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ORIGINAL ARTICLE

Technology in Support of Collaborative Learning

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Abstract This paper reviews the research conducted in the last 20 years on the application of technology in support of collaborative learning in higher education. The review focuses primarily on studies that use Internet-based technologies and social interaction analysis. The review provides six sets of observations/recommendations regarding methodology, empirical evidence, and research gaps and issues that may help focus future research in this emerging field of study.

Keywords Collaborative learning · Technology for collaborative learning

The recent interest in technology-supported collaborative learning in higher education represents a confluence of trends: the development of new tools to support collaboration (Johnson & Johnson, 1996), the emergence of constructivist-based approaches to teaching and learning (Kirschner, Martens, & Strijbos, 2004), and the need to create more powerful and engaging learning environments (Oblinger & Oblinger, 2005). Chickering's seven principles for good practice in undergraduate education (Chickering & Ehrmann, 1996) have been widely adopted, and technology has often been used in their implementation. Two of Chickering's principles relate directly to cooperative/collaborative learning: "Good practice develops reciprocity and cooperation among students," and "Good practice uses active learning techniques."

Although a variety of technologies may be used to support cooperative/collaborative learning, this paper focuses on the ways computer-mediated networks support social interaction, cooperation, and collaboration, for learning and knowledge building. Current

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practices include technology-rich learning environments, network-enhanced learning environments, blended/hybrid learning environments (combining face-to-face and online interaction), and virtual learning environments.[1] Harasim, Hiltz, Teles, and Turoff (1995) defined online collaborative learning as "a learning process where two or more people work together to create meaning, explore a topic, or improve skills." At the outset of this review, it must be acknowledged that collaborative learning is a complex concept and not a clearly defined one. There is no universally adopted meaning of the terms 'collaborative' and 'cooperative' learning or agreement on precisely what their differences or commonalities are. This may result from the fact that educational researchers often have different purposes, goals, and perspectives, which prohibit a clear distinction between these two approaches. Panitz (1996) views collaboration as a philosophy of interaction and personal lifestyle, while cooperation is viewed as a structure of interaction designed to facilitate accomplishment of an end product or goal through people working together in groups. Slavin (1997) associates cooperative learning with well-structured knowledge domains, and collaborative learning with ill-structured knowledge domains. Roschelle and Teasley (1995) state that: "Cooperation is accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving..." while collaborative learning involves the "... mutual engagement of participants in a coordinated effort to solve the problem together" (p. 70). Dillenbourg (1999) agrees when he stressed that "cooperation refers to a more fixed division of labor" (p. 22). Despite the differences drawn between these two constructs, Kirschner (2001) indicates that both share a number of common elements including:

- Learning is active
- The teacher is usually more a facilitator than a "sage on the stage"
- Teaching and learning are shared experiences
- Students participate in small-group activities
- Students take responsibility for learning
- Students reflect on their own assumptions and thought processes
- Social and team skills are developed through the give-and-take of consensus- building

These similarities closely align with the view of Johnson and Johnson (1996) that collaborative and cooperative learning both involve the instructional use of small groups in which students work together to maximize their own and each other's learning.

Globally, the growth in the use of technology to support collaborative learning in higher education has attracted a rapidly growing number of research studies focused on some aspect of technology-supported collaborative learning examined from different theoretical perspectives. As the boundaries of the research expand, the confluence of the trends suggest a movement towards the understanding of Technology in Support of Collaborative Learning as an emerging field of study. The intention of this paper is to provide the reader with a sampling of the important research issues, challenges, and directions in the emerging area of research. A set of observations/recommendations that take into account methodological issues and empirical evidence, as well as research gaps, is presented.

[1] Computer-supported collaborative learning is encouraged in campus-based classrooms or distance education. In the latter case see (IHEP, 2001; WASC, 2000).

The Emerging Paradigm of Computer-Supported Collaborative Learning (CSCL)

The term computer-supported collaborative learning was used as early as 1989 by O'Malley and Scanlon and was recognized by Koschmann as an important area of research focus in 1996 (Lipponen, Hakkarainen, & Paavola, 2004). CSCL is emerging as a dynamic, interdisciplinary, and international field of research focused on how technology can facilitate the sharing and creation of knowledge and expertise through peer interaction and group learning processes. The CSCL field of inquiry includes a range of situations in which interactions take place among students using computer networks to enhance the learning environment. It includes the use of technology to support asynchronous and synchronous communication between students on-campus as well as students who are geographically distributed. The primary aim of CSCL is to provide an environment that supports collaboration between students to enhance their learning processes (Kreijns, Kirschner, & Jochems, 2003), facilitate collective learning (Pea, 1994), or group cognition (Stahl, 2006).

Researchers typically draw upon theoretical frameworks and constructs derived from constructivist epistemology (Piaget) and cognitive science's theoretical perspectives emphasizing that cognition is a social rather than a fixed entity (e.g., Levine, Resnick, & Higgins 1993; anchored instruction, Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; cognitive apprenticeship, Brown, Collins, & Duguid, 1989; cognitive flexibility theory, Spiro, Coulson, Feltovich, & Anderson, 1988; collaborative visualization, Pea, 1994; distributed cognition, Hutchins, 1995; Salomon, 1993; Salomon & Perkins, 1998; distributed constructionism, Kafai & Resnick, 1996; group cognition, Stahl, 2006; knowledge building, Bereiter & Scardamalia, 1993; learning communities, Brown, 1997; situated cognition, Lave & Wenger, 1991). Research in CSCL is also increasingly becoming a trans-disciplinary field of inquiry including cognitive science, learning sciences (psychology, computer science, education), educational psychology, educational technology, communication, epistemology, social psychology (small group research), artificial intelligence, and informatics (group support systems).

A review of the CSCL research literature demonstrates a diversity of approaches and methodologies used, ranging from experimental to ethnography, action, and design research. The methods vary by the type of theoretical framework employed by the researcher, but often share a common focus on the interaction, discourse, and the participation processes emerging among community members in particular social and physical contexts (Lipponen *et al.*, 2004). Studies also vary in their level of analysis. Research may focus on group and classroom/community processes adopting analytical frameworks such as activity or systems theory (Gifford & Enyedy, 1999; Jones, Dirckinck-Holmfeld, & Lindström, 2006) or may focus on peer-to-peer interaction adopting analytical frameworks such as interaction analysis and small group processes. Methods of analysis include graphing note distributions and coding the semantics of the notes through the use of systematic and emergent observation categories, as well as coding schemes of a generic or specific nature, e.g., Interaction Process Analysis, (Bales, 1950); Gunawardena, Lowe, and Anderson (1997); social network analysis (Wasserman & Faust, 1994) and latent semantic analysis (Landauer, Foltz, & Laham, 1998). Methods to analyze participation patterns have also been developed (Howell-Richardson & Mellar, 1996).

The review included theoretical research, peer-reviewed case studies, as well as design research and experiments. It is increasingly clear that researchers are faced with a difficult challenge to take into account the great diversity of research results in their research perspective, so that their contributions build on, and go beyond, what is known. As an object of design or inquiry, the technology itself provides focus. For instance, research on

CSCL environments, although emerging from differing theoretical approaches, evolves around specific computer applications (i.e., platforms, forums, videoconferencing systems). The designed environment may be totally online or hybrid (including both online and classroom interaction) but both have a technical and a social dimension. There is a substantial body of knowledge on collaborative learning in face-to-face settings, but less is known about CSCL. Research activity examining technology use in support of collaborative learning occurs in many different contexts because of the widescale infusion of electronic resources into learning environments, including ones that support asynchronous and synchronous communication between geographically distributed individuals. Because of the growing use of CSCL, questions are asked about the effectiveness of this approach to teaching and learning.

To assess the potential of a particular technology for supporting collaborative learning, researchers usually rely on specific analytical models. It is evident that multiple factors are at play in face-to-face and online learning environments including pedagogical strategies, context, interaction with peers and instructor, and assessment (Laurillard, 2001). Systemic models are useful for situating technology use within a broader context. For instance, Engeström's (1987) activity theory framework allows researchers to assess activity change within a technology-supported learning community by analyzing role shifts, emerging rules and routines, and new learning and knowledge-building artifacts. There are also frameworks that may be useful in assessing the added value of technology support for collaborative learning in higher education. One such framework is Biggs' (1989) 3Ps generic model that includes:

- Presage variables provide the context in which a learning experience is conducted and includes the instructor, curriculum, learning environment, and learner characteristics.
- Process variables include the interventions, interactions, pedagogical approaches, duration of educational experiences, type of student participation, assessment, use of distance learning, etc.
- Product variables include the quality of learning outcomes.

This framework was used in reviewing the growing body of research in technology-supported collaborative learning and in offering recommendations that may help address the challenges in developing coherence from the diversity of theoretical approaches, methodologies, contexts, subject matter domains, and learners in this emerging field of study.

Recommendation 1. To afford greater potential for replicability, researchers are encouraged to conduct evidence-based research providing thick descriptions of the participants, contextual elements, and analysis methods.

It is challenging to compare and analyze CSCL studies because of the divergent views of what should be studied and how it should be studied. Contributing to the complexity in developing a coherent view are differences in the ways CSCL is defined and whether one should primarily study the *effects of* or *effects with* CSCL (Lipponen, 2002). CSCL studies also vary in the learning context and knowledge domain (e.g., undergraduate science, second-language education, graduate engineering course), the complexity and duration of learning tasks, the type and size of the groups, and the number of participants, to mention a few.

There are also differences in methodological approaches, ranging from descriptive studies using ethnography, discourse analysis, interaction analysis, and qualitative research procedures, to established and widely accepted educational experimental research paradigms.

The differences in methodological approaches are reflected in views such as those of Valcke and Martens (2006), who underscore the need for the design and development of more valid and reliable instruments and methodologies in CSCL studies. Strijbos, Martens, Prins, and Jochems (2006) add that only a few studies included in proceedings of CSCL conferences provide psychometric data or information about the reliability and/or validity of the measures employed in the studies. The lack of this information limits the ability to replicate or build upon the research findings. Similarly, De Wever, Schellens, Valcke, and Van Keer (2006), in reviewing CSCL research, indicate that a large number of instruments used for content analysis in CSCL studies have a weak theoretical and empirical basis. They also note the lack of replication studies that may strengthen the quality of existing content analysis instruments. Other researchers point out that collaborative knowledge building is a complex and subtle process that is not easily studied using traditional experimental approaches. They put the emphasis on process accounts (Holliman & Scanlon, 2006; Roschelle & Teasley, 1995) to yield insights on the relationships between the nature of social and cognitive processes and successful learning and knowledge building.

All of these issues are reflective of a new and emerging field of research that continues to grow, both in the quantity and focus of studies. There is also a realization of the need to further develop the theoretical-empirical bases of CSCL research and new journals such as the *International Journal for Computer Supported Collaborative Learning* (IJCSCL) are being created to support these efforts.

Recommendation 2. Future CSCL studies should focus less attention on the question of whether computer-supported collaborative learning is better than face-to-face collaborative learning, but rather focus on what is uniquely feasible with new technology (group cognition, collaborative knowledge building) and the different ecologies and affordances of CSCL environments and tools that are diverging further and further from face-to-face learning environments.

The review identified four instructional motives for the use of technology in support of collaborative learning:

To prepare students for the knowledge society (collaboration skills and knowledge creation) Teachers respond to the social demands of a highly diverse, interdependent, and technologically rich workplace that has undergone an explosive development of knowledge in many fields that calls for teamwork (UNESCO, 2005). Schrage (1990) conceptualized collaboration as "the process of shared creation." Referring to Andriessen, Baker, and Suthers (2003) and Bereiter (2002), Wegerif (2006) emphasized the historical shift in work and life practices. He posited an argument for broadening and deepening the way students engage in online dialogue when thinking skills are the pedagogical intent: "constructing representations with cognitive tools needs to be balanced and augmented by the metaphorical image of stepping back from identity commitments in order to actively listen to others and thereby to deepen and expand creative dialogic spaces of reflection." (p. 156).

To enhance student cognitive performance or foster deep understanding Rationales underlying the use of CSCL for enhancing cognitive performance (e.g., Rimmershaw, 1999) or fostering deep understanding (Stone-Wiske, 2002) are similar to those fostering cooperative/collaboration learning opportunities without the use of networked computers

(Guimond, 2001; Johnson, Johnson, & Smith, 1998b; Monteil & Huguet, 1999; Slavin, 1996). On-site and online social interaction is considered a source of cognitive advancement, and may play an important role in academic achievement.

To add flexibility of time and space for cooperative/collaborative learning The new workspace is increasingly a virtual one in which work is done by individuals who are distributed in place and time. Based on this trend, instructors want to create opportunities for their students to learn to work independently of place and time (e.g., Collis & Moonen, 2001; Palmieri, 1997).

To foster student engagement and keep track of student cooperative/collaborative work (online written discourse) Research has linked collaborative tasks to student engagement in knowledge construction (Brett, 2004; Stahl, 2004). Moreover, instructors who use CSCL can monitor student understanding and achievement in collaborative learning activities (Holliman & Scanlon, 2006). In addition, students can review what they wrote or what their peers wrote, and instructors can analyze the discourse of team members using semi-automatic data analysis procedures for facilitation, moderation, or grading purposes.

The use of CSCL also needs to be justified in terms of the benefits to students (product variables). The benefits of cooperative learning in face-to-face settings are well established (Johnson, Johnson, & Smith, 1998a). There is emerging evidence of the learning benefits of CSCL. These include development of higher order thinking skills, student satisfaction with the learning experience, and improved productivity. Currently, however, research is still shallow regarding product variables:

- *Academic Achievement* The results of studies examining cooperative, competitive, and individualistic learning using computers (Johnson & Johnson, 1989; Johnson *et al.*, 1998b; Johnson, Johnson, Stanne, & Garibalde, 1990; Johnson, Johnson, Stanne, Smizak, & Avon, 1987) found that computer-assisted cooperative learning yields higher quantity and quality of daily achievement, greater mastery of factual information, and greater success in problem solving than computer-supported individualistic learning. In higher education, similar results were found: MBA students who engaged in collaborative learning using a group decision support system obtained test grades significantly higher than those of the other group of students who participated in the experiment (Alavi, 1994); students in industrial technology achieved better critical thinking through collaborative learning (Gokhale, 1995).
- *Development of Higher order Thinking Skills*. There is research supporting the idea that online environments are as powerful as, or more so, than campus-based classes (Lockyer, Patterson, & Harper, 2001; Mason & Romiszowski, 1996). Students report higher levels of learning in online compared to face-to-face groups. Researchers found that online groups, compared to face-to-face groups, engaged in broader, more complex, and more cognitively challenging discussions (Benbunan-Fich, Hiltz, & Turoff, 2003). Thinking skills have been emphasized as a focus of online discourse by a number of researchers (Wegerif, 2006).
- *Student Satisfaction*. The evidence is strong and consistent across a broad array of educational research studies that students engaged in peer interaction, whether face-to-face, online or both, have more positive attitudes toward subject matter, increased motivation to learn more about the subject, and are better satisfied with the experience than students who have few opportunities to interact with their peers and the instructor

(Johnson *et al.*, 1998a; Springer, Stanne, & Donovan, 1998). Students preferred to collaborate in the traditional face-to-face manner but, when working online, they were just as satisfied with the end product as when working onsite (Ocker & Yaverbaum, 2001).

- *Individual and Group Products*. When compared to face-to-face groups, online groups deliver more complete reports, make decisions of higher quality, and perform better on tasks that require groups to generate ideas (Benbunan-Fich *et al.*, 2003; Fjermestad, 2004).
- *Group Cognition*. Stahl's proposal (2006) to focus CSCL research on group cognition expands and limits the domain and clarifies the specificity of CSCL research. Group cognition, argues Stahl, is visible online because participants' building of knowledge can be observed through individual contributions and their linkages. We suggest that CSCL basic elements could be uncovered, as did Johnson and Johnson (1989) for cooperative learning when they suggested positive interdependence, individual accountability, promotive interaction, appropriate use of social skills, and group processing as core elements of effective cooperative learning.

Recommendation 3. Researchers are encouraged to apply what they know about face-to-face collaborative learning in their analysis of online interaction in CSCL environments.

An extensive base of knowledge has been developed related to cooperative learning without online technical support. Although technology affords new tools and environments to support collaborative learning, many of the goals, pedagogical strategies, and interactions are similar. Productive lines of research could be based on what is common to both environments, as well as what is unique to technology-supported collaboration. Critical elements for effective CSCL include the development of instructional goals that target higher-order thinking skills and complex problem solving (Dirckinck-Holmfeld, 2002; Hmelo-Silver, 2004). Successful collaboration requires the careful design of the learning environment for group interaction and the provision of scaffolding, leadership, and support by the instructor (Pea, 2004; Strijbos, Kirschner, & Martens, 2004) to facilitate meaning-making by the students. Our review highlights the fact that basic factors continue to influence peer-to-peer interaction when technology is used to support collaborative learning. Technology affordances, however, facilitate the teacher's task, as the following sections suggest.

Group Composition

There is limited research in CSCL on effects of the size of the group. But there is recognition that group size depends on the scope, duration, and complexity of the task. The learning group, however, needs to be small enough to enable students to participate fully and to build group cohesion (Barkley, Cross, & Major, 2005; Schellens & Valcke, 2006). Bean (1996) asserts a group size of five may be optimal for many learning situations because larger groups may dilute the experience for the learner. In formal learning tasks, groups of four tend to break into pairs, and groups of three split into a pair and an outsider. Groups of three, however, work effectively for base groups (Smith, 1996).

There are a variety of ways in which groups can be constituted. Membership in a group can be teacher-determined, selected by students, or random, and the groups can be heterogeneous or homogeneous. There is some evidence supporting the claim that groups that are heterogeneous in terms of participants' gender, status, culture, or expertise are more productive, even at low age, for collaborative learning (Cranton, 1998; Johnson & Johnson, 1996; Webb & Palincsar, 1996). Such groups expose the learner to multiple perspectives on issues and tasks based on the diverse backgrounds and experiences of the other members of the group. Distributing minority or female students among groups to achieve heterogeneity, however, can also result in isolation or students' marginalization (Felder, Felder, Mauney, Hamrin, & Dietz, 1995).

Community Ethos

The term community is described in various ways by researchers, but generally includes the group members' feelings of connectedness and commonality of learning expectations and goals (Rovai, 2002). Although the context of collaborative learning has received relatively little attention by researchers (Cockrell, Caplow, & Donaldson, 2000), it is recognized that the classroom context, ethos, or culture may impact learning (Brown & Duguid, 2000; Dede, 1996). It is particularly important to understand the way the affordances for combining onsite and online interaction offer new environments and possibilities for collaborative learning (Jones, Scanlon, Blake, 2000; Littleton & Whitelock, 2005; Warschauer, 1997). Distributed communities are also coming of age (Scardamalia, 2002; Stone-Wiske, 2002); however, a challenge confronting them is how to increase the social presence of the instructor and the learners. Social presence is defined as the ability of learners to project themselves socially and affectively into a community of inquiry (Rourke, Anderson, Garrison, & Archer, 2001).

Teacher-Student/Student-Student Online Interaction

In an analysis of 145 experiments using synchronous and asynchronous communication as an independent variable over a twenty-year span of research, Fjermestad (2004) observed a 29.2% effect of group support systems (GSS) over face-to-face methods, and goes on to suggest that the use of a GSS improves decision quality, depth of analysis, equality of participation, and satisfaction more effectively than face-to-face methods. However, online interaction is sensitive to the ways the teacher plans, structures, and supports the interaction.

Task Structuring

Relevant to the issues of collaborative vs. cooperative learning is the extent to which the learning environment, roles, and tasks are structured for the learner. Rules and scripts determine the level of task structure (Bernard *et al.*, 2004; Lou, Abrami, & d'Apollonia, 2001). A script is "a story or scenario that the students and tutors play as actors play a movie script" (Dillenbourg, 2002, p. 11). Strijbos, Martens, and Jochems (2004) suggested that prescribed functional roles in instruction appear to affect the perceived level of group efficiency. Some research results show that structuring is required to avoid information overload (Lim & Liu, 2006), and that too much scripting leads to less interaction.

Co-constructivist forms of scripting, like problem-based learning and project-based learning, have been associated with positive learning outcomes (Blumenfeld, Marx, Soloway, & Krajcik, 1996; Duisburg & Hoope, 1999; McManus & Aiken, 1995; Pearson, 2006; Rummel & Spada, 2005; Steinkuehler, Derry, Hmelo-Silver, & DelMacelle, 2002). The ability of participants to see what they build together, i.e., group visualization (Pea, 1994), is also another form of structure that has been effectively applied to the learning of scientific concepts and phenomena. It is also reflected in the use of shared online whiteboards and other tools that enable students to interact in real time.

Scaffolding and Group Leadership

There is a consensus among researchers on the importance of the instructor's leadership role and behavior in online collaborative learning in supporting group learning processes (Pea, 2004; Wallace, 2003; Weinberger, Fischer, & Mandl, 2002). Online interaction does not evolve towards higher levels of discussion without proper grounding, monitoring, modeling, coaching, or contributing on the part of the instructor, particularly at the onset of instruction (Brandon & Hollingshead, 1999; Hiltz, Dufner, Holmes, & Poole, 1991). It is also important to create a "joint problem space" (Teasley & Roschelle, 1993) and establishing jointly agreed upon goals (Chan, Burtis, & Bereiter, 1997).

Meaning-Making

For Dillenbourg, Baker, Blaye, and O'Malley (1996), meaning-making refers to the meaning of utterances during negotiation of a learning task or object of knowledge that allows for different views, ideas, and opinions to be formulated and contributes to group intersubjective understanding (Koschmann, 2002). It is facilitated by the process of collaborative construction of knowledge through social negotiation (Jonassen, 1994). Meaning-making, as a critical element of learning, involves active participation (Lave & Wenger, 1991) in a networked community (Barab, Kling, & Gray, 2004; Schlager & Fusco, 2004). Grounding is often an issue, and the basic requirement is that learners add to their common ground in an orderly way by trying to establish for each utterance the mutual belief that all have understood what the speaker meant (Clark & Schaefer, 1989). Roschelle (1992) asserts that the crux of collaboration is convergence, and analyzes collaboration as a process that gradually leads to a convergence of meaning between two or more people. Students' representations of authority, however, may lead them to converge too early in developing shared meaning (Hübscher-Younger & Narayanan, 2003).

An essential condition for meaning-making is that students must actively engage in meaningful discourse related to the learning task or issue. Student participation in discourse, however, can sometimes represent a challenge for instructors. Gunawardena et al. (1997), for example, found low levels of discourse among students using a five-level model of co-construction of knowledge. For higher levels of discourse to be observed, and providing that the above factors are taken into consideration, a whole new epistemology and its own suite of tools may be necessary.

Collaborative Knowledge Building

From the knowledge building perspective, the notion of task is replaced by that of intentional goals (Bereiter & Scardamalia, 1989) and idea improvement (Scardamalia & Bereiter, 2003). Scardamalia and Bereiter defined knowledge building "as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (2003, p. 1371). Hakkarainen (2006) suggests a trialogical approach to working with knowledge, one in which knowledge building is a knowledge practice distinct from acquisition and participation practices (Sfard, 1998). At the higher education level, critical factors in the use of technology in support of collaborative efforts for knowledge advancement have been identified: student engagement (Brett, 2004); teacher scaffolding for the development of an explanation-orientation in the students' discourse (Lipponen, 2000); pedagogical strategies to transform a traditional classroom into a knowledge building community (Hewitt, 2002); and peer scaffolding (Lai & Law, 2005). Stahl (2006) also emphasizes quality group interaction for knowledge building purposes.

When engaging in knowledge building, participants seek deep understanding of knowledge objects and are encouraged to create artifacts of value to others through a process of idea improvement, be they the members of an on-campus community or an off-campus community.

Time Requirements

Teaching time required for facilitation, moderation, or scaffolding is well acknowledged. While technology affordances (e.g., scaffolds, visual computation of group activity, or representations of group thinking) may be helpful supports, social affordances (teacher, peers, broader context) remain key. Some examples of the many unanswered questions are: How much of the scaffolding responsibility can be transferred to students (peer scaffolding)? What are the ways in which the learning artifacts of one cohort may be used as mediation tools by an upcoming cohort? Cumulative case studies would provide insights into the time required for designing, monitoring, supporting, and assessing learning in online collaborative environments and provide rich descriptions of faculty experiences, benefits, and challenges in using CSCL.

Research in the above areas may help refine our knowledge about what technology supported collaborative learning shares with face-to-face collaborative learning and what is unique to each environment.

Recommendation 4. Research is needed on student characteristics, particularly of the neo-millennial students now entering higher education and for whom connectivity and communication via technology (e.g., IMing, Blogs, personal web pages, Wikis) is a major part of their lives outside of the classroom. Research is needed to determine whether these students will more likely embrace CSCL, or whether they will feel unnecessarily constrained by the affordances of the current CSCL environments and, if so, what elements will need to change.

The Net Generation (N-Geners, Tapscott, 1998; McCain & Jukes, 2001) is now in colleges and universities. Technology is more transparent to them than to previous generation because digital technology is a part of their lives (cell phones, Nintendo and PlayStation, PS2, MySpace, YouTube). Tapscott (1998) argued that this has created a generation of students who have become independent, inclusive, and innovative.

Nonetheless, Wallace, in his review of online interaction between higher education instructors and students, found that student engagement with cognitively complex ideas is not common (2003). Personal factors such as students' prior knowledge, metacognitive and collaborative skills, as well as contextual cues such as cultural compatibility (Francescato *et al.*, 2006; Reeder, Macfadyen, Roche, & Chase, 2004; van Aalst & Chan, 2001) and instructional methods (e.g., teacher scaffolding) influence student engagement.

Student prior knowledge is known as the most important variable determining the quality of students' contributions both in online and face-to-face environments. Wilson (2000) noted that successful, high achieving, high aptitude students present the same characteristics whether they are engaged in onsite or online interaction. Moreover, female high aptitude, and "sensing-making" (as opposed to "intuitive-feeling") students make more contributions. Personality types and preferred learning strategies are also related to student performance in online or onsite collaboration (Wilson, 2000). There are other variables that may affect student performance in CSCL including the student's attitudes towards, and competence in using, technology. For example, lack of keyboarding skills or ignorance of more advanced functionalities can limit a student's participation in live chats. In addition, students may not understand the benefits of online collaboration or have had prior experience in working collaboratively. Lockyer *et al.* (2001) recommends that learners be supported in their development of group process skills (e.g., interaction modelling).

Recommendation 5. More research is needed on the design elements of CSCL tool software to determine the extent to which they support, structure, regulate, facilitate or constrain the interactions of teachers and students (Strijbos et al., 2004).

Generic tools such as e-mail, file attachments, electronic bulletin boards, chat, blogs, wikis, digital audio and videoconferencing systems, asynchronous/synchronous communication tools of Web-based Instructional Management Systems (Course Management System, CMS; Learning Management System, LMS), and virtual learning environments (Blackboard/WebCT, Moodle, Sakai, Claroline, FirstClass) are not only widely used for business or educational delivery of information purposes, but are also used to support online collaboration. There are an increasing number of tools and online environments emerging that are especially designed with affordances to support collaborative learning or knowledge building. For instance, the database with embedded tools in Knowledge Forum enables learners to engage in intentional learning and high-level processes of collaborative inquiry through progressive discourse (Scardamalia & Bereiter, 1994). Initially, the database is empty, and students use, within certain constraints, the tools to collectively improve their ideas. Other advanced CSCL environments have capabilities to support specific collaborative purposes. For example, TAPPED_IN offers numerous virtual rooms for distributed communities to communicate synchronously (Schlager & Schank, 1997). Belvedere was designed for collaborative learning through inquiry diagrams (Suthers, Weiner, Connelly, & Paolucci, 1995); CoVis used collaborative visualization for cooperative project work in high-school science (Pea, Edelson, & Gomez, 1994); and CoWeb is a collaborative hypertext environment that enables anyone to create or edit Web pages (Rick & Gudzial, 2006).

In spite of the increasing availability of platforms and tools designed to support collaborative learning, advanced technologies to support online collaboration are still in early stages of adoption in campus-based or distance courses. In contrast, Internet browsers have rapidly become effective for transmitting or accessing information for administrators, teachers, and students, but provide limited support for the individual and group understanding that drives collaboration. Gibson's (1979) ecological approach to perception is instructive here. He defined an affordance as the possibility-to-act in a given environment. Gaver (1996) argued that a relation needs to be established between the designer's and the user's intentions. For instance, a teacher may select an electronic conferencing system for its features that support progressive discourse (Scardamalia & Bereiter, 1996), negotiation (Lim, 2003), or argumentation (Andriessen *et al.*, 2003; McAllister, Ravenscroft, & Scanlon, 2004). The students, however, may not perceive or understand the use of the system's features, thereby preventing or limiting the desired facilitation and support of peer-to-peer online interactions (Ferdig, 2006; Murphy, 2004; Veerman & Treasure-Jones, 1999).

In its early years, CSCL research focused on the use of technology as a mediational tool within collaborative methods of instruction (Koschmann, 1996). Soon, researchers found that teachers and students seldom used technology in the classroom as intended by designers, and they began to focus on online social interaction (Stahl, 2006). Research is needed to better understand the ecologies of online collaborative learning and the types of tools and affordances that may best support and enhance the process.

Recommendation 6. Research is needed on the organizational issues related to implementing CSCL in higher education to determine the essential conditions that must be in place for effective faculty use of CSCL (with particular attention to the level of support provided).

The organizational issues related to the use of CSCL in higher education need to be better understood. Higher education policies and organizational structures have evolved over many years to support the traditional paradigm of teaching and learning and create obstacles for faculty who wishes to incorporate pedagogical strategies such as CSCL. There is, however, growing recognition of the need to change learning methods and models in higher education to prepare students with the skills they will need to be competitive in a rapidly changing, knowledge-based global society. For example, the Business-Higher Education Forum (2003) in their report, *Building a Nation of Learners: The Need for Changes in Teaching and Learning to Meet Global Challenges*, underscores the need for developing new leadership and vision to redesign learning in our colleges and universities. To achieve this goal, universities will need to understand the role that the latest technology advancements can play in providing more effective learning environments. They must also provide high quality faculty development, technology resources, infrastructure, software tools, and technical support.

As noted earlier, little attention has focused on the educational design of CSCL environments (Strijbos, Martens, Jochems, & Broers, 2004). There is also a tendency to focus on a limited number of approaches, even though different learning tasks require different environments, support structures, and technological tools. Lipponen *et al.* (2004) emphasize that the design of CSCL settings should consider the relationships between the learning framework and the goal of collaboration as well as the technological tools and instructional approach. Similarly, Kirschner *et al.* (2004) advocate the concept of multiple collaborative environments, in which the design of the CSCL environment is shaped by decisions about educational, technological, and social affordances of the specific learning task.

Research is needed on the adoption of CSCL as an educational innovation within higher education in real-world settings. Such research will help to identify both the barriers and facilitators to the use of CSCL as well as other socio-constructivist approaches to learning. It will also provide a better understanding of the circumstances of use or conditions related to learning and knowledge building outcomes in higher education settings, and lead to the development of viable designs for adoption strategies within organizations. (See Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004; Rick & Gudzial, 2006; Jones *et al.*, 2006; Lonchamp, 2006).

Conclusion

Many perspectives contribute to the understanding of technology in support of collaborative learning. The last 20 years have been highly productive for CSCL. The advances of the learning sciences, combined with the needs of the knowledge society, have heightened the requirements for flexible (time and space) and challenging (problem-solving and knowledge building) learning environments. New analytical frameworks, derived from a number of theoretical perspectives (e.g., activity theory), offer new directions for research on collaborative learning. It may also be useful to consider the framework of presage, process, and product variables in developing future studies. Research is needed to better understand presage variables such as student characteristics and the technology affordances that enhance or constrain collaborative learning. A better understanding is also needed of critical processes or mediating variables, such as task-structuring, well or ill-defined problems, student engagement, teacher scaffolding, and the ways they combine to create online written discourse. Lastly, research should focus on the product variables that are claimed to be the most important outcomes of collaboration, such as higher-order thinking, deep understanding, and knowledge creation.

Critical to the advancement of collaborative learning is its theoretical-empirical basis, and a growing number of researchers posit both new possibilities and challenges to its continuing development. Yet, the extent to which instructors will choose to engage students in collaborative learning remains a moral issue (Goodlad, Soder, & Sirotnik, 1990), one grounded in each instructor's own beliefs about teaching.

References

Alavi, M. (1994). Computer-mediated collaborative learning: An empirical evaluation. *MIS Quarterly, 18*(2), 59–174.

Andriessen, J., Baker, M., & Suthers, D. (2003). Argumentation, computer support, and the educational context of confronting cognitions. In J. Andriessen, M. Baker, & D. Suthers (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 1–25). Dordrecht: Kluwer.

Bales, R. F. (1950). *Interaction process analysis.* Chicago: University of Chicago Press.

Barab, S. A., Kling, R., & Gray, J. (Eds.) (2004). *Designing for virtual communities in the service of learning.* Cambridge, UK: Cambridge University Press.

Barkley, E., Cross, K., & Major, C. (2005). *Collaborative learning techniques: A handbook for college faculty.* San Francisco, CA: Jossey-Bass.

Bean, J. C. (1996). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom*. San Francisco, CA: Jossey-Bass.
Benbunan-Fich, R., Hiltz, S. R., & Turoff, M. (2003). A comparative content analysis of face-to-face vs. asynchronous group decision making. *Decision Support Systems, 34*(4), 457–469.
Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.
Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 361–392). Hillsdale, NJ: Earlbaum.
Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. Chicago, IL: Open Court.
Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., *et al.* (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439.
Biggs, J. B. (1989). Approaches to the enhancement of tertiary teaching. *Higher Education Research and Development, 8*(1), 7–25.
Blumenfeld, P. C., Marx, R. W., Soloway, E., & Krajcik, J. (1996). Learning with peers: From small group cooperation to collaborative communities. *Educational Researcher, 25*(8), 43–46.
Brandon, D. P., & Hollingshead, A. B. (1999). Collaborative learning and computer-supported groups. *Communication Education, 48*(2), 108–125.
Bransford, J. D., Sherwood, R. D., Hasselbring, T. S., Kinzer, C. K., & Williams, S. M. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology* (pp. 115–141). Hillsdale, NJ: Erlbaum.
Brett, C. (2004). Off-line factors contributing to online engagement. *Technology, Pedagogy and Education, 13*(1), 83–95.
Brown, A. L. (1997). Transforming schools into communities of thinking and learning about serious matters. *American Psychologist, 52*(4), 399–413.
Brown, J. S., & Duguid, P. (2000). *The social life of information*. Cambridge, MA: Harvard Business School Press.
Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.
Business-Higher Education Forum (2003). *Building a nation of learners: The need for changes in teaching and learning to meet global challenges*. Washington, DC: Business-Higher Education Forum. Available: http://www.bhef.com/publications.
Chan, C., Burtis, J., & Bereiter, C. (1997). Knowledge building as a mediator of conflict in conceptual change. *Cognition and Instruction, 15*(1), 1–40.
Chickering, A., & Ehrmann, S. C. (1996). Implementing the seven principles: Technology as lever. *AAHE Bulletin*. October, 3–6. Available: http://www.tltgroup.org/programs/seven.html.
Clark, H. H., & Schaefer, E. F. (1989). Contributing to discourse. *Cognitive Science, 13*(2), 259–294.
Cockrell, K. S., Caplow, H., & Donaldson, J. F. (2000). A context for learning: Collaborative groups in the problem-solving learning environment. *The Review of Higher Education, 23*(3), 347–363.
Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectations*. London, UK: Kogan Page.
Cranton, P. (1998). *No one way: Teaching and learning in higher education*. Toronto: Wall & Emerson.
Dede, C. (1996). Emerging technologies and distributed learning. *American Journal of Distance Education, 10*(2), 4–36.
De Wever, B., Schellens, T., Valcke, M., & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education, 46*(1), 6–28.
Dillenbourg, P. (Ed.), (1999). *Collaborative learning. Cognitive and computational approaches*. Oxford: Elsevier.
Dillenbourg, P. (2002). Overscripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL?* (pp. 61–91). Heerlen: Open Universiteit Nederland.
Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Reiman (Eds.), *Learning in Humans and Machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford: Elsevier.
Dirckinck-Holmfeld, L. (2002). Designing virtual learning environments based on problem oriented project pedagogy. In L. Dirckinck-Holmfeld & B. Fibiger (Eds.), *Learning in virtual environments* (pp. 31–54). Frederiksberg: Samfundslitteratur Press.
Duisburg, M., & Hoope, U. (1999). Computer supported interaction analysis of group problem solving. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the Conference on Computer Supported Collaborative Learning, CSCL-99* (pp. 398–405). Palo Alto, CA.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki, Finland: Orienta-Konsultit.

Felder, R. M., Felder, G. N., Mauney, M., Hamrin, Jr., C. E., & Dietz, E. J. (1995). A longitudinal study of engineering student performance and retention. III. Gender differences in student performance and attitudes. *Journal of Engineering Education, 84*(2), 151–163.

Ferdig, R. E. (2006). Assessing technologies for teaching and learning: Understanding the importance of technological pedagogical content knowledge. *British Journal of Educational Technology, 37*(5)749–760.

Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J., & Soloway, E. (2004). Creating a framework for research on systemic technology innovations. *The Journal of the Learning Sciences, 13*(1), 43–76.

Fjermestad, J. (2004). An analysis of communication mode in group support systems research. *Decision Support Systems, 37*(2), 239–263.

Francescato, D., Porcelli, R., Mebane, M., Cuddetta, M., Klobas, J., & Renzi, P. (2006). Evaluation of the efficacy of collaborative learning in face-to-face and computer-supported university contexts. *Computers in Human Behavior, 22*(2), 163–176.

Gaver, W. W. (1996). Situating action II: Affordances for interaction: The social is material for design. *Ecological Psychology, 8*(2), 111–129.

Gibson, J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.

Gifford, B., & Enyedy, N. D. (1999). Activity centered design: Towards a theoretical framework for CSCL. In *Proceedings of the third international conference on computer support for collaborative learning-99* (pp. 189–197). University of Stanford. Available: http://www.gseis.ucla.edu/faculty/enyedy/pubs/Giffcrd&Enyvedy_CSCL2000.pdf.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education, 7*(1), 22–30.

Goodlad, J., Soder, R., & Sirotnik, K. (1990). *The moral dimensions of teaching.* San Francisco, CA: Jossey-Bass.

Guimond, S. (2001). Introduction to the special issue: The social psychology of academic achievement: Progress and prospects. *Social Psychology of Education, 4*(3–4), 215–217.

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

Hakkarainen, K. (2006, August). *Developing methods of studying knowledge practices.* Paper presented at the Knowledge building Summer Institute, OISE/UT, Toronto.

Harasim, L. M., Hiltz, S. R., Teles, L., & Turoff, M. (1995). *Learning networks: A field guide to teaching and learning online.* Cambridge, MA: MIT Press.

Hewitt, J. (2002). From a focus on tasks to a focus on understanding: The cultural transformation of a Toronto classroom. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *Computer supported cooperative learning volume 2: Carrying forward the conversation* (pp. 11–41). Mahwah, NJ: Erlbaum.

Hiltz, S. R., Dufner, D., Holmes, M., & Poole, S. (1991). Distributed group support systems: Social dynamics and design dilemmas. *Journal of Organizational Computing, 2*(1), 135–159.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

Holliman, R., & Scanlon, E. (2006). Investigating cooperation and collaboration in near synchronous computer mediated conferences. *Computers & Education, 46*(3), 322–335.

Howell-Richardson, C., & Mellar, H. (1996). A methodology for the analysis of patterns of participation within computer-mediated communication courses. *Instructional Science, 24*(1), 47–69.

Hübscher-Younger, T., & Narayanan, N. H. (2003). Authority and convergence in collaborative learning. *Computers & Education, 41*(4), 313–334.

Hutchins, E. (1995). *Cognition in the wild.* Cambridge, MA: MIT Press.

IHEP (2001). *Quality on the line: Benchmarks for success in Internet-based distance education. Institute for Higher Education Policy.* Washington, DC: Institute for Higher Education Policy.

Johnson, D. W., & Johnson, R. (1989). *Cooperation and competition: Theory and research.* Edina, MN: Interaction.

Johnson, D. W., & Johnson, R. T. (1996). Cooperation and the use of technology. In D. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 785–812). London: MacMillan.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998a). *Cooperative learning: Increasing college faculty instructional productivity, ASHE-ERIC Higher Education Reports, N. 4.* Washington, DC: George Washington University.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998b). Cooperative learning returns to college: What evidence is there that it works? *Change, 30*(4), 26–35.

Johnson, D. W., Johnson, R., Stanne, M., & Garibaldi, A. (1990). The impact of group processing on achievement in cooperative groups. *Journal of Social Psychology, 130*, 507–516.

Johnson, R., Johnson, D. W., Stanne, M., Smizak, B., & Avon, J. (1987). *Effect of composition pairs at the word processor on quality of writing and ability to use the word processor.* Minneapolis: Cooperative Learning Center, University of Minnesota.

Jonassen, D. (1994). Thinking technology: Toward a constructivist design model. *Educational Technology, 34*(4), 35–36.

Jones, C., Dirckinck-Holmfeld, L., & Lindström, B. (2006). A relational, indirect, meso-level approach to CSCL design in the next decade. *International Journal of Computer-Supported Collaborative Learning 1*(1), 35–56.

Jones, A., Scanlon, E., & Blake, C. (2000). Conferencing in communities of learners: Examples from social history and science communication. *Educational Technology and Society, 3*(3), 215–226.

Kafai, Y. B., & Resnick, M. (Eds.), (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world.* Mahwah, NJ: Erlbaum.

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

Kirschner, P. A., Martens, R. L., & Strijbos, J. W. (2004). CSCL in higher education? A framework for designing multiple collaborative environments. In J. W., Strijbos, P. A., Kirschner, & R. L., Martens (Eds.), *What we know about CSCL: And implementing it in higher education* (pp. 3–30). Boston, MA: Kluwer.

Koschmann, T. (Ed.) (1996). *CSCL: Theory and practice of an emerging paradigm.* Mahwah, NJ: Erlbaum.

Koschmann, T. (2002). Dewey's contribution to the foundations of CSCL research. In *Proceedings of Computer Support for Collaborative Learning 2002* (pp. 17–22). Boulder, CO.

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

Lai, M., & Law, N. (2005). Peer scaffolding of knowledge building through collaboration of groups with differential learning experiences. *CSCL Proceedings.* Taiwan.

Landauer, T. K., Foltz, P. W., & Laham, D. (1998). Introduction to latent semantic analysis. *Discourse Processes, 25*(2–3), 259–284.

Laurillard, D. (2001). *Rethinking university teaching: A conversational framework for the effective use of educational technology.* London: Routledge.

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

Levine, J. M., Resnick, L. B., & Higgins, E. T. (1993). Social foundations of cognition. *Annual Review of Psychology, 44*(1), 585–603.

Lim, J. (2003). A conceptual framework on the adoption of negotiation support systems. *Information and Software Technology, 45*(8), 469–477.

Lim, J., & Liu, Y. (2006). The role of cultural diversity and leadership in computer-supported collaborative learning: A content analysis. *Information and Software Technology, 48*(3), 142–153.

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

Lipponen, L. (2002). Exploring foundations for computer-supported collaborative learning. In G. Stahl (Ed.), *Computer support for collaborative learning: Foundations for a CSCL community. Proceedings of the Computer-Supported Collaborative Learning 2002 Conference* (pp. 72–81). Hillsdale, NJ: Erlbaum.

Lipponen, L., Hakkarainen, K., & Paavola, S. (2004). Practices and orientations of CSCL. In J. W. Strijbos, P. A. Kirschner, & R. L. Martens (Eds.), *What we know about CSCL in higher education* (pp. 31–51). Dordrecht: Kluwer.

Littleton, K., & Whitelock, D. (2005). The negotiation and co-construction of meaning and understanding within a postgraduate online learning community. *Learning, Media and Technology, 30*(2), 147–164.

Lockyer, L., Patterson, J., & Harper, B. (2001). ICT in higher education: Evaluating outcomes for health education. *Journal of Computer Assisted Learning, 17*(3), 275–283.

Lonchamp, J. (2006). Supporting synchronous collaborative learning: A generic, multi-dimensional model. *International Journal of Computer-Supported Collaborative Learning, 1*(2), 246–276.

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

Mason, R., & Romiszowski, A. (1996). Computer-mediated communication. In D. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 438–456). New York: Macmillan.

McAllister, S., Ravenscroft, A., & Scanlon, E. (2004). Combining interaction and context design to support collaborative argumentation using a tool for synchronous CMC. *Journal of Computer Assisted Learning, 20*(3), 194–204.

McCain, T., & Jukes, I. (2001). *Windows in the future: Education in the age of technology.* Thousand Oaks, CA: Corwin.

McManus, M., & Aiken, R. (1995). Monitoring computer-based problem solving. *Journal of Artificial Intelligence in Education, 6*(4), 307–336.

Monteil, J. M., & Huguet, P. (1999). *Social context and cognitive performance: Towards a social psychology of cognition*. Hove, East Sussex: Psychology.

Murphy, E. (2004). Recognizing and promoting collaboration in online asynchronous discussions. *British Journal of Educational Technology, 35*(4), 421–431.

Oblinger, D. G., & Oblinger, J. L. (Eds.). (2005). *Educating the Net generation*. Washington, DC: Educause. Available: http://www.educause.edu/educatingthenetgen.

Ocker, R. J., & Yaverbaum, G. L. (2001). Collaborative learning environments: Exploring student attitudes and satisfaction in face-to-face and asynchronous computer conferencing settings. *Journal of Interactive Learning Research, 12*(4), 427–448.

Palmieri, P. (1997). Technology in education ... Do we need it? *ARIS Bulletin, 8*(2), 1–5.

Panitz, T. (1996). A definition of collaborative versus cooperative learning. *Deliberations* [Online]. Available: http://www.londonmet.ac.uk/deliberations/collaborative-learning/panitz-paper.cfm.

Pea, R. D. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communications. *The Journal of the Learning Sciences, 3*(3), 219–225.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education and human activity. *The Journal of the Learning Sciences, 13*(3), 423–451.

Pea, R. D., Edelson, D. C., & Gomez, L. M. (1994, February). *Distributed collaborative science learning using scientific visualization and wideband telecommunications*. Paper presented at the 160th Meeting of the American Association for the Advancement of Science, in the symposium: "Multimedia information systems for science and engineering education: Harnessing technologies », Northwestern University, Evanston, IL.

Pearson, J. (2006). Investigating ICT using problem-based learning in face-to-face and online learning environments. *Computers & Education, 47*(1), 56–73.

Reeder, K., Macfadyen, L. P., Roche, J., & Chase, M. (2004). Negotiating cultures in cyberspace: Participation patterns and problematics. *Language Learning and Technology, 8*(2), 88–105.

Rick, J., & Gudzial, M. (2006). Situating CoWeb: A scholarship of application. *International Journal of Computer-Supported Collaborative Learning, 1*(1), 89–115.

Rimmershaw, R. (1999). Using conferencing to support a culture of collaborative study. *Journal of Computer Assisted Learning, 15*(3), 189–200.

Roschelle, J. (1992). Learning by collaboration: Convergent conceptual change. *The Journal of the Learning Sciences, 2*(3), 235–276.

Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In C. E. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69–197). Berlin Heidelberg New York: Springer.

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2001). Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education, 14*(2), 51–70.

Rovai, A. (2002). A preliminary look at the structural differences of higher education classroom communities in traditional and ALN courses. *Journal of Asynchronous Learning Networks, 6*(1), 41–56.

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer-mediated settings. *Journal of the Learning Sciences, 14*(2), 201–241.

Salomon, G. (Ed.) (1993). *Distributed cognition: Psychological and educational considerations*. Cambridge, UK: Cambridge University Press.

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

Scardamalia, M. (2002). Collective responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal Education in a Knowledge Society* (pp. 67–98). Chicago, IL: Open Court.

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

Scardamalia, M., & Bereiter, C. (1996). Engaging student in a knowledge society. *Educational Leadership, 54*(3), 6–10.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of education* (2nd ed. pp. 1370–1373). New York: Macmillan.

Schellens, T., & Valcke, M. (2006). Fostering knowledge construction in university students through asynchronous discussion groups. *Computers & Education, 46*(4), 349–370.

Schlager, M., & Fusco, J. (2004). Teacher professional development, technology, and communities of practice: Are we putting the cart before the horse? In S. Barab, R. Kling, & J. Gray (Eds.), *Designing* *for virtual communities in the service of learning* (pp. 120–153). Cambridge, UK: Cambridge University Press.

Schlager, M. S., & Schank, P. (1997). Tapped in: A new online community concept for the next generation of Internet technology. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Proceedings of the Second International Conference on Computer Support for Collaborative Learning*. (pp. 231–240). Hillsdale, NJ: Erlbaum.

Schrage, M. (1990). *Shared minds: The new technologies of collaboration*. New York: Random House.

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

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

Slavin, R. E. (1997). *Educational psychology: Theory and practice* (5th ed.). Needham Heights, MA: Allyn & Bacon.

Smith, K. A. (1996). Cooperative learning: Making "group work" work. In T. E. Sutherland & C. C. Bonwell (Eds.), *Using active learning in college classes: A range of options for faculty* (pp. 71–82). San Francisco: Jossey-Bass.

Spiro, R. J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In *The Tenth Annual Conference of the Cognitive Science Society*. Hillsdale, NJ: Erlbaum.

Springer, L., Stanne, M., & Donovan, S. (1998). Effects of cooperative learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21–51.

Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of CSCL. In J.-W. Strijbos, P. Kirschner, & R. Martens (Eds.), *What we know about CSCL: And implementing it in higher education* (pp. 53–86). Boston, MA: Kluwer.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Steinkuehler, C. A., Derry, S. J., Hmelo-Silver, C., & DelMarcelle, M. (2002). Cracking the resource nut with distributed problem-based learning in secondary teacher education. *Journal of Distance Education, 23*(1), 23–29.

Stone-Wiske, M. (2002). New technologies to support teaching for understanding. *International Journal of Educational Research, 35*(5), 483–501.

Strijbos, J. W., Kirschner, P. A., & Martens, R. L. (Eds.) (2004). *What we know about CSCL: And implementing it in higher education*. Berlin Heidelberg New York: Springer.

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

Strijbos, J. W., Martens, R. L., Jochems, W. M. G., & Broers, N. (2004). The effect of functional roles on group efficiency. Using multilevel modeling and content analysis to investigate computer supported collaboration in small groups. *Small Group Research, 35*(2), 195–229.

Strijbos, J. W., Martens, R. L., Prins, F. J., & Jochems, W. M. G. (2006). Content analysis: What are they talking about? *Computers & Education, 46*(1), 29–48.

Suthers, D., Weiner, A., Connelly, J., & Paolucci, M. (1995). Belvedere: Engaging students in critical discussion of science and public policy issues. In J. Greer (Ed.), *Proceedings of AI-ED 95: World Conference on Artificial Intelligence in Education* (pp. 266–273). Washington, DC: AACE.

Tapscott, D. (1998). *Growing up digital: The rise of the net generation*. New York: McGraw-Hill.

Teasley, S. D., & Roschelle, J. (1993). Constructing a joint problem space: The computer as a tool for sharing knowledge. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as Cognitive Tools* (pp. 229–258). Hillsdale, NJ: Erlbaum.

UNESCO (2005). *Towards knowledge societies: Unesco World report (WSIS)* [Online]. Available: http://unesdoc.unesco.org/images/0014/001418/141843e.pdf.

Valcke, M., & Martens, R. (2006). The problem arena of researching computer supported collaborative learning: Introduction to the special section. *Computers & Education, 46*(1), 1–5.

van Aalst, I., & Chan, C., (2001). Beyond sitting next to each other: A design experiment on knowledge building in teacher education. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *Proceedings of the First European Conference on Computer-Supported Collaborative Learning* (pp. 20–28). Maastricht: University of Maastrich.

Veerman, A. L., & Treasure-Jones, T. (1999). Software for problem solving through collaborative argumentation. In P. Poirier & J. Andriessen (Eds.), *Foundations of argumentative test processing* (pp. 203–230). Amsterdam: Amsterdam University Press.

Wallace, R. (2003). Online learning in higher education: A review of research on interactions among teachers and students. *Education, Communication & Information, 3*(2), 241–280.
Warschauer, M. (1997). Computer-mediated collaborative learning: Theory and practice. *The Modern Language Journal, 81*(4), 470–481.
WASC (2000). *Guidelines for Distance Education: Principles of Good Practice.* Alameda, CA: Western Association of Schools and Colleges.
Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications.* Cambridge: Cambridge University Press.
Webb, N. M., & Palincsar, A. S. (1996). Group processes in the classroom. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 841–873). New York: Simon & Schuster.
Wegerif, R. (2006). Towards a dialogic understanding of the relationship between teaching thinking and CSCL. *International Journal of Computer Supported Collaborative Learning, 1*(1), 143–157.
Weinberger, A., Fischer, F., & Mandl, H. (2002). Fostering computer supported collaborative learning with cooperation scripts and scaffolds. In G. Stahl (Ed.), *Computer support for collaborative learning: foundations for a CSCL community* (pp. 573–574). Mahwah, NJ: Erlbaum.
Wilson, E. (2000). Student characteristics and computer-mediated communication. *Computers and Education, 34*(2), 67–76.