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CSCL Theories

by Jy Wana Daphne Lin Hsiao

I. What is Computer-Supported Collaborative Learning (CSCL)?

Computer supported collaborative learning (CSCL) has grown out of wider research into computer supported collaborative work (CSCW) and collaborative learning. CSCW is defined as a computer-based network system that supports group work in a common task and provides a shared interface for groups to work with (Ellis et al. 1991). Collaborative learning is defined as groups working together for a common purpose (Resta, 1995). The differences between CSCW and CSCL are that CSCW tends to focus on communication techniques themselves, and CSCL focuses on what is being communicated; CSCW is used mainly in the business setting, CSCL is used in the educational setting; the purpose of CSCW is to facilitate group communication and productivity, and the purpose of CSCL is to scaffold or support students in learning together effectively. They both are based on the promise that computer supported systems can support and facilitate group process and group dynamics in ways that are not achievable by face-to-face, but they are not designed to replace face-to-face communication. CSCL and CSCW systems typically tailored for use by multiple learners working at the same workstation or across networked machines. These systems can support communicating ideas and information, accessing information and documents, and providing feedback on problem-solving activities. The research of CSCL and CSCW covers not only the techniques of the groupware but also their social, psychological, organizational, and learning effects.

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II. The Emergence of Theories of CSCL

Many theories contribute our understanding of the computer supported collaborative learning. These theories are sociocultural theory (based on Vygotsky's intersubjectiveness and Zone of Proximal Development), constructivism theory, self-regulation learning (skill, will, and execute control), situated cognition, cognitive apprenticeship, problem-based learning (Cognition and Technology Group at Vanderbilt), Spiro et al.'s (1988, 1991) cognitive flexibility theory , and Salomon et al.'s (1993) distributed cognition ("effect of" and "effect with" technology). These theories are based on the same underlying assumptions that individuals are active agents that they are purposefully seeking and constructing knowledge within a meaningful context. CSCL aims at providing both an authentic environment and multiperspectives that can tie in students' prior knowledge. Computer supported systems are cognitive tools that can team individuals with the technology to form a joint intelligence which shares the labor during the group process. To solve the problem of the limited human working memory (7+-2), CSCL can function as scaffolder to provide resources and modify individuals' cognitive ability. Pea (1985) mentions that computer also can off-load part of cognitive process, such as modeling how to find information, so individuals can focus cognitive resources elsewhere. In principle, individuals will develop the cognitive skills necessary to accomplish many of the cognitive process that are demonstrated in the partnership (the "effect with" technology). An explicit goal of the CSCL environment is to facilitate deep understanding. Though, each CSCL software may have different functions, one general characteristic is to promote reflection and inquiry that assist the in-depth learning.

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II.1 Vygotsky's Sociocultural Theory

Vygotsky's sociocultural theory of learning emphasizes that human intelligence originates in our society or culture, and individual cognitive gain occursfirst through interpersonal (interaction with social environment) than intrapersonal (internalization). Miller (1995), based on Vygotsky's sociocultural theory, conducted four-year long ethnographic study to examine classroom context for open-forum English literature discussion. Teachers in the study promote scaffolding, metacognitive reflective, inquiry strategies to encourage students to think critically and response to the context and each other. After one year of experiment, students are able to internalize the teacher-scaffolded discussion and reflective strategies. However, whether students adapt the strategies learned in the open-forum English class to other class content depend on whether the social contexts value or invite interaction and actively engage thinking. This study shows how social environment can influence students' learning and thinking. Forman and Cazden (1985) observe students' discourse in solving collaborative problems. Their results support Vygotsky's two phases of social process. In the initial phase of problem solving, students encourage, support, and guide each other are often observed. In the second phase, students come to their own conclusions based on experimental evidence, and resolve their conflict by articulating their argumentation. Forman and Cazden (1985), thus, concluded that students can gain new strategies through peer collaboration by interpersonal discourse.

Another aspect of Vygotsky's theory is the idea that the potential for cognitive development is limited to a certain time span which he calls the "Zone of Proximal Development" (ZPD). Vygotsky defined ZPD as a region of activities that individuals can navigate with the help of more capable peers, adults, or artifacts. In Vygotsky' view, peer interaction, scaffolding, and modeling are important ways to facilitate individual cognitive growth and knowledge acquisition. ZPD can compose of different levels of expertise of individuals (students and teachers), and can also include artifacts such as books, computer tools, and scientific equipments. The purpose of ZPD is to support intentional learning. Vygotsky's sociocultural approach of learning and ZPD can be successfully employed in the study of Computer supported collaborative learning (CSCL) environment.

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II. 2 Constructivism Theory

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Basically, constructivism views that knowledge is not 'about' the world, but rather 'constitutive' of the world (Sherman, 1995). Knowledge is not a fixed object, it is constructed by an individual through her own experience of that object. Constructivist approach to learning emphasizes authentic, challenging projects that include students, teachers and experts in the learning community. Its goal is to create learning communities that are more closely related to the collaborative practice of the real world. In an authentic environment, learners assume the responsibilities of their own learning, they have to develop metacognitive abilities to monitor and direct their own learning and performance. When people work collaboratively in an authentic activity, they bring their own framework and perspectives to the activity. They can see a problem from different perspectives, and are able to negotiate and generate meanings and solution through shared understanding. The constructivist paradigm has led us to understand how learning can be facilitated through certain types of engaging, constructive activities. This model of learning emphasizes meaning-making through active participation in socially, culturally, historically, and politically situated contexts. A crucial element of active participation is dialog in shared experiences, through which situated collaborative activities, such as modeling, discourse and decision making, are necessary to support the negotiation and creation of meaning and understanding.

In sum, the contemporary constructivist theory of learning acknowledges that individuals are active agents, they engage in their own knowledge construction by integrating new information into their schema, and by associating and representing it into a meaningful way. Constructivists argue that it is impractical for teachers to make all the current decisions and dump the information to students without involving students in the decision process and assessing students' abilities to construct knowledge. In other words, guided instruction is suggested that puts students at the center of learning process, and provides guidance and concrete teaching whenever necessary. Perkins (1991) indicates that students may easily get lost in management without any experience to guide them through the information jungle. This student-centered guided learning environment is considered, however, more appropriate for ill-structured domains or higher-level learning (CTGV, 1991).

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II.3 Problem-Based Learning / Anchored Instruction

Problem-based learning (PBL), anchored instruction, is a student-centered, contextualized approach to schooling. In this approach, learning begins with a problem to be solved rather than content to be mastered. This is consistent with new models of teaching and learning that suggest the emphasis of instruction needs to shift from teaching as knowledge transmission to less teacher-dependent learning. The concept of anchored instruction was stimulated by the "inert knowledge problem" which states that the knowledge can be recallable only when individual is questioned explicitly in the context in which it was learned (CTGV, 1993). The issue of learning transfer, situated cognition, and collaborative learning are primarily concerns in anchored instruction (CTGV, 1990). It emphasizes the importance of creating an anchor or focus that generates interest and enables students to identify and define problems and to pay attention to their own perception and comprehension of these problems (Bransford, J.D. et al, 1990).

PBL was originally developed to help medical students to learn the basic biomedical sciences. The goals of PBL include: 1) developing scientific understanding through real-world cases, 2) developing reasoning strategies, and 3) developing self-directed learning strategies. Besides its origin in medical education, PBL has been used in other settings such as engineering and architecture. As students articulate and reflect upon their knowledge in PBL, they develop more coherent understandings of the problem space (Hmelo, et al.,1995). The active learning used in PBL should promote the self-directed learning strategies and attitudes needed for lifelong learning (Bereiter and Scardamalia, 1989). Self-directed learning objectives of PBL are particularly important because PBL may facilitate development of lifelong learning strategies necessary to stay current in the face of rapid technological advances.

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II.4 Distributed Cognition

The concept of distributed cognition emphasizes the interaction among individual, environment, and cultural artifacts.

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It claims that development and growth of cognitions of individuals should not be isolated events, rather the changes should be a reciprocal process. It starts from the minds of individuals, through the reciprocal teaching and guide each others or acquainting themselves with the tools. It leads to the changes of the subsequent joint performances and products, the improved competencies then can distribute among and reside in individuals. As who plays the leading role in influencing distributed cognitions is really situated bounded. For example, in a well-balanced group interaction, group competencies may play a dominate role, in the presence of powerful tools, the tools may help to guide individual, and in absence above two sources, individual's competence will dominate. Oshima, Bereiter, and Scardamalia (1995) based on distributed cognition, examines students in knowledge construction and transforming in CSILE network environments. The results indicated that students who benefited most from the activities, engaged more in knowledge-transformation. This system allows students to distribute information and interact with information resources in a joint space, can prompt conceptual progress (knowledge assimilation and knowledge construction). Dede (1996) predicts a distributed learning and knowledge-building community will be the new paradigm of 21st century education.

Three sources emerge from the theory of distributed cognition: First, the increasingly important role that technology plays to handle intellectual tasks to ease individual cognitive load. Second, the reemphasis on Vygotsky's sociocultural theory, a theory that describes how the character of social interactions and externally mediated action makes explicit certain processes, that come to be internalized in the private thought of the individual. Third, dissatisfied with cognition is only in one's mind, shifting attention on cognitions that are situated dependent and distributed in nature (Salomon, 1994).

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II.5 Cognitive Flexibility Theory

Spiro, et al., (1988) suggested that people acquire knowledge in ill-structured domains by constructing multiple representations and linkages among knowledge units. This can be achieved by designing hypermedia documents that present multiple cases where similar concepts are linked across cases (Spiro & Jehng, 1990). Learners visit, and more importantly revisit, the same case or concept information in a variety of contexts.

Sprio's Cognitive flexibility theory and criss-crossed landscape theory approaches address important issue in transfer, how general knowledge is transferred in ill-structured domains. They suggest a mixture of well- and ill- structuredness in the early stages, to familiar learners with grounded knowledge yet avoid establishing rigid presentation. Intermediate course of cases were selected to seek a balance between continuity and discontinuity; a partial overlapping across cases rather than from any single perspective that running through many cases, this will strengthen the interconnectedness of the cases. Spiro, et al. (1995) illustrate how to apply cognitive flexibility and constructivism theories into designing instruction in ill-structured domains that promote advanced knowledge acquisition.

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II.6 Cognitive Apprenticeship

Cognitive apprenticeship is a term for the instructional process that teachers provide and support students with scaffolds as the students develop cognitive strategies. Wilson and Cole (1994) describe the core characteristics of cognitive apprenticeships model: heuristic content, situated learning, modeling, coaching, articulation, reflection, exploration, and order in increasing complexity. Cognitive apprenticeship is a culture that permits peers to learn through their interactions, to build stories about common experiences, and to share the knowledge building experiences with the group. Collaborative discussion occuring in CSCL is important for student learning because it activates prior knowledge which facilitates the processing of new information. CSCL is designed to help students at acquiring cognitive and metacognitive knowledge by means of observation and guided practice(Collins et al, 1989).

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Teaching Teleapprenticeships model is an example that based on the theory of cognitive apprenticeship, developed by The College of Education at the University of Illinois. It extends the face-to-face apprenticeships used in the traditional teacher education program by conducting in electronic network collaborative learning environments. The goal is to link teacher education to practice teaching. Both qualitative and quantative methods are used to evaluate the project. Research results can be found in Levin & Waugh,(1996 in press).

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II.7 Situated Cognition

It is not possible to separate cognitive tasks from social tasks, because all cognitive tasks have a social component (Perret-Clermont, 1993). Constructivists view cognition as situation-bound and distributed rather than decontextualized tools and product of minds (Lave, 1988 ; Pea, 1994). Thinking is both physically and socially situated that problem tasks can be significantly shaped and changed by the tools made available and the social interactions that take place during problem solving. Situated cognition, a new paradigm of learning, emphasizes apprenticeship, coaching, collaboration, multiple practice, articulation of learning skills, stories, and technology (Brown, Collins & Duguid, 1989). "Community of practice," a concept emerging from situated cognition, emphasizes sharing and doing, construct meaning in a social unit (Roschelle, 1995). Situated learning occurs when students work on authentic tasks that take place in real-world setting (Winn, 1993). However, the very difference between metacognition approach of learning and situated belief of learning is that situated learning is usually unintentional rather than purposeful. These ideas are what Lave & Wenger (1991) call the process of "legitmate peripheral participation."

As Lave (1991) states that learning is a function of the activity, context and culture in which it occurs, which contrasts with most classroom learning which is abstract and out of context. Education can apply the two basic principles of situated cognition into classroom practice: 1. present in an authentic context, 2. encourage social interaction and collaboration. It is believed that rich contexts can reflect students' interpretation of the real world and improve their knowledge being transferred in different situations. Collaboration can lead to articulation of strategies that can then be discussed, which, in turn, can enhance generalizing grounded in students' situated understnading.

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II.8 Self-Regulated Learning / Metacognition

Flavell (1976) first invented the term metacognition. He defined metacognition as one's knowledge regarding one's own cognition as well as control and monitor one's own cognition. The terms self-regulated learning and metacognition are interchangeable in the current discussion.

A self-regulated leaner is aware when she knows a fact or has a skill and when she does not. She views acquisition as a systematic and controllable process, and she accepts greater responsibility for her achievement. In other words, She is the initiator of the learning process. Self-regulated learning has played a part in behavioral theory, cognitive theory, social cognitive theory, and constructivism theory. In behavioral theory, regulation is through external reinforcement. In cognition theory, self-regulation is equivalent to metacognition, knowing about and regulating cognition. Social cognition theory views self-regulation as combining self-observation, self-judgment, and self-reaction. Constructivism theory perceives individuals as active agents who construct and reconstruct their knowledge (Davidson, K., 1995) .

Self-regulation plays a crucial role in all phases of learning and cross-domains. Schoenfeld (1987) states that self-regulation has the potential to increase the meaningfulness of students' classroom learning, and the creation of a "mathematics culture "in the classroom best fosters metacognition. Schoenfeld (1983) showed that many problem-solving errors are due to metacognitive failure rather than lack of basic mathematics knowledge. He further insists that all metacognitive strategies are illustrated in action, should be developed by students, not declared by the teachers. Study metacognitive strategies are important as well, in reading to learn and can be applied to enhance text processing

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(Grow, 1996a). To teach students to become active, motivated, self-regulated learners is a continuing issue in education. Authentic and meaningful classroom activities that are relevant to real-life situations are likely to engender students' cognitive activity and conceptual change (transfer). Scaffolding, dual instructions (verbal persuasion and modeling), and teaching appropriate cognitive strategies are believed to have positive impact on increasing students' efficacy.

Teachers or instructors can help students set achievable goals and provide feedback highlighting progress toward goals (Gerald Grow's SSDL model, 1996b). Linking students' success and failure with cause, is a highly persuasive source of efficacy. Ensure appropriate leaner control in the task that requires students to become self-directed learners. It is assumed that students can be taught to become more self-regulated learners by acquiring effective strategies and by enhancing perceptions of self-efficacy. Poor learners can benefit from reciprocal teaching that through process of modeling, guiding, and collaborative learning. The major responsibility of teachers is not to dispense knowledge, and no single teacher can teach students everything they need to know in their entire lifetime. Equipping students with self-regulated strategies will provide them with necessary techniques for becoming independent thinkers and lifelong learners. Dede and Palumbo, (1991) indicate that develop constructive instructional systems should be grounded in the psychology of learning and transfer rather than in the human factors and technological design issues. They further claim that the development of constructive systems should support metacognition and problem-solving skills development.

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III. CSCL Tools

Computer-supported systems are often categorized according to the time/location matrix: synchronous (same time) vs. asynchronous (different times), and face-to-face (same place) vs. remoted (different places). Synchronous tools support the simultaneous interaction among group members, for example, videoconferencing. Asynchronous tools support individual work alone to contribute group process. E-mail is an example of asynchronous tool. More detail descriptions of CSCL tools can be found in Dr. Resta's CSCL class of Fall 1996 and Yu-Ping Hsiao's homepage. Following are two examples of CSCL environments.

Collaborative Learning Environment (CSILE)

CSILE, an educational knowledge media system, developed by Scardamalia & Bereiter at Ontario Institute for Studies in Education. This system is designed to support students in purposeful , intentional, and collaborative learning, in a local network environment. Students can select different communication modes (text, video, audio, animation) to generate "nodes." These nodes contain ideas or information that related to the topic under study. Nodes are available for others to comment on, leading to dialogues, and an accumulation of knowledge. A series of research has been conducted cross different curricula in these environments. The body of CSILE research presents the most complete view to date of the educational potential of LAN for support collaborative learning (Breiter & Scardamalia, 1984, 1987, 1989,1992, in press). CSILE based on Zimmerman's (1989) self-regulated learning (CSILE term is intentional learning) and constructivists' view of learning. It emphasizes on building a classroom culture supportive of active knowledge construction that can extend individual intentional learning to the group level. The purpose is to make students think and reflect their thought process which provoke question asking and answering in a public forum. The ultimate goal is to get students involved in knowledge itself rather than improve one's mind, a World 3 view , which shifts from individual mastery learning to improve the quality of public collective knowledge (Scardamalia, et al., 1994).

III. 2 Collaboratory Notebook

Collaboratory Notebook, a shared hypermedia database designed to provide a scaffold for students to conduct collaborative open-ended inquiry, created by the Learning through Collaborative Visualization (CoVis). Collaborative inquiry is considered desirable, in part, because it reflects the authentic practice of science by scientists. The Collaboratory Notebook has been designed to scaffold students as they learn to conduct open-ended inquires in a collaborative context. A primary function of Collaboratory Notebook is to allow teacher to monitor and guide students' process of learning. It emphasizes learning process instead of learning outcomes. Edelson, et al., (1995) analyzed Collaboratory Notebook usage, indicated that students with more positive attitudes about science and more experience using on-line communications media, took better advantage of the features of the environment. (Edelson, et al, 1995).

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IV. Research Findings

Following are some of research findings of computer supported collaborative learning:

¥ A numerous research evidence suggests that a combination of group rewards and strategy training produces much better outcomes than either one alone (Fantuzzo et al., 1992).

¥ The results of ACOT's two years (1986-87) study of seven classrooms that represented a cross section of America's K-12 schools are promising. Teachers are able to translate traditional text-based instructional approaches to the new electronic medium. Student deportment and attendance improved across all sites, their attitude towards self and learning showed improvement as well. In terms of test scores, at the very least, students are doing as well as they might without all of the technology and some are clearly performing better (Apple Research Labs Publications).

¥ Sherry and Myers (1996) study group dynamics of graduate students collaboratively design WWW process. They confirm Scardamalia, et al's. (1994) "World 3" view that the group becomes a self-reflective, and self-organizing system that each member contributes her own expertise and, in turn, learning new skills and extending the group knowledge based.

¥ Study shows that the more skilled teacher participates with the technology, the more positive attitudes they have developed toward technology (Zhao & Compbell, 1995).

¥ There is substantial evidence that students working in groups can master science and mathematics materials better than students working alone (Slavin, 1989).

¥ King (1989) observes verbal interaction and problem solving behavior of small collaborative peer groups working on CAI tasks. He finds successful group involved in more task talks than social talks. They ask more task related questions, spend more time on strategies use, and obtain higher elaboration scores than did unsuccessful groups.

¥ Weir (1992) indicates that both teachers and researchers find that students who work together on "real world problems show increased motivation, deeper understanding of the concept and an increased willingness to tackle difficult questions that they cannot answer alone." This focus on authenticity and experiential learning is reiterated in numerous articles.

¥ A series of CSILE studies conducted by Scardamalia and Breiter, indicate that students gain deeper understanding and collaboratively construct knowledge while working in CSILE environments.

¥ CSCL environment can accommodate a larger group size (can up to 20, studies show size =60 is too big) that increases idea generation and decision making. The ideal size of face-to-face group is four.

¥ The role of the teacher will shift from primary source of knowledge to that of expertise in learning. A good teacher should be an expert learner, who can facilitate students' learning and information searching (Riel, 1994).

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V. Further Research Questions

Educators increasingly provide comupter-supported tools to collaborative groups of students. There are many research questions, however, need answer for new technological implementation. Of particular interests are the following groups: theoretical perspectives, learners'(teachers' and students') perspectives, subject domains, and tool designing perspectives.

¥ How do participants become aware of the benefits of collaboration via computer-supported tool, and how can these subsequently improve their learning?

¥ What kinds of strategies (collaborative strategies, self-regulated strategies, social interpersonal skills) do learners use in cscl environment? and how much do they gain through the process?

¥ What theories of learning can be transferable to CSCL systems?

¥ What are the roles of teachers in the CSCL environments? what are their attitudes toward the CSCl systems? What makes them use or not use the systems? What kind of supports and training they need to integrate into their curriculua?

¥ Does computer mediation require the development of new and special pedagogical techniques?

¥ How can best utilize the attributes of the CSCL systems in designing a particular subject domain? The best computer-supported tools should not simply offer the same content in a new format, rather they should provide new ways of thinking in that domains (Resnick, 1995).

¥ What are the important design considerations for developing CSCL applications ? What are some of the problems of implementation? Koschmann,(1995)

¥ How to apply CSCW experience to CSCL? CSCW that supports business teams will not be the same for students in an educational setting. There is a need to redefine the role of individual, her responsibilities, the level of interaction, and environment (Olson et. al, 1993) .

¥ How to marry methodologies from CSCW and educational research to CSCL? Webb (1993) identified that questionnaire and content analysis based on critical thinking and social interaction are powerful methods to study on-campus on-line conferencing.

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VI. Educational Implementation (Future Trend)

Education should shift from individual, technology-free cognition to a resourceful collaborative learning, and distributed intelligence. Learners should be empowered through thoughtful use of technologies as well as through innovative use of technologies, and benefit from social distributions of cognitions. I agree with Salomon et al.'s comments (1991) that education should pay more attention to the "effects of" technology rather than the "effects with" technology, so that autonomous performance may be achieved.

How to design CSCL tools for educational purpose? Scaradamalia et al. (1989) argue that it should be students not the computers to solve problems, make planning, and set the learning goals. The role of computers should be to promote and facilitate learners to maximize use of their intelligence and knowledge. In other words, the intellectual tools design should focus on Salomon's suggestion to provide quality scaffolding that entails metacognitve guidance to facilitate students learning how to learn (the "effect of" technology), rather than off-loading and task dividing that try to ease students' cognitive burden (the "effect with" technology). The idea of distributed cognition is relatively new yet crucial. The attempt of my proposed dissertation is to investigate self-regulated (metacognitive) strategy use in computer

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supported collaborative learning environment. To see whether this kind of higher-order knowledge can be distributed among peer and environment.

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