min and Rada (1993), computer scientists, are focusing on educational applications of their groupware and its underlying model of collaborative hypermedia. Kaye (1989) describes one of the number of collaborative initiatives at the Open University (UK) relating to the design and use of an 'electronic campus' to support some of the OU's distance delivery. Doll (1990) discusses design guidelines for 'instructional groupware' which are phrased in an educational vocabulary but which can also be useful in CSCW and in synergistic CL-CSCW research.

5. Conclusion: Where Next for Collaborative Learning

But, despite these examples, the cross-fertilization of CSCW and educational research remains in its infancy. What is needed is a context not specifically placed in the classroom or in the office is which both CL and CSCW researchers are both central contributors, neither feeling to be an outsider in the other's reference group. The support of professional communities of teachers such as that in the LabNet Project (Ruopp, et al., 1993) is one such possibility but not likely to have the focus or mass necessary to generate adequate funding and motivation for cooperation. The application of distance education and training, particularly the training and open and flexible learning orientation, is more promising and is adequate motivation for various large-scale multidisciplinary research projects in Europe (the BCOLE and JITOL Projects mentioned earlier, and more generally, the overall DELTA Project (Brande, 1993). Brande summarizes the European Commission's reasons for giving high priority to research that stimulates European-wide flexible and distance learning and stresses the need for technical and pedagogical synergy in the research that the Commission funds in this area. Thus it would seem that the support of more effective and efficient distance learning in a training context, when this context is also pedagogically important, is the most likely framework to stimulate meaningful collaboration between educational researchers experienced in the support of cooperative learning and CSCW researchers. This is similar to what Pea and Gomez call for in the American context (although they keep their appeal at the school level, rather than the training context); this is what is occurring in the DELTA framework in Europe.

Until such large-scale opportunities present themselves, however, it is important, as a very first step, that researchers interested in collaboration in internetworked setting at least become aware of the work and insights relevant to this domain that are accruing from two generally distinct research communities, one based in education and the other labelled now as CSCW. This paper is intended as a contribution to this awareness. Research and design issues related to internetworked cooperative learning will increasingly be shaped not only by the educational community but by the agendas and vocabulary of TMLs and DMLs, of distance education, of open and flexible training and learning, and of CSCW. Beyond the basic-awareness level,
much more significant interaction with other research communities such as those involved with the above agendas and vocabularies is going to become necessary for educational researchers hoping to make a meaningful contribution to the social science of collaboration.

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