2

Searching for Learner-Centered, Constructivist, and Sociocultural Components of Collaborative Educational Learning Tools

Curtis Jay Bonk
Donald J. Cunningham
Indiana University

As Bednar, Cunningham, Duffy, and Perry (1995) argued, instructional strategies and tools must be based on some theory of learning and cognition. Of course, crafting well-articulated views that clearly answer the major epistemological questions of human learning has exercised psychologists and educators for centuries. What is a mind? What does it mean to know something? How is our knowledge represented and manifested? Many educators prefer an eclectic approach, selecting "principles and techniques from the many theoretical perspectives in much the same way we might select international dishes from a smorgasbord, choosing those we like best and ending up with a meal which represents no nationality exclusively and a design technology based on no single theoretical base" (Bednar et al., 1995, p. 100). It is certainly the case that research within collaborative educational learning tools has drawn upon behavioral, cognitive information processing, humanistic, and sociocultural theory, among others, for inspiration and justification. Problems arise, however, when tools developed in the service of one epistemology, say cognitive information processing, are integrated within instructional systems designed to promote learning goals inconsistent with it. When concepts, strategies, and tools are abstracted from the theoretical viewpoint that spawned them, they are too often stripped of meaning and utility. In this chapter, we embed our discussion in learner-centered, constructivist, and sociocultural perspectives on collaborative technology, with a bias toward the third. The principles of these perspectives, in fact, provide the theoretical rationale for much of the research and ideas presented in this book.

Theory certainly cannot operate within a vacuum. Views on questions such as the nature of mind are developed by considering not only philosophical questions like the form of underlying mental representation, but also the world within which learners function. Cunningham (1996) has proposed three models of mind that could guide our conceptions of learning and cognition: mind as computer (a symbol manipulation device), mind as brain (a parallel distributed processing device), and mind as rhizome (an infinity of connections with and within the social cultural milieu). Each of these metaphors points to a view of instruction in general and of collaborative learning tools in particular: (a) learning as information processing—a cognitive skills approach, (b) learning as experiential growth and pattern recognition—a cognitive constructivist approach, and (c) learning as a sociocultural dialogic activity—a social constructivist or sociocultural approach. If learning is predominantly information processing, then instruction should provide for efficient communication of information and effective strategies for remembering. If learning is predominantly experiential growth, then instruction should focus on experiences and activities that promote the individual development of the appropriate cognitive networks or mind maps. And, finally, if learning is predominantly a sociocultural dialogic, then instruction should provide opportunities for embedding learning in authentic tasks leading to participation in a community of practice.

But each of these views presumes the availability, in the world of experience, of tools and structures to support them. In a way, each of these three views can be identified and embodied in the tools and cultural practices of the late 20th century; though none is so apparent and consequential as the sociocultural. As we see later, recent developments in cultural tools and instructional practices have allowed rapid advances in sociocultural theory by providing embodiments and instantiations of this theory undreamed of only decades ago.

We truly live in interesting times (whether this is a curse or blessing, we leave it to the reader to decide)! Daily advances in fiber optics, multimedia, and telecomputing technology continue to force new sectors of society to grapple with information access, transmission, and collaboration issues. In the midst of this social and technological drama, vast resources at our fingertips are restructuring the way we humans work, live, learn, and generally interact regardless of "geography, distance, resources, or disability" (United States, Department of Labor, Secretary's Commission on Achieving Necessary Skills, 1991). Technology is becoming increasingly interactive and distributed, such that individual learners have available, at rapidly declining cost, the means to participate in incredibly complex networks of information, resources, and instruction. For instance, Internet navigation and discovery tools like the World Wide Web (WWW) have brought to many of our desktops an immense array of text, video, sound, and communication resources unthinkable even 10 years ago.

Such changes cannot fail to influence our views of the teaching–learning process and the education of our children. During the past few years we have all witnessed the exploding interest in the Internet among teachers, students, and other learning communities. But the underlying views of learning held by students and teachers of the Internet remain unclear. With the dramatic growth in both the means and impact of collaborative communication, there is a heightened need for theoretically based collaborative educational learning tool use. At the same time, educational leaders need reassurance and guidance that as the formats for electronic collaboration proliferate, computer-mediated communication will enhance student–teacher and student–student interaction and positively reorganize the learning process of K–12 schools and institutions of higher learning.

Some educators claim that online environments are particularly appropriate for collaborative learning approaches because they emphasize group interaction (Harasim, 1990). But as the menu of technology choices in schools, workplaces, and on college campuses escalates, instructional decisions regarding how to communicate with learners across these settings are becoming increasingly critical and complex. The lack of pedagogical guidance about integrating tools for collaboration and communication into one's classroom or training setting leaves instructors across educational settings with mounting dilemmas and confusion.

Predictably, the traditional teacher-centered model in which knowledge is "transmitted" from teacher to learner is rapidly being replaced by alternative models of instruction (e.g., learner-centered, constructivist, and sociocultural ideas) in which the emphasis is on guiding and supporting students as they learn to construct their understanding of the culture and communities of which they are a part (A. L. Brown et al., 1993; J. S. Brown, Collins, & Duguid, 1989; Cobb, 1994; Collins, 1990; Duffy & Cunningham, 1996; Pea, 1993b). In the process of shifting our attention to the constructive activity of the learner, we recognize the need to anchor learning in real-world or authentic contexts that make learning meaningful and purposeful.

The blending of these technological and pedagogical advancements has elevated the importance of research on electronic student dialogue, text conferencing, information sharing, and other forms of collaboration. Clearly, as specialized software is developed to support the exchange of information across workstations (e.g., text, graphics, and other digitized material) and various instructional strategies are experimented with and modified, collaborative tools will present unique opportunities for facilitating, augmenting, and redefining learning environments (Koschmann, Myers, Feltovich, & Barrows, 1994). Rapid tool development during the 1990s has naturally multiplied concerns within a number of human–computer interaction subfields for identifying, empirically examining, and adapting the design of collaborative learning tools. In fact, one such subfield, *computer-supported* *collaborative learning* (CSCL) (Koschmann, 1994, 1996), has merged various technological and instructional trends to offer major promise for coping with this current change.

Advances in interactive technologies for learning collaboration within CSCL are evident in new journals, conferences, technology tool announcements, instructional labs, and professional organizations. Prominent CSCL technologies for computer conferencing and collaboration are bringing students close to real-world environments and mentoring situations. As these collaborative technologies provide increasing opportunities for working with online communities of learners (Harasim, 1993), the pedagogic potential of every connected classroom multiplies. Given all these new technologies for conferencing and collaboration, faculty in higher education as well as those in public schools and the corporate world have a growing number of instructional possibilities to consider. And there is certainly no sign of a letup in collaborative tool development! The primary issue facing these educators, therefore, is what sort of framework they will have for incorporating these tools for learning collaboration into K–12, higher education, and corporate classrooms. Just what is the most effective way to understand and use these tools?

THEORETICAL PERSPECTIVES ON COLLABORATIVE LEARNING TOOLS

As indicated, the chapters in this book primarily draw on three general and overlapping theoretical perspectives on collaborative learning tools: learner-centered instruction, constructivism, and sociocultural theory. We consider each of these in turn.

A Learner-Centered View on Collaborative Technology

In 1990, the American Psychological Association (APA) and the Mid-continent Regional Educational Laboratory (McREL) joined forces to create a task force on psychology in education that recognized that research and theory on learning, development, and motivation was not having as great an impact in school reform and restructuring activities as expected. As a result, an eclectic mix of 12 learner-centered principles (LCPs) were drafted, which later evolved into 14 basic principles from the APA (American Psychological Association, 1993, 1997; see also Table 2.1). Because these learner-centered principles have extensive research backing (Alexander & Murphy, 1994), they have begun to provide a foundation for educational reform and transformation across age levels and organizations. With all the media attention on tangible and cost-effective changes in schools, these reform efforts, not surprisingly, are especially conspicuous in technology-rich learning environments wherein the role of the teacher is under intense scrutiny and transformation.

TABLE 2.1
Learner-Centered Psychological Principles Revised

Cognitive and Metacognitive Factors
1. *Nature of the learning process.* The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.
2. *Goals of the learning process.* The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.
3. *Construction of knowledge.* The successful learner can link new information with existing knowledge in meaningful ways.
4. *Strategic thinking.* The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.
5. *Thinking about thinking.* Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.
6. *Context of learning.* Learning is influenced by environmental factors, including culture, technology, and instructional practices.
Motivational and Affective Factors
7. *Motivational and emotional influences on learning.* What and how much is learned is influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states.
8. *Intrinsic motivation to learn.* The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.
9. *Effects of motivation on effort.* Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without the learner's motivation to learn, the willingness to exert this effort is unlikely without coercion.
Developmental and Social Factors
10. *Developmental influences on learning.* As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.
11. *Social influences on learning.* Learning is influenced by social interactions, interpersonal relations, and communication with others.
Individual Differences
12. *Individual differences in learning.* Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.
13. *Learning and diversity.* Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.
14. *Standards and assessment.* Setting appropriately high and challenging standards and assessing the learner as well as learning progress—including diagnostic, process, and outcome assessment—are integral parts of the learning process.

Note. For a full text of the principles listed as well as additional rationale and explanation, call or write to the American Psychological Association (APA) for the December 1995 report *The Learner-Centered Psychological Principles: A Framework for School Redesign and Reform* (this summary of the 14 LCPs appeared in the *Newsletter for Educational Psychologists*, "Learner-Centered Psychological Principles revised," 1996, Vol. 19, Issue 2, p. 10) or see: American Psychological Association (1997) *Learner-Centered Psychological Principles: A Framework for School Redesign and Reform* (On-line), Available at URL: http://www.apa.org/ed/lcp.html.

But what does “learner-centered technology” look like? According to Wagner and McCombs (1995), technology-enhanced instructional settings, such as distance learning, offer special opportunities for implementing learner-centered principles and demonstrating them in action. They pointed out that distance-learning technology can offer greater opportunity to experience learning activities that are internally driven and constructed, goal oriented and reflective, personally meaningful and authentic, collaborative and socially negotiated, and adaptive to individual needs and cultural backgrounds.

As indicated in Table 2.1, the framework of the LCPs begins with cognitive and metacognitive aspects of learning. In directly addressing these first six LCPs, technology is often touted as affecting the nature and goals of the learning process (i.e., LCPs #1 and #2) by placing tools in the hands of learners to build, browse, link, draw, juxtapose, represent, and summarize information (Lehrer, 1993). Such construction of knowledge and emphasis on mental operations also aligns with the third, fourth, and fifth LCPs. More strikingly, the sixth LCP, on the “context of learning,” explicitly notes that learning is influenced by environmental factors such as technology, instruction, and culture. Thus, this sixth LCP has relevance to all the research presented in this text because the collaborative technologies explored in this volume have been designed, modified, and/or enhanced to create new contexts for learning. Equally important, this principle is derived from sociocultural theory and research, detailed later, which is the framework we feel is best suited for research investigations involving CSCL tools. From our point of view, therefore, LCP #6 should be the first LCP.

The three motivationally related LCPs (#’s 7–9) point to the role of novelty, optimal difficulty, curiosity, personal choice, control, effort, and emotions. Certainly these, too, have applicability in technology-mediated settings. The intrigue of answering questions posted by one’s foreign peers as well as the delight of posting one’s ideas and work on the WWW builds a personal sense of pride and ownership over the task (Harasim, 1990). The linkage between collaborative technologies and learner-centered instruction, therefore, is extremely strong with both the cognitive and motivational principles.

The third category of LCPs relates to developmental and social factors in learning (i.e., LCPs #10 and 11). Adapting collaborative technology to the developmental issues stated in the 10th LCP is simultaneously the most tenuous and promising of these principles, however. Technology alone is not adaptive, but the design and use of it most definitely can be. The following LCP, on the other hand, is an important corollary to the sociocultural ideas of LCP #6 highlighted previously, because it addresses the social interactional factors in learning as well as the importance of interpersonal relations and communication with others. This LCP clearly corresponds to the supposed benefits of electronic conferencing and collaboration tools. It is here, in the social relations, that the cognitive and motivational activities addressed by the first 9 LCPs spring forth. The social interactional nature of collaborative educational technologies can foster many emotions and cognitions, including: (a) the tension of debate with students from distant lands who may come within one's field of vision, (b) the query of a student seeking to fill in a gap in his or her knowledge base, (c) the warming feedback of a keyboard-generated smile, and (d) the encouragement of someone recently befriended on the electronic superhighway. In effect, a common ground of interest and understanding is becoming a more determinant factor of who one communicates with than some shared "physical" space or geographic proximity. The fortunes of the learner-centered movement may, in fact, hinge on the success of emerging collaborative technologies in promoting interaction among those with common interests as well as finding learners new proximities of interest along the way.

Finally, the last three LCPs, related to individual differences in learning such as prior knowledge (LCP #12), linguistic and cultural backgrounds (LCP #13), and challenging standards (LCP #14), each can be linked to collaborative learning technologies. The use of global communication tools can make learner differences in prior knowledge (LCP #12) more salient, while forcing learners to consider variations between the way they view the world and those individuals from distinctly different social, economic, cultural, and linguistic backgrounds (LCP #13). At the same time, when students gather information to share with classmates from other cultures, their performance becomes elevated as one does not want to "look dumb" to his or her foreign peers. In this way, perhaps more challenging learning standards are established for both parties as is hoped for in the final LCP.

These 14 LCPs have arisen, in part, to satisfy public school teachers and higher education faculty who are no longer satisfied teaching in the familiar and routine way in which they themselves were taught. Many of these educators are seeking to use collaborative technologies to build new interaction patterns and learning communities based on a philosophy that puts the learner first. But although the emergence of more learner-centered teaching practices and technology tools for constructing knowledge applies to a myriad of school settings, most teachers still lack the support and direction to use collaborative technology from such a learner-centered perspective (Blumenfeld, Marx, Soloway, & Krajcik, 1996). For instance, teachers previously trained in the benefits of collaborative learning need to know how to embed grouping strategies when using CSCL tools. Furthermore, teachers trained in teacher-centered technologies such as overheads and videotape, or tool-centered media such as computer-assisted instruction or databases and spreadsheets, are now being asked to adopt CSCL technologies that place increasing responsibility for learning squarely in the hands of the learner. Fourteen individual statements are helpful but not enough. Teachers need assistance in identifying opportunities for the use of these principles in instruction and in evaluating their effectiveness. CSCL tools should provide a number of windows for doing so.

These 14 LCPs have generated much discussion and debate among educators, and as such, have been very productive. Yet, at the same time, they seem far too broad and eclectic and are not focused upon significant issues of mind. What is the nature of meaningful knowledge representations, for example? Are thinking and reasoning strategies abstract algorithms to be transferred to the learner or are they tied to the everyday cognition of humans in action? As with the learner-centered approach, constructivism has recently achieved some prominence as a theoretical foundation for teaching and leaning. We now turn to constructivist approaches to better understand collaborative tool learning.

A Constructivist View on Collaborative Technology

Constructivism is a recent perspective or philosophy on learning with ancient roots (von Glasersfeld, 1995) that has extensive implications for the use of collaborative learning tools. In employing constructivism, some teachers believe that better learning occurs when knowledge is the result of a situated construction of reality (Brooks, 1990). Unfortunately, although constructivist revolutionaries have ventured onto the battlefield of epistemological change, most have not provided practicing educators with the wherewithal to reconstitute and embed constructivist ideas within their personal philosophies and teaching practices. Teachers might, in fact, design useful constructivistic learning environments and strategies, but may not recognize that they operate from a constructivist paradigm (Harris & Pressley, 1991). Even when constructivism is recognized as valuable, few guidelines exist for implementing and assessing it. So, when CSCL tools enter the instructional arsenal of public schools and higher education settings, constructivism may not be the theory of choice. And, undoubtedly, many scholars and researchers fuel this problem with intense debates that most practitioners simply lack the time and energy to deal with (e.g., see Ernest, 1995; von Glasersfeld, 1995).

Further muddying the debate, there is no canonical form of constructivist theory. Cobb (1994) identified two variations—cognitive constructivist and social constructivist—and there are undoubtedly more. Cognitive constructivists tend to draw insight from Piaget and focus on individual constructions of knowledge discovered in interaction with the environment (see Table 2.2). Social constructivists rely more on Vygotsky (1978) and view learning as connection with and appropriation from the sociocultural context within which we are all immersed (see Table 2.3). In Tables 2.2 and 2.3, we try to clarify some of the distinct differences in teaching practices between these

TABLE 2.2
Cognitive Constructivistic Teaching Practices and Principles

1. *Mind:* The mind is in the head; hence, the learning focus is on active cognitive reorganization.
2. *Raw Materials:* Use raw or primary data sources, manipulatives, and interactive materials.
3. *Student Autonomy:* Ask students for personal theories and understandings before any instruction. Allow student thinking to drive lessons and alter instruction based on responses. Place thinking and learning responsibility in students' hands to foster ownership.
4. *Meaningfulness and Personal Motivation:* Make learning a personally relevant and meaningful endeavor. Relate learning to practical ideas and personal experiences. Adapt content based on student responses to capitalize on personal interests and motivation.
5. *Conceptual Organization/Cognitive Framing:* Organize information around concepts, problems, questions, themes, and interrelationships, while framing activities using thinking-related terminology (e.g., classify, summarize, predict).
6. *Prior Knowledge and Misconceptions:* Adapt the cognitive demands of instructional tasks to students' cognitive schemes, while building on prior knowledge. Design lessons to address students' previous misconceptions, for instance, by posing contradictions to original hypotheses and then inviting responses.
7. *Questioning:* Promote student inquiry and conjecture with open-ended questions. Also, encourage student question-asking behavior and peer questioning.
8. *Individual Exploration and Generating Connections:* Provide time for the selection of instructional materials and the discovery of information, ideas, and relationships. Also includes encouraging students to generate knowledge connections, metaphors, personal insights, and build their own learning products.
9. *Self-Regulated Learning:* Foster opportunity for reflection on skills used to manage and control one's learning. Help students understand and become self-aware of all aspects of one's learning, from planning to learning performance evaluation. Given the focus on individual mental activity, the importance of cooperative learning or peer interaction is in the modeling of and support for new individual metacognitive skill.
10. *Assessment:* Focus of assessment is on individual cognitive development within predefined stages. Use of authentic portfolio and performance-based measures with higher order thinking skill evaluation criteria or scoring rubrics.

Note. From Bonk, Oyer, and Medury (1995), Brooks (1990), A. L. Brown et al. (1993), Duffy and Cunningham (1996), Ernest (1995), Savery and Duffy (1996), von Glasersfeld (1995), Wells and Chang-Wells (1992).

two positions as well as some of the more subtle ones, which are really more a matter of emphasis than epistemological divergence.

It is worth pointing out that collaborative learning tools can be used from both a cognitive constructivist and social constructivist perspective. CSCL tools can place students in an authentic learning situation wherein an assortment of primary data and human resources are at their fingertips. A wealth of Internet and local area network tools, in fact, are now available in many public schools and universities to offer students significant opportunities to explore personal interests and expand on prior experiences. Moreover, many technology tools enable teachers to structure learning activities that address student misconceptions, seek student elaboration of their answers, and pose questions. Perhaps, even more importantly, a few educators have come to recognize the importance of social constructivism for electronic learning

TABLE 2.3
Social Constructivistic Teaching Practices and Principles

1. *Mind:* The mind is located in the social interaction setting and emerges from acculturation into an established community of practice.
2. *Authentic Problems:* Learning environments should reflect real-world complexities. Allow students to explore specializations and solve real-world problems as they develop clearer interests and deeper knowledge and skills.
3. *Team Choice and Common Interests:* Build not just on individual student prior knowledge, but on common interests and experiences. Make group learning activities relevant, meaningful, and both process and product oriented. Give students and student teams choice in learning activities. Foster student and group autonomy, initiative, leadership, and active learning.
4. *Social Dialogue and Elaboration:* Use activities with multiple solutions, novelty, uncertainty, and personal interest to promote student–student and student–teacher dialogue, idea sharing, and articulation of views. Seek student elaboration on and justification of their responses with discussion, interactive questioning, and group presentations.
5. *Group Processing and Reflection:* Encourage team as well as individual reflection and group processing on experiences.
6. *Teacher Explanations, Support, and Demonstrations:* Demonstrate problem steps and provide hints, prompts, and cues for successful problem completion. Provide explanations, elaborations, and clarifications where requested.
7. *Multiple Viewpoints:* Foster explanations, examples, and multiple ways of understanding a problem or difficult material. Build in a broad community of audiences beyond the instructor.
8. *Collaboration and Negotiation:* Foster student collaboration and negotiation of meaning, consensus building, joint proposals, prosocial behaviors, conflict resolution, and general social interaction.
9. *Learning Communities:* Create a classroom ethos or atmosphere wherein there is joint responsibility for learning, students are experts and have learning ownership, meaning is negotiated, and participation structures are understood and ritualized. Technology and other resource explorations might be used to facilitate idea generation and knowledge building within this community of peers. Interdisciplinary problem-based learning and thematic instruction is incorporated wherever possible.
10. *Assessment:* Focus of assessment is on team as well as individual participation in socially organized practices and interactions. Educational standards are socially negotiated. Embed assessment in authentic, real-world tasks and problems with challenges and options. Focus on collaboration, group processing, teamwork, and sharing of findings. Assessment is continual, less formal, subjective, collaborative, and cumulative.

Note. From Bonk et al. (1995), A. L. Brown et al. (1993), Duffy and Cunningham (1996), Ernest (1995), Savery and Duffy (1996), Wells and Chang-Wells (1992).

because the potential for collaboration and negotiation embedded within it provides the learner with the opportunity to obtain alternative perspectives on issues and offer personal insights; in effect, to engage in meaning making and knowledge negotiation (Duffy & Cunningham, 1996).

As Scardamalia and Bereiter (1996) discovered, when CSCL tools are developed and used from a social constructivist viewpoint, new communities of learning often emerge. Whereas cognitive constructivists focus on making learning more relevant, building on student prior knowledge, posing contradictions, and addressing misconceptions (Brooks, 1990), social constructivists emphasize human dialogue, interaction, negotiation, and collaboration (Bonk, Oyer, & Medury, 1995). Across both viewpoints, constructivistic educational practices and orientations emphasize active, generative learning, with curricula wherein teachers continue to perform a critical learning function as learning consultants and guides (Cognition and Technology Group at Vanderbilt, 1991; Tharp & Gallimore, 1988). For additional discussion of constructivist uses of technology tools across different subject matter domains, see Bonk, Medury, and Reynolds (1994), Lehrer (1993), Pea (1993b), Ruopp, Gal, Drayton, and Pfister (1993), Scardamalia and Bereiter (1996), Schoenfeld (1988), Scott, Cole, and Engel (1992), and Songer (in press).

In our separate research endeavors (e.g., Bonk et al., 1994; McMahon, O'Neill, & Cunningham, 1992), we have discovered that tools fostering social interaction and learner-centered instructional practices are transforming learning from silent, solitary acts to lively, meaning-making events rich in discussion and interchange. This research has led us to believe that what is now needed is national and international leadership to move educational technology to the next phase of development focusing on social interaction and dialogue tools. As becomes clear later, we believe that sociocultural theory and social constructivist teaching practices provide the backbone for such leadership (in fact, we use the terms social constructivism and sociocultural theory interchangeably).

Sociocultural Views on Collaborative Technology

As worldwide learning forums or educational "networlds" (Harasim, 1993) arise, the resulting electronic interactions between humans should be investigated through suitable social and cultural lenses (J. Brown, 1986; Scott et al., 1992). Fortunately, paralleling the recent advances in technology for global collaboration and dialogue, many educators and human-learning researchers are finding promise in Vygotsky's (1978, 1986) sociocultural ideas about learning in a social context (Cognition and Technology Group at Vanderbilt, 1990, 1991; Duffy & Jonassen, 1991; Forman, Minick, & Stone, 1993; Moll, 1990; Palincsar, 1986). A primary tenet of Vygotskian psychology is that individual mental functioning is inherently situated in social interactional, cultural, institutional, and historical contexts. Therefore, to understand human thinking and learning, one must examine the context and setting in which that thinking and learning occurs.

Mediation. As noted in Table 2.4, which summarizes 10 key sociocultural terms and principles, individual learning and development is dependent on the institutions, settings, and cultural artifacts in one's social milieu. The tools and signs one is exposed to, therefore, influence or mediate new patterns

TABLE 2.4
Sociocultural Theory and Principles for CSCL Environments

- *Mediation:* According to sociocultural theorists, genetic or developmental analyses need to be used to understand the origins and transitions of mental functions; there are four levels of development: microgenetic, ontogenetic, phylogenetic, and sociohistorical. From this view, social and individual psychological activity is influenced or mediated by the tools and signs in one's sociocultural milieu (e.g., written language, maps, artwork, diagrams, computer screens, etc.). Because individual development is dependent on institutional settings and cultural artifacts in one's learning environment, as technology advances to alter the available cultural tools and settings, so, too, does it alter mind.
- *Zones of Proximal Development (ZPD):* This terms refers to the distance between actual or independent problem solving and performance when provided with learning assistance from adults or more capable peers. It assumes that social interaction is central to the development of new patterns of thought and strategic behaviors; hence, if computer tools can be considered a more capable peer, they might mediate new patterns of thought within one's ZPD.
- *Internalization:* Sociocultural theorists believe that development appears twice, once socially with others and later as independent problem-solving behavior; in other words, it moves from an external to an internal plane. Internalization, therefore, is the process of taking new information that was experienced or learned within a social context and developing the necessary skills or intellectual functions to independently apply the new knowledge and strategies. Private or inner speech is important to development because it can be a bridge for the internalization of self-regulatory behaviors. A key assumption here is that learning is not an exact copying process, but, instead, the learner appropriates or applies the skills or information based on his or her own skills, needs, and experiences.
- *Cognitive Apprenticeship:* Refers to a socially interactive relationship similar to the master–apprentice one in skilled trades and crafts. The concept assumes that newcomer learners should be acculturated into an established community of practice by observing and participating on the periphery. Teachers and communities, therefore, should apprentice and scaffold young learners into authentic learning activities, while gradually ceding control of the learning task to the student. Hence, novice learners move from the fringes of the culture to a more central role within it.
- *Assisted Learning:* Because learning precedes development, effective instruction can provoke developmental growth or rouse new skills to life. As a result of this malleability of intelligence to instruction, teachers are vital in creating learning environments rich in meaning making and social negotiation activities. There are a range of techniques for teachers to assist in the learning process (e.g., modeling, coaching, scaffolding and fading, questioning, directly instructing, task structuring, management and feedback, and pushing students to explore, reflect, and articulate ideas).
- *Teleapprenticeship:* As a result of advances in technology tools, there are a myriad of online learning environments that are mediated by experts, peers, mentors, teachers, and so on, to help learners and teachers build and share knowledge through access to specialized expertise and information.
- *Scaffolded Learning:* This term relates to the various forms of support or assistance provided to a learner by an expert or more capable peer that enables the learner to complete a task or solve a problem that would not have been possible without such support. Scaffolding could include hinting, elaborating, guiding, questioning, prompting, probing, simplifying, or other similar learning supports. The goal is to actively engage the learner while providing only the necessary supports for eventual independent use of such strategies.

(Continued)

TABLE 2.4
(Continued)

- *Intersubjectivity:* This concept refers to a temporary shared collective reality among individuals. Conferencing and collaborative technologies can foster such shared space or situational understanding between learning participants that can help them negotiate meaning, design new knowledge, and perceive multiple problem-solving perspectives.
- *Activity Setting as Unit of Analysis:* Sociocultural theorists argue that the proper unit of analysis for research should be the activity or word meaning. Specific circumstances of an event or activity are essential to understanding how people act in their attempt to reach their goals. In effect, because consciousness is a product of society, we should explore the individual-in-social action.
- *Distributed Intelligence in a Learning Community:* Student higher order mental functioning has its roots in social relations. The mind, therefore, is distributed in society, and extends beyond one's skin. Because knowledge is negotiated by members of a community of practice, the classroom should be organized to guide student learning toward membership in a learning community. Participation in such a classroom is no longer didactic or transmissive, but a sophisticated instructional conversation. Though technology is vital here, it is but one resource of a learning community; other resources that should also be utilized include: experts, mentors, peers, curriculum/textbooks, teachers, self-reflection, assessment, parents, and the funds of capital within one's local community.

Note. From Bonk and Kim (1998), Cobb (1994), Duffy and Cunningham (1996), Teles (1993), Wertsch (1991a, 1991b).

of thought and mental functioning (Wertsch, 1991a). One repercussion is that intelligence is no longer viewed as static, but dynamic. Mediational tools and signs could be mathematical symbols, artwork, or diagrams as well as software visualizations, electronic messages, WWW course homepages and student conferences, and other electronically displayed information. The critical point here is that as technology advances to alter cultural tools and institutional settings, the available mediational means that can impact cognitive functioning also change (Wertsch, 1991b). Given the technological changes we have experienced in recent years, there are undoubtedly a myriad of untapped human-learning possibilities from a sociocultural point of view.

Zone of Proximal Development. According to sociocultural theorists, an individual acquires new mental functions and patterns of thought from the mediational assistance of tools, signs, and human scaffolding when it is offered within his or her zone of proximal development (ZPD) (Salomon, 1988; Wertsch, 1991a, 1991b). Vygotsky defined the ZPD as the distance between a child's independent problem-solving level and that obtained under adult guidance or in collaboration with more capable peers (Wertsch, 1985). Wells (1997) cautioned us, however, that a ZPD is formed not just within an individual learner, but in the interaction between the learner, coparticipants, and available tools during involvement in a common activity. ZPDs, therefore, depend on the quality of the total interactive context as well as individual learner capabilities.

A ZPD might be evident in online communities when students teach their peers about their particular region or locale (Harasim, 1993; Riel, 1990, 1993) as well as when the teaching comes directly from a computer tool in the form of thinking-related prompts and feedback mechanisms (Daiute & Dalton, 1988; Zellermayer, Salomon, Globerson, & Givon, 1991). Such computer prompts embed strategies intended to be internalized by the learner (Bonk & Reynolds, 1992). The resulting intellectual benefits from electronic collaboration with peers, teachers, and technology tools may rest, however, on the extent of student reflection and general “mindfulness” (Salomon, 1988) during these learning collaborations and collective knowledge-building experiences (Scardamalia & Bereiter, 1996).

Internalization. Central to the premise of ZPDs, and sociocultural theory itself, is Vygotsky’s suggestion that higher mental functioning is dependent on the process of internalization. From a Vygotskian perspective, electronic social interaction utilizes, extends, and creates ZPDs to foster learner skills and capacities that originally were active only in collaborative or assisted learning situations, but gradually become internalized as independent self-regulatory processes (Bereiter & Scardamalia, 1985; A. L. Brown & Palincsar, 1989). In other words, internalization has occurred when processes first performed with others on a social plane are successfully executed by a learner in an independent learning activity.

But this prompts a key question here. Can we use learning environments rich in electronic social interaction to test Vygotsky’s (1978) axiom that every function in one’s development must appear on an interpsychological or social plane and later intrapsychologically as independent problem-solving skills or strategies? If the answer is yes, just how do individual learners, or learning communities for that matter, come to display this internalization in subsequent independent problem-solving situations, as well as in new socially constituted ones? And how do learners, or sets of learners, within this internalization process, appropriate the new skills and information initially encountered on the social plane for their own unique needs (Rogoff, 1990).

Cognitive Apprenticeship. In asserting that learning is most effective when it approximates real-world situations or problem scenarios, sociocultural research on collaborative technology also draws on insights from cognitive apprenticeship theory (Collins, 1990; Collins, J. S. Brown, & Newman, 1989; Pea, 1993a). As highlighted in the chapter by Sugar and Bonk (chap. 6, this volume), situating students as “legitimate peripheral participants” within an authentic community, apprentices or guides their learning until they can assume a more engaged and central role in that activity (Lave & Wenger, 1991). As mentors negotiate and support novice learners through experiences suitable to their ZPDs, they, in turn, gradually cede control of the task to the student (J. S. Brown et al., 1989). When the learning participants gradually assume greater task responsibility, they begin to internalize standard cultural practices (Rogoff, 1995). Such apprenticing situations and activities do not always imply vertical "teacher-to-student" relationships, however (see Zhu, chap. 10, this volume). Teachers may, in fact, assume colearner or coparticipant role in some of these learning situations, whereas their role in others may center on performance feedback and review. Collins et al. (1989) provided a rationale for at least six teaching methods of these cognitive apprenticeships: (a) modeling, (b) coaching, (c) scaffolding and fading, (d) articulation, (e) reflection, and (f) explorations, which are briefly defined next.

Assisted Learning. Not only is the environment transformed when adopting sociocultural practices, but so, too, is the pedagogical role of the teacher. Clearly, the focus here is on assisting learning, not directing it (Tharp & Gallimore, 1988). According to Tharp (1993), adept sociocultural teaching is responsive in nature; instead of assigning tasks, relying on text readings, and fostering standard practices (e.g., teacher *i*nitiation of a question or comment followed by pupil *r*esponse and teacher *e*valuation; known as the I-R-E recitation script), sociocultural teachers value assisting or supporting the performance of their students. Tharp further argued that there are seven basic ways for teachers to "assist" in the learning process: (a) modeling, (b) feedback, (c) contingency management, (d) instructing, (e) cognitive structuring, (f) questioning, and (g) task structuring. Bonk and Kim (1998) pointed out that merging these seven forms of learning assistance with Collins et al.'s six cognitive apprenticeship techniques, mentioned above, renders the following socioculturally based teaching techniques: (a) *modeling* to illustrate performance standards and verbalize invisible processes, (b) *coaching* to observe and supervise students, thereby guiding them toward expert performance, (c) *scaffolding* and *fading* to support what learners cannot yet do and gradually removing that support as competence is displayed, (d) *questioning* to request a verbal response from learners while supporting them with mental functions they cannot produce alone, (e) encouraging student *articulation* of their reasoning and problem-solving processes, (f) pushing student *exploration* and application of their problem-solving skills, (g) fostering student *reflection* and self-awareness (e.g., through performance replays), (h) providing *cognitive task structuring* by explaining and organizing the task within students' ZPDs, (i) *managing instruction* with performance feedback and positive reinforcement, and (j) using *direct instruction* to provide clarity, needed content, or missing information. When these means of assistance are woven together, the teaching–learning situation evolves into a rich "instructional conversation" (Gallimore & Tharp, 1990, p. 196; Tharp

& Gallimore, 1988, p. 111). By using this instructional framework to imagine rich, interactive conversations among students and teachers and beyond, we are optimistic that CSCL technologies can provide effective learning assistance within learner ZPDs.

Teleapprenticeship. In merging the aforementioned strategies with global networking technologies for "teleapprenticeship" (Teles, 1993), many universities and public schools are exploring CSCL tool features that provide unprecedented student-student social interaction opportunities and momentous cross-cultural activities and events (Harasim, 1990; Levin, Kim, & Riel, 1990; Riel, 1993). Now, online apprenticeships can involve experts and peers demonstrating ideas, posing questions, offering insights, and providing relevant information when needed. Recent breakthroughs in videoconferencing tools showcase such authentic avenues for student and instructor social interaction and dialogue (Fetterman, 1996b). A series of CSCL breakthroughs, in fact, have resulted in fully accredited online PhD programs, which feature electronic file exchange, E-mail office hours, electronic libraries, virtual cafes, whiteboards, debates and opinion polls, role-taking activities, and student dialogue transcripts (Fetterman, 1996a; Harasim, Hiltz, Teles, & Turoff, 1995). Such tools and strategies collectively function to electronically apprentice and assist in student learning.

Another celebrated example of a cognitive apprenticeship is to involve students in genuine scientific data collection and reporting about the weather. Recent projects here include the Collaborative Visualization (CoVis) project (Edelson, Pea, & Gomez, 1996; Pea, 1993a), the GLOBE Program (1995), Kids as Global Scientists (Songer, in press), and the Indiana Weather Project (Bonk, Hay, & Fischler, 1996). Along these same lines, Ruopp et al. (1993) used the Internet to build communities of physics teachers who then apprenticed less skilled learners through a mix of microcomputer laboratory activities and electronic sharing of results with students and teachers at other locales. Similarly, Sugar and Bonk in chapter 6 of this text employed such apprenticeship techniques to enhance the scientific learning possibilities of students in an Arctic expedition learning adventure. In these types of projects, peer and mentor collaborations validate and enhance students' sense of participation in communities of practice.

Scaffolded Instruction. Such cognitive apprenticeships are, of course, inherently reliant on a mentor or guide who effectively uses "scaffolded instruction." In selecting scaffolded instruction, a mentor or guide provides the learner with the support or assistance necessary to complete a task that would not have been completed without the help. Examples of this support might include prompts, hints, comments, explanations, questions, counterexamples, and suggestions. A learning scaffold may be embedded in an explicit request to include additional information or a more general question or comment intended to spur new idea linkages or course connections. Of course, these learning aids are faded and removed as the learner assumes control over the activity. Through such assistance, the learner (or a team of learners) solves a problem, generates solutions, and gains insights that would ordinarily rest beyond his or her independent abilities. In terms of such scaffolded learning activities, collaborative technologies can offer opportunities for both peer and mentor electronic guidance and feedback that stimulate student discussion and internal reflection. As in both the Zhu and the Sugar and Bonk chapters of this volume, electronic experts and learning guides might instigate learning activities through timely messages, questions, and quotes. On the other hand, experts might also provide electronic demonstrations and task assistance.

Such electronic tool support and scaffolded assistance is especially important for young children because the support structure aiding the acquisition of oral communication, which has developed over many thousands of years, is not available for young readers and writers. Until recently, reading and writing were strangely removed forms of communication not necessarily driven by human interaction; they simply involved a mark-making process that *required* explicit awareness of metalinguistic aspects of language (Downing, 1979). Unfortunately, reading and writing literacies do not develop spontaneously from spoken language; they are inaccessible to consciousness without the aid of a literate partner or guide. For young children, this means that, unlike their speech system, when reading or writing, there are no outside others to support and provide feedback on their communicative ability. We argue, therefore, that electronic tools not only might enhance literacy guidance possibilities, but extensive research in this area might inform sociocultural theorists of the types and conditions of effective teacher and mentor guidance and scaffolding.

Intersubjectivity. According to the sociocultural perspective, scaffolded instruction is bound to be more effective when the players of the learning situation experience intersubjectivity. Intersubjectivity refers to a temporary shared collective understanding or common framework among learning participants. As learners find common ground (Rogoff, 1990) or shared thoughts (Levine & Moreland, 1991), they can more easily exchange their ideas, build new knowledge, and negotiate meanings. Not surprisingly, in Michael Schrage's (1990) journeys across the country to find and document collaborative communication tools, he discovered that the most promising ones were those that created a mental "shared space" (e.g., electronic whiteboards, conferencing tools, group brainstorming tools, etc.). As Schrage found, these communication tools promote new forms of social interaction and productivity. In addition to the many apprenticeship possibilities, therefore, electronic conferencing tools open up new avenues for students to take the perspective of peers and better understand their expectations and potential reactions (Bonk, Appelman, & Hay, 1996).

In moving beyond local area networks, global networks and associated curricula bring new audiences to young learners. As the work of Sugar and Bonk (chap. 6, this volume) and Siegel and Kirkley (chap. 13, this volume) points out, there are a wealth of instructional design possibilities and pedagogical strategies for fostering electronic perspective taking. Computer-conferencing and collaboration technologies, for instance, might encourage learners to consider alternative perspectives and viewpoints by providing expert feedback windows, interactive debate forums, juxtapositions of opinions, scrollable dialogue-tracking devices, private reflection notes, peer commenting windows, public text-pointing devices, and interactive prompts available on demand. These are the types of tools that need to be developed and tested to help egocentric or culturally unaware students decenter from their own narrow points of view and engage in extensive dialogue with their peers. Such tools not only bring unique opportunities for enhancing perspective taking and intersubjectivity, but, in fact, provide a glimpse into the entire "activity" of electronic collaboration.

Activity Setting as Unit of Analysis. From a sociocultural perspective, the lifeblood of new intellectual functioning is, in fact, the activity setting. The concept of an activity setting was derived from the sociocultural school of Vygotsky–Leont'ev–Luria in the Soviet Union during the 1930s (see Davydov & Radzikhovskii, 1985). Vygotsky and many of his followers emphasized the mediational role of signs in socially meaningful activity (Kozulin, 1986). As Cole (1985) further pointed out, analysis of human activity in real, not contrived, settings links individuals and social systems and provides insights into both cultural practices and individual higher order thinking. It is from activity settings that one can simultaneously begin to understand groups or individuals, products or processes, and cognitions or cultures. Similarly, Wertsch (1995) proposed using human action as the primary unit of analysis because it helps one understand the sociocultural context as well as the mental functioning of individuals operating within it.

Ideas about activity settings have penetrated psychological research in a variety of domains, including early literacy in the home (Gallimore & Goldenberg, 1993), classroom learning (Chang-Wells & Wells, 1993; Tharp & Gallimore, 1988), after-school computer play environments (Nicolopoulou & Cole, 1993), and even workplace settings such as navy vessels (Hutchins, 1993) and medical practices (Engestrom, 1993). Quotes such as, "the mind rarely works alone" (Pea, 1993b, p. 47) and the mind "can be said to extend beyond the skin" (Wertsch, 1991a, p. 90), indicate that thinking in such settings is distributed. Accordingly, by attempting to understand activity settings, the focus of evaluation has shifted from individual mental functioning to groups of minds in interaction (Hutchins, 1993).

Distributed Intelligence in a Learning Community. Whereas an activity system includes subjects, rules, communities, objects, and divisions of labor (Cole & Engestrom, 1993), it is the tools that mediate the activity and connect humans to objects and other people (Wells, 1996). And, as the research in this book demonstrates, there are a myriad of CSCL tools to create new forms of activity settings for both human–human and human–computer interaction and collaboration. The current generation of collaborative educational learning tools present unique opportunities for supporting and organizing human conversations and creating new communities of learning (Blumenfeld et al., 1996). Because human mental functioning is rooted in social relations and intellectual performance is distributed among members of a learning community, it is critical to begin to understand how electronic tools might enhance the collective intelligence of such a community. What types of electronic tools foster the negotiation of meaning and sophisticated conversations among community participants? How can they be married with other learning resources—experts, mentors, teachers, text resources, and the local community—to foster learning? When sociocultural theory is finally merged with electronic tool development and use, the answers to these questions may arise in rich, instructional conversations (Tharp & Gallimore, 1988) among learning participants wherein new meanings and insights are coconstructed and debated. Certainly that should be the benchmark for this field.

Some Sociocultural "Ifs"

Although the research on collaborative technologies is in a prime position to test and extend sociocultural theory, many questions and issues remain. For instance, if the mind is distributed in society, then the tools for collaboration should offer a unique way to illustrate this in action. But have they? Second, if cultural artifacts and institutions underpin human development, then we need to grasp unique opportunities for human development as new collaborative educational learning tools spring forth and intersect. Instead of simply purchasing the latest CSCL tools and systems, therefore, one must first grasp their utility as scaffolded learning devices. Even the social context of extremely popular instructional techniques, such as using a word processor for collaborative writing, for instance, are only beginning to be documented and better understood (Daiute & Dalton, 1988; Kumpulainen, 1996).

In terms of activity settings, collaborative tools should also offer interesting windows on the negotiation of meaning and learner interaction. If the interaction with experts and more capable peers on a social plane leads to student intellectual growth and new competencies, then we need to create and test electronic situations wherein students represent and share knowledge (Pea, 1994; Vosniadou, 1996). In order to test whether development moves from the external to the internal plane, the activities appearing within collaboration tools must be later seen in students' independent problem-solving acts. And, if speech is a bridge for movement from the external plane to new strategic behaviors, then the dialogue patterns of electronic social interaction as well as any ensuing journal writings and private reflections must be captured and inspected.

Still other sociocultural questions face collaborative learning tool advocates. For instance, if scaffolded instruction is important in moving students from novice to more expertlike behavior, then we need to create situations wherein the cognitive apprenticeship and dialogue possibilities of collaborative tools can be fostered and examined. Pedagogically intriguing electronic apprenticeship tools should allow for various types of learning assistance and social interaction. For instance, explicit displays of shared knowledge should foster greater participant intersubjectivity and perspective taking. In addition, if learning prefaces development as Vygotsky proposed, then effective forms of electronic learning assistance and scaffolding need to be better understood. Finally, this field is in dire need of learning benchmarks, signposts, and standards. How will CSCL researchers and educators really know when they have made an impact on human learning? Certainly, new collaborative problem-solving or problem-finding assessments need to be developed and tested. Perhaps some innovative assessment ideas and approaches can be found in various sections of this text. The ensuing chapters should provide some tentative answers for the questions raised earlier or at least make explicit related issues and dilemmas.

Ending the Search

The appearance on a nearly daily basis of new interactive technologies has sorely taxed the ability of educators to conceptualize and capitalize upon the processes of learning and teaching in this brave new world. Familiar definitions of school, teacher, textbook, subject matter content, and so forth seem increasingly irrelevant in a world where access to information is expanding at explosive rates and where the ability to communicate on a global basis is as simple as pointing and clicking a screen icon. In response, learner-centered, constructivist, and sociocultural models have arisen to place emphasis on guiding and supporting students as they construct their understanding of the cultures and communities of which they are a part (J. S. Brown et al., 1989; Cobb, 1994). In the process of shifting our attention to the knowledge-building and social negotiation activities of a learner in meaningful environments, we recognize the need to anchor learning in real-world or authentic contexts that give it meaning and purpose. Perhaps, even more important, we have come to recognize the significance of collaboration in learning when it provides opportunities to receive a myriad of alternative perspectives, test contrary ideas, and collect new data and insights (Duffy & Cunningham, 1996; Riel, 1993).

This search for learner-centered, constructivist, and sociocultural components of collaborative educational learning tools was in response to the dearth of theoretical grounding related to CSCL tools (Koschmann, 1994). Although our theoretical search indicates that useful components and connections are being made, more knowledge is desperately needed about the relevance, prevalence, and consequence of these innovative learning tools. For pedagogical progress to be made in electronic learning environments, educators must begin to realize that the lockstep factory model of education is out of sync with prevailing views of learning. Today, with the complementary nature of sociocultural theory and collaborative learning tools, learning is viewed as fundamentally social and derived from authentic engagement with others in a community of practice (Kahn, 1993).

Just where we are headed is uncertain given the tremors of change and parallel tension in the nature of learning and schooling in the 1990s. However, this uncertainty has been fostered, at least in part, by the emergence of CSCL tools and their associated learning activities. What is clear is that recent advancements in collaborative tools parallel new developments in psychological theory on human teaching and learning. What is also apparent is that further inroads into the use of collaborative educational learning tools will help educational researchers design more powerful learning environments during the early stages of the next millennium.

In this particular chapter, we have tried to make salient the theoretical viewpoints from which CSCL tools can be evaluated and discussed. Although the theoretical frameworks presented here—learner centered, constructivist, and sociocultural—do overlap, we find most hope for CSCL developments within the latter. And while some perspectives emphasize such critical issues as meaningful learning, developing higher order thinking strategies, and encouraging learners to link new information to old, the social context of learning too often does not play a central enough role in these approaches. In contrast, a sociocultural view on collaborative tools explicitly points to the social origin of higher mental functions, the distributed nature of learning and problem solving, and the importance of technology tools in mediating individual and cultural development. Ongoing developments in CSCL technology, therefore, make possible the embodiments of sociocultural theory not possible in Vygotsky's days. And, correspondingly, continued theoretical development will serve to strengthen the underbelly of effective tool use in both public school and higher education settings. Some of those tool developments and practices are reflected in the remaining chapters of this book. Enjoy.

REFERENCES

Alexander, P. A., & Murphy, P. K. (1994, April). *The research base for APA's learner-centered psychological principles*. Paper presented at the American Educational Research Association annual meeting, New Orleans.

American Psychological Association. (1993). *Learner-centered psychological principles: Guidelines for school reform and restructuring*. Washington, DC: Author and the Mid-continent Regional Educational Laboratory.

American Psychological Association. (1997). *Learner-centered psychological principles: A Framework for School Redesign and Reform* (Online), Available at URL: http://www.apa.org/ed/lcp.html.

Bednar, A., Cunningham, D. J., Duffy, T., & Perry, D. (1995). Theory in practice: How do we link? In G. Anglin (Ed.), *Instructional technology: Past, present, and future* (2nd ed., pp. 100–112). Englewood, CO: Libraries Unlimited.

Bereiter, C., & Scardamalia, M. (1985). Cognitive coping strategies and the problem of "inert knowledge." In J. W. Segal, S. F. Chipman, & R. Glaser (Eds.), *Thinking and learning skills* (Vol. 2, pp. 65–80). Hillsdale, NJ: Lawrence Erlbaum Associates.

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.

Bonk, C. J., Appelman, R., & Hay, K. E. (1996). Electronic conferencing tools for student apprenticeship and perspective taking. *Educational Technology*, *36*(5), 8–18.

Bonk, C. J., Hay, K. E., & Fischler, R. B. (1996). Five key resources for an electronic community of elementary student weather forecasters. *Journal of Computing in Childhood Education*, *7*(1/2), 93–118.

Bonk, C. J., & Kim, K. A. (1998). Extending sociocultural theory to adult learning. In M. C. Smith & T. Pourchot (Ed.), *Adult learning and development: Perspectives from educational psychology* (pp. 67–88). Mahwah, NJ: Lawrence Erlbaum Associates.

Bonk, C. J., Medury, P. V., & Reynolds, T. H. (1994). Cooperative hypermedia: The marriage of collaborative writing and mediated environments. *Computers in the Schools*, *10*(1/2), 79–124.

Bonk, C. J., Oyer, E. J., & Medury, P. V. (1995, April). *Is this the S.C.A.L.E.?: Social constructivism and active learning environments*. Paper presented at the annual convention of the American Educational Research Association, San Francisco.

Bonk, C. J., & Reynolds, T. H. (1992). Early adolescent composing within a generative-evaluative computerized framework. *Computers in Human Behavior*, *8*(1), 39–62.

Brooks, J. G. (1990). Teachers and students: Constructivists forging new connections. *Educational Leadership*, *47*(5), 68–71.

Brown, A. L., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J. C. (1993). Distributed expertise in the classroom. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 188–228). New York: Cambridge University Press.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. Resnick (Ed.), *Cognition and instruction: Issues and agendas* (pp. 393–451). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. (1986). From cognitive to social ergonomics and beyond. In D. Norman & N. Draper (Eds.), *User centered system design: New perspectives on human-computer interaction* (pp. 457–486). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–41.

Chang-Wells, G. M., & Wells, G. (1993). Dynamics of discourse: Literacy and the construction of knowledge. In E. A. Forman, N. Minick, & C. A. Stone (Eds.), *Contexts for learning:*

Sociocultural dynamics in children's development (pp. 58–90). New York: Oxford University Press.

Cobb, P. (1994). Where is mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher*, *23*(7), 13–20.

Cognition and Technology Group at Vanderbilt. (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher*, *19*(6), 2–10.

Cognition and Technology Group at Vanderbilt. (1991). Technology and the design of generative learning environments. *Educational Technology*, *31*(5), 34–40.

Cole, M. (1985). The zone of proximal development: Where culture and cognition create each other. In J. V. Wertsch (Ed.), *Culture, communication, and literacy: Vygotskian perspectives* (pp. 162–179). New York: Cambridge University Press.

Cole, M., & Engestrom, Y. (1993). A cultural approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 1–46). New York: Cambridge University Press.

Collins, A. (1990). Cognitive apprenticeship and instructional technology. In L. Idol & B. F. Jones (Eds.), *Educational values and cognitive instruction: Implications for reform* (pp. 119–136). Hillsdale, NJ: Lawrence Erlbaum Associates.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cunningham, D. J. (1996). Time after time. In W. Spinks (Ed.), *Semiotics 95* (pp. 263–269). New York: Lang Publishing.

Daiute, C., & Dalton, B. (1988). Let's brighten it up a bit: Collaboration and cognition in writing. In B. A. Rafoth & D. L. Rubin (Eds.), *The social construction of written communication* (pp. 249–269). Norwood, NJ: Ablex.

Davydov, V. V., & Radzikhovskii, L. A. (1985). Vygotsky's theory and the activity-oriented approach in psychology. In J. V. Wertsch (Ed.), *Culture, communication, and literacy: Vygotskian perspectives* (pp. 35–65). New York: Cambridge University Press.

Downing, J. (1979). *Reading and reasoning*. London: Chambers.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 170–198). New York: Scholastic.

Duffy, T. M., & Jonassen, D. H. (1991). New implications for instructional technology. *Instructional Technology*, *31*(5), 7–12.

Edelson, D. C., Pea, R. D., & Gomez, L. (1996). Constructivism in the collaboratory. In B. G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 151–164). Englewood Cliffs, NJ: Educational Technology Publications.

Engestrom, Y. (1993). Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In S. Chailklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 64–103). New York: Cambridge University Press.

Ernest, P. (1995). The one and the many. In L. P. Steffe & J. Gale (Ed.), *Constructivism in education* (pp. 459–486). Hillsdale, NJ: Lawrence Erlbaum Associates.

Fetterman, D. M. (1996a). Ethnography in the virtual classroom. *Practicing Anthropologist, 18*(3), 2, 36–39.

Fetterman, D. M. (1996b). Videoconferencing on-line: Enhancing communication over the Internet. *Educational Researcher*, *25*(4), 23–27.

Forman, E. A., Minick, N., & Stone, C. A. (Eds.). (1993). *Contexts for learning: Sociocultural dynamics in children's development*. New York: Oxford University Press.

Gallimore, R., & Goldenberg, C. (1993). Activity settings of early literacy: Home and school factors in children's emergent literacy. In E. A. Forman, N. Minick, & C. A. Stone (Eds.), *Contexts for learning: Sociocultural dynamics in children's development* (pp. 3–16). New York: Oxford University Press.

Gallimore, R., & Tharp, R. (1990). Teaching mind in society: Teaching, schooling, and literate discourse. In L. C. Moll (Ed.), *Vygotsky in education: Instructional implications of sociohistorical psychology* (pp. 175–205). New York: Cambridge University Press.

The GLOBE Program. (1995). *The GLOBE Program*, 744 Jackson Place (Internet World Wide Web Server Address: http://www.globe.gov), Washington, DC, National Oceanic and Atmospheric Administration.

Harasim, L. (1990). Online education: An environment for collaboration and intellectual amplification. In L. Harasim (Ed.), *Online education: Perspectives on a new environment* (pp. 39–64). New York: Praeger.

Harasim, L. M. (1993). Networlds: Networks as a social space. In L. M. Harasim (Ed.), *Global networks* (pp. 15–34). Cambridge, MA: MIT Press.

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

Harris, K. R., & Pressley, M. (1991). The nature of cognitive strategy instruction: Interactive strategy construction. *Exceptional Children*, *57*(5), 392–404.

Hutchins, E. (1993). Learning to navigate. In S. Chailklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 35–63). New York: Cambridge University Press.

Kahn, T. M. (1993). *A learning agenda: Putting people first*. Palo Alto, CA: Institute for Research on Learning.

Koschmann, T. D. (1994). Toward a theory of computer support for collaborative learning. *Journal of the Learning Sciences*, *3*(3), 219–225.

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

Koschmann, T. D., Myers, A. C., Feltovich, P. J., & Barrows, H. S. (1994). Using technology to assist in realizing effective learning and instruction: A principled approach to the use of computers in collaborative learning. *Journal of the Learning Sciences*, *3*(3), 219–225.

Kozulin, A. (1986). The concept of activity in Soviet psychology: Vygotsky; his disciples and critics. *American Psychologist*, *41*(3), 264–274.

Kumpulainen, K. (1996). The nature of peer interaction in the social context created by the use of word processors. *Learning and Instruction*, *6*(3), 243–261.

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

Learner-centered psychological principles revised. (1996). *Newsletter for Educational Psychologists*, *19*(2), 10.

Lehrer, R. (1993). Authors of knowledge: Patterns of hypermedia design. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 197–227). Hillsdale, NJ: Lawrence Erlbaum Associates.

Levin, J., Kim, H., & Riel, M. (1990). Analyzing instructional interactions on electronic messaging networks. In L. Harasim (Ed.), *Online education: Perspectives on a new environment* (pp. 185–213). New York: Praeger.

Levine, J. M., & Moreland, R. L. (1991). Culture and socialization in work groups. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 257–279). Washington, DC: American Psychological Association.

McMahon, H., O'Neill, W., & Cunningham, D. (1992). "Open" software design: A case study. *Educational Technology*, *32*(2), 43–55.

Moll, L. C. (Ed.). (1990). *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*. New York: Cambridge University Press.

Nicolopoulou, A., & Cole, M. (1993). Generation and transmission of shared knowledge in the culture of collaborative learning: The Fifth Dimension, its play-world, and its institutional contexts. In E. A. Forman, N. Minick, & C. A. Stone (Eds.), *Contexts for learning: Sociocultural dynamics in children's development* (pp. 283–314). New York: Oxford University Press.

Palincsar, A. S. (1986). The role of dialogue in providing scaffolded instruction. *Educational Psychologist*, *21*(1 & 2), 73–98.

Pea, R. D. (1993a). The collaborative visualization project. *Communications of the ACM*, *36*(5), 60–63.

Pea, R. D. (1993b). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 47–87). New York: Cambridge University Press.

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

Riel, M. (1990). Cooperative learning across classrooms in electronic learning circles. *Instructional Science*, *19*, 445–466.

Riel, M. (1993). Global education through learning circles. In L. Harasim (Ed.), *Global networks* (pp. 221–236). Cambridge, MA: MIT Press.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Rogoff, B. (1995). Observing sociocultural activity: Participatory appropriation, guided participation, and apprenticeship. In J. V. Wertsch, P. D. Rio, & A. Alvarez (Eds.), *Sociocultural studies of mind* (pp. 139–164). New York: Cambridge University Press.

Ruopp, R., Gal, S., Drayton, B., & Pfister, M. (Eds.). (1993). *LabNet: Toward a community of practice*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Salomon, G. (1988). AI in reverse: Computer tools that turn cognitive. *Journal of Educational Computing Research*, *4*(2), 123–139.

Savery, J. R., & Duffy, T. M. (1996). Problem-based learning: An instructional model and its constructivist framework. In B. G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 135–148). Englewood Cliffs, NJ: Educational Technology Publications.

Scardamalia, M., & Bereiter, C. (1996). Adaptation and understanding: A case for new cultures of schooling. In S. Vosniadou, E. De Corte, R. Glaser, & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 149–163). Mahwah, NJ: Lawrence Erlbaum Associates.

Schoenfeld, A. H. (1988). Mathematics, technology, and higher order thinking. In R. S. Nickerson & P. Z. Zodhiates (Eds.), *Technology in education: Looking toward 2020* (pp. 67–96). Hillsdale, NJ: Lawrence Erlbaum Associates.

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

Scott, T., Cole, M., & Engel, M. (1992). Computers and education: A cultural constructivist perspective. *Review of Educational Research*, *18*, 191–251.

Songer, N. (in press). Can technology bring students closer to science? In K. Tobin & B. Fraser (Eds.), *The international handbook of science education*. Dordrecht, The Netherlands: Kluwer.

Teles, L. (1993). Cognitive apprenticeship on global networks. In L. M. Harasim (Ed.), *Global networks: Computers and international communications* (pp. 271–281). Cambridge, MA: MIT Press.

Tharp, R. (1993). Institutional and social context of educational reform: Practice and reform. In E. A. Forman, N. Minick, & C. A. Stone (Eds.), *Contexts for learning: Sociocultural dynamics in children's development* (pp. 269–282). New York: Oxford University Press.

Tharp, R., & Gallimore, R. (1988). *Rousing minds to life: Teaching, learning, and schooling in a social context*. Cambridge, MA: Cambridge University Press.

United States, Department of Labor, Secretary's Commission on Achieving Necessary Skills. (1991). *What work requires of schools: A SCANS report for America 2000*. Washington, DC: Secretary's Commission on Achieving Necessary Skills.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 3–15). Hillsdale, NJ: Lawrence Erlbaum Associates.

Vosniadou, S. (1996). Learning environments for representational growth and cognitive flexibility. In S. Vosniadou, E. De Corte, R. Glaser, & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 13–23). Mahwah, NJ: Lawrence Erlbaum Associates.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Cambridge, MA: Harvard University Press.

Vygotsky, L. (1986). *Thought and language* (Rev. ed.). Cambridge, MA: MIT Press.

Wagner, E. D., & McCombs, B. L. (1995). Learner-centered psychological principles in practice: Designs for distance education. *Educational Technology*, *35*(2), 32–35.

Wells, G. (1996). Using the tool-kit of discourse in the activity of learning and teaching. *Mind, Culture, and Activity: An International Journal*, *3*(2), 74–101.

Wells, G. (1997). *The zone of proximal development and its implications for learning and teaching*. Available at: http://www.iose.utoronto.ca/~gwells/zpd.discussion.txt

Wells, G., & Chang-Wells, G. L. (1992). *Constructing knowledge together: Classrooms as centers of inquiry and literacy*. Portsmouth, NH: Heinemann.

Wertsch, J. V. (1985). *Vygotsky and the social formation of the mind*. Cambridge, MA: Harvard University Press.

Wertsch, J. V. (1991a). A sociocultural approach to socially shared cognition. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 85–100). Washington, DC: American Psychological Association.

Wertsch, J. V. (1991b). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Wertsch, J. V. (1995). The need for action in sociocultural research. In J. V. Wertsch, P. Del Rio, & A. Alvarez (Eds.), *Sociocultural studies of mind* (pp. 56–74). New York: Cambridge University Press.

Zellermayer, M., Salomon, G., Globerson, T., & Givon, H. (1991). Enhancing writing-related metacognitions through a computerized writing partner. *American Educational Research Journal*, *28*, 373–391.