

Theories of CSCL

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Abstract

With its focus on collaborative learning as cognition at the small-group unit of analysis, CSCL raises theory questions concerning the interrelationships among individual, collective and cultural cognition. It simultaneously offers access to empirical investigation of these matters through its computer support—which both fosters collaboratively creative learning processes and captures interaction data that occurs during collaboration, making visible the cognition involved. Theoretical insights arising through such CSCL research can, in turn, suggest ways of enhancing and supporting cognition by individuals, groups and communities, as well as testing interventions that explore the impact of collaborative-learning processes using methods of CSCL analysis. The contrast between CSCL environments and social media apps points to future support for the adoption in classrooms of computer-supported collaborative learning that exceeds the transfer of personal opinions and promotes knowledge-building efforts that surpass the ability of individual minds.

Keywords

Actor-network theory, agency, cultural-historical, dialogism, epistemic mediation, ethnomethodology, group cognition, group practice, inter-objectivity, intersubjectivity, instrumental genesis, knowledge artifact, knowledge building, knowledge construction, orchestration, practices, sequentiality, social media, socio-cognitive, socio-cultural, triologic knowledge.

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Definitions & Scope: Theory of Theories (995)

Theories of CSCL are important because they can help to define what is unique about CSCL and to counter misunderstandings about the nature and aims of CSCL as an evolving research field. In particular, this chapter’s discussion of theories of CSCL is based on the following characterizations of CSCL:

- CSCL is a *vision* of what collaborative learning could be like in the future, thanks to the design of innovative computational supports and the development of new ways of thinking about knowledge (epistemology), thought (cognition) and (collaborative) learning—largely influenced by contemporary theories of CSCL. That is, CSCL is not simply a study of the use of existing technologies in traditional educational settings, as analyzed by popular methods and theories.
- CSCL needs to study collaborative learning on *multiple levels of description*, especially at the individual, small group and classroom/community/cultural/societal units of analysis. It must understand the interactions and mutual influences among these different levels.
- CSCL poses a contrast and *alternative to popular social media*. Whereas social media have been designed to support and encourage simplistic exchange of opinions among individuals, CSCL technology is intended to support complex collaborative-knowledge construction that exceeds the limitations of individual unaided minds.
- CSCL requires a theoretical foundation that incorporates *twenty-first century conceptualizations* that exceed traditional philosophical perspectives underlying commonsense assumptions. The new theories have implications for CSCL analytic methodology, as well as for the understanding of learning and the design of supportive technologies.

Given these characterizations of CSCL, what kind of theory is appropriate and useful for understanding and pursuing CSCL? The theory of science has morphed considerably in recent decades from former positivist conceptions of theory and of science (see, i.e., Latour & Woolgar, 1979). Today, the theory of CSCL is a controversial moving target, not an established canon of universally accepted principles.

The title, “Theories of CSCL,” is rife with ambiguities and alternative interpretations. The expression’s first word, “theory,” is perhaps the most open to a multiplicity of meanings. Some conceptions of theory are systems of rules or principles that claim *a priori* status: they define a field and determine the tools and methods of research, as well as the definition of facts and the nature of explanations. Other approaches derive theory out of findings and experiences of research, for instance, articulating conceptualizations that

seem central to the field, and perhaps continuously refining these concepts based on research observations and discoveries. Still others view theory as a guiding light, illuminating possible directions for exploration. Within the field of CSCL, a number of theories have been prominent during the past 25 years. The most frequently espoused theories are generally built upon historically dominant philosophies, such as rationalism, empiricism, pragmatism or materialism. These philosophical foundations may be explicit or assumed. In some cases, contemporary theories are defined through critique of these traditions. In other cases, new theories have developed in CSCL as a result of observations or findings of on-going CSCL research.

Differences of approach to theory determine what a theory “of” CSCL would be. The CSCL research field is multidisciplinary, and participants bring with them various theories from cognate fields. This has resulted in a confusing variety of theories influential within CSCL research. For instance, the most common theories in the background of empirical CSCL studies identified in recent content meta-analyses (e.g., Akkerman et al., 2007; Jeong & Hmelo-Silver, 2016; Jeong, Hmelo-Silver & Yu, 2014; Kienle & Wessner, 2006; Lonchamp, 2012; Schwarz & Wise, 2017; Tang, Tsai & Lin, 2014) were constructivist, socio-cultural, social-psychological and information-processing frameworks. It is not clear what specific theories correspond to these vague classifications, which are often based on author self-identification. Difficulties in comprehensively characterizing CSCL theories reflect the complexity of the evolving field, where different research questions require different kinds of investigation. Meta-analyses tend to privilege certain kinds of research methods, ignore theoretical papers, obscure important distinctions through aggregation, and accentuate conventional approaches over innovative ones. In response, one could try to organize a conceptual or historical spectrum along which to organize these choices (see Stahl, 2019, Investigation 15); or one could unify them into an overarching theory; or else one could develop a new theory that describes core phenomena of CSCL, such as collaboration, knowledge building and technological mediation (see below).

Then there is the question of just what “CSCL” is. Some treat it as simply a form of educational technology, where students communicate over networked devices, possibly enhanced through some AI application. CSCL can involve learning “through” or “around” CSCL technology (Lehtinen et al., 1999). The former involves CSCL environments mediating learners’ synchronous or asynchronous interaction, whereas the latter engages learners interacting and co-creating around digital devices. Technological development is, however, blurring boundaries of such activities, as all knowledge work increasingly involves computers. Others define CSCL in distinction to “cooperative” learning, where tasks are divided among students in a group working on a task, whereas collaborative learning involves pursuit of shared epistemic objects (Knorr Cetina, 2001) that learners seek to understand together. CSCL is also contrasted with CSCW, where adults collaborate on their work using computer support. Still others focus on the intersubjective or “inter-objective” aspect (Latour, 1996), in which multiple people learn as a group by building joint meaning or constructing shared artifacts within technologically rich contexts. CSCL is part of a trans-disciplinary learning science (Sawyer, 2014), where researchers were trained in specific fields—such as education, design, psychology, computer science, anthropology or linguistics—and brought with them theories, methodology and philosophies of science from these quite different enterprises.

This chapter will review the changing role of theory in CSCL, the major theories that are currently influential in the field, as well as their methodological underpinnings. A central question—much discussed among researchers—is whether the various theories are incommensurate or whether they can be united in a single theory of CSCL. The chapter will suggest an approach to a more unified approach, driven by findings of CSCL as well as trends in cognate research fields and transformations in the world at large.

History & Development: Interdependence of Theory and Method (1190)

Shifts in theory both influenced and responded to changes in the research practices, analysis methods and focal concerns of CSCL research. The theories influence how researchers define their object of study, how they investigate it and how they interpret their findings. Much theory in CSCL comes from scientific approaches in psychology—cognitive, educational and social psychology—and contributes assumptions and research methods for CSCL. Although the pioneering contributions of psychologist Brown (1992) highlighted the importance of pursuing field studies in actual classrooms, the psychological sciences generally prioritize controlled laboratory experiments and statistical measures of collected data.

During recent decades, the traditional approaches from psychology have been critiqued, complemented, expanded and partially replaced by approaches that emphasize materially and socially distributed aspects of thinking and learning. Such development has been critical for the development of CSCL, given its connection to the technological and social mediation of learning. One way to understand the history of psychological theories is as a sequence from positivism and behaviorism to cognitivism and then to socio-cultural theory—or from individual cognition to situated, distributed, group and social cognition. Epistemologically, this represents a move away from focusing on the observable behavior of the individual student or from viewing that behavior as an expression of mental representations manipulated by a rational mind. Controlled experiments to measure increased learning outcomes by manipulation of independent variables derived from cognitive psychology have been either complemented or replaced with in-depth case studies or longitudinal ethnographies, without which emerging CSCL practices could not have been understood, explained or deliberately fostered.

The developing recognition of the complexity of learning in CSCL settings necessitates extending the theory and bringing in conceptualizations and methods from related fields. As theories developed within CSCL, they increasingly invoked and adapted methods from social sciences, like linguistics or anthropology. The resulting participatory approaches to cognition address thinking and learning as involving people situated in dialog with others, within a world of language, artifacts and culture. Such contextual CSCL studies often use interaction analysis or design-based research to understand and explore how groups of students interact using technological artifacts and systems. Finally, enactive theories of cognition conceptualize the learner as embodied in an active, physical body with needs, emotions, perspectives and motivations (Stewart et al., 2010). Especially in CSCL, the primary actor, cognitive agent or collaborative learner may be seen as the small group itself (Stahl, 2006). Collaborative learning can be studied at various interdependent units of analysis—such as linguistic moves and embodied actions (e.g., gesturing, sketching and prototyping)—and at different levels of social organization—such as an individual person, team, classroom, community or culture.

Surveys of methodological practices of CSCL reflect on how theoretical frameworks affect the analysis methods of investigators. However, there is also an opposite influence by which the chosen methods provide access to specific kinds of data and empirical phenomena, in turn inspiring the refinement of CSCL theory. Hence, theories and methods of CSCL are interdependent. In human sciences, method can create the very phenomena (research objects) of investigation. The instruments used by researchers play an important role in shaping theories of social sciences. Such a “tools-to-theories heuristic” (Gigerenzer, 1994) appears to be particularly suitable for examining theories of CSCL. As Hoppe (2007, p. 5) argued, CSCL is a research field that, to a significant extent, creates its own research objects. In the development of the field of CSCL, interventions with discussion forums gave rise to theories of computer-mediated communication; the use of video games resulted in micro-analytic studies of small-group cognition; and studies of collaborative environments, such as Knowledge Forum, shaped knowledge-building theories. The recent emergence of digital fabrication technology and educational maker spaces expand the scope of

CSCL epistemologically, theoretically and methodologically to centrally involve the role of materially embodied artifacts in collaboration.

CSCL studies rely on complementary bodies of thick, thin and rich big data (c.f., Hillman & Säljö, 2016). The foundation of CSCL studies involves collecting *thick data* (i.e., interpreted, humanly understood, meaningful data) of technology-mediated collaborative activities through ethnographic and participant observations, interviews and document analyses of design experiments. Such data is needed for understanding, examining and further refining learners' and teachers' socio-digital epistemic practices. Thick data is provided by interventions and triangulation across many data sources. Further, CSCL studies may also utilize *thin data* (i.e., self-report response data) that enables tracing learning, motivation and socio-digital activity retrospectively or in real time (i.e., sampling experiences, analyzing log files). Social networking questionnaires can collect relational attributes as well as attributes of individuals, so that thin data may address collaborative phenomena. Although thin self-report data tends to be non-contextual, it may be needed for showing the actual impact of interventions. In addition, technology now provides convenient instruments and methods for collecting *rich big data* for tracing and analyzing contextual digitally mediated learning activities and processes; such data can be interpreted in connection with thick-process data and thin self-report data. From the perspective of CSCL, the development of procedures for tracing social-learning processes (Buckingham Shum & Ferguson, 2011), 21st century skills (Buckingham Shum & Crick, 2016) and epistemic networks in the background of knowledge-creation processes (Chen & Zhang, 2016) appear crucial. The development of mobile and wireless technologies and associated development of learning analytics enable multi-level tracing of personal and social learning processes across time and space.

It follows that the traditional opposition between quantitative and qualitative does not hold for CSCL. Investigators may answer certain research questions by quantifying processes and outcomes of groups, possibly across longitudinal sequences, and using statistical correlations or multi-level analysis (Cress, 2008) for measuring effects at the individual, small-group and classroom levels. Alternatively, one can analyze the group's discursive interaction (Jordan & Henderson, 1995), requiring qualitative understanding of meaning-making communication. Such investigation could involve using quantitative measures for tracing participant intensity or use social network analysis for determining the epistemic centrality of group members. One could use quantitative methods at one unit of analysis (e.g., individual) and qualitative at another (e.g., social aspects of activity)—and then identify links between the levels, perhaps through interaction at the group level.

The field of CSCL has significantly advanced through interdependent theoretical and methodological advances. As a result of the development of theory and methodology in recent decades, there is now a growing recognition that human cognition takes place on multiple, interdependent levels, and that research methods should include approaches at the individual, small group, community and network units of analysis. Although design-based and interventionist approaches appear to dominate CSCL, it is also important to continue pursuing controlled experiments for examining the educational impact of well-defined and -understood aspects of technology-mediated learning. A central open question involves how to unify the theory and methodology of the field of CSCL by understanding how the different levels interact. How is cognition at the individual, small group, community and network levels of description derived from each other and how do they influence each other? This must be a central concern of theories of CSCL today.

State of the Art: Diversity of Theories

Traditional Oppositions (618)

Given the large number of different theories used within CSCL research, it is common to collect them into opposed views, such as socio-cognitive vs. socio-cultural. An alternative approach to considering the diversity of theories is to try to find a common thread, with each theory making a unique, constructive contribution to that central theme. For instance, one could argue that what is central to CSCL is its focus on collaboration. That is what distinguishes it from other forms of learning, cognition and education. The distinction between socio-cognitive and socio-cultural can also be seen as relative to analysis centered on the collaborating group unit. Socio-cognitive theory focuses on the individual mind—admitting that student learning is influenced by the social context but measuring the effects of participation in the group on the individual members as psychological subjects. Socio-cultural theory is more oriented to the social, community and cultural levels of analysis. It is concerned with analyzing and cultivating the social practices on which learning is embedded and the social institutions that structure learning activity. The collaborative group then stands in the middle, between the individuals who participate in the group and the community or larger network whose practices the group adopts and adapts as it learns. One can also focus on the group itself as the unit of analysis. As collaborative learning takes place by the group, it can have consequences at the other levels, leading to learning outcomes for the individuals or transformation of social structures.

One can understand the array of theories as evolving through a series of historical developments. The history of Western philosophy from the early Greeks to the present provides many of our now commonsensical assumptions about scientific method (Stahl, 2019, Investigation 15). Empiricism, for instance, culminated in positivism and its view of objective knowledge. Rationalism assumed that all cognition took place in individual minds, which used propositions in the head to represent facts in the world and to derive knowledge. In psychology, behaviorism limited science to empirical study of a subject's externally observable behavior. That was challenged by cognitivism, which argued that learning and knowledge required mediation by the mind, for instance using language and rational deduction (Chomsky, 1959). This led to the computational theory of mind that characterized early stages of cognitive science. The early efforts of developing AI relied on this computer metaphor of encapsulated mind with internal models, representations, processing units, memory storage and information processing (Gardner, 1985).

Constructivism and social constructivism followed (Packer & Goicoechea, 2000). They accepted Kant's (1787) philosophical insight that the human mind structures all knowledge of the world. Educationally, this implies that students should be guided to make sense of new information in terms of their own understandings (past knowledge, personal perspective, existing conceptualizations, motivations). While this had radical consequences for educational theory, it still focused on the individual as learner. The resulting "constructivist" theories tended to be uninformative (everything can be seen as in some vague sense constructed). Alternative socio-historically motivated theories then developed based on the dynamic, historical, social philosophy of Hegel (1807) and Marx (1867/1976), which shaped Vygotsky's, Bakhtin's and other investigators' theories of the social mind. The social theories of mind also built on the pioneering work of such pragmatists as Baldwin, Janet, Mead and Dewey (Valsiner & van der Veer, 2000). From the perspective of the emerging socio-cultural framework, cognitive development and learning are seen as results of dialectics between personal activity, group interactions, social practices and cognitive-cultural macro-structures. This can be viewed as a watershed transformation from individualism to recognition of the group and social community as pivotal to learning, opening the way for CSCL as an educational practice.

Development and Learning in Vygotsky (788)

Vygotsky (1930/1978) developed an approach to educational psychology appropriate to the philosophical methods of Hegel and Marx. His writings point beyond individual psychology to a recognition of group and social cognition. Thereby, they offer an important starting point for CSCL theory.

Vygotsky distinguishes a child's cultural "development" from the child's individual "learning." A central principle of his theory is that development occurs first through mediated inter-subjective interaction in dyads or small groups, paving the way for possible subsequent individual learning or individual cognitive growth through complex and extended transformations:

Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (*inter-psychological*), and then *inside* the child (*intra-psychological*). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher [human mental] functions originate as actual relations [interactions] between human individuals. (Vygotsky, 1930/1978, p. 57)

Given this, collaborative learning as the source of cognitive development may be considered not just an optional and rare mode of instruction, but rather a basis of all human learning. Group cognition is seen as a foundation of human cognition (planning, problem solving, deduction, storytelling, etc.) at all levels. Vygotsky's experiments illustrate ways in which group cognition forms a foundation for individual cognition. By incorporating language, external symbols and other cultural artifacts, this process also connects the cultural and community level to the small group and individual levels.

The gap between cultural development and individual learning is what Vygotsky calls the "zone of proximal development" (ZpD). This includes what a child will next be able to learn. It is a prime arena for CSCL intervention, because students in this zone can learn collaboratively what they cannot yet learn by themselves. In Vygotsky's well known discussion of the ZpD, he cites a study in which children "could do only under guidance, in collaboration and in groups at the age of three-to-five years what they could do independently when they reached the age of five-to-seven years" (1930/1978, pp. 86f). CSCL can be seen precisely as such an effort to stimulate students within their ZpD—on tasks they cannot yet master individually but are close to being ready to learn—under guidance, in collaboration and in groups. If the desired results of this do not show up as learning outcomes measurable in individuals (outside of their group context) for several years, then the key effect will be systematically missed by traditional methods of testing individuals.

In his "Problems of Method," Vygotsky (1930/1978, pp. 58-75) called for a new paradigm of educational research almost a century ago. Arguing that one cannot simply look at visible post-test results of an experiment, he proposed a method of "double stimulation" where a child is confronted by both an object to work on and an artifact to mediate that work. Vygotsky does not call for a controlled experiment that compares learning outcomes with and without the furnished artifact. "The experiment is equally valid," he points out, "if, instead of giving the children artificial means, the experimenter waits until they spontaneously apply some new auxiliary method or symbol that they then incorporate into their operations." Taking this approach in a collaborative setting requires an attention to the children's interaction and the sense making that is involved in creative, unanticipated collaborative accomplishments. The essence of Vygotsky's method of double stimulation is the CSCL practice of engaging learners themselves in co-creating artifacts for transforming problem situations and re-mediating their learning processes. Moreover, the method of double stimulation can be expanded to consider extended processes of knowledge creation (see Ritella & Hakkarainen, 2012; Paavola & Hakkarainen chapter in this volume). It involves understanding the unique trajectories of different *groups*, which cannot be statistically aggregated or sorted into standardized categories. This suggests the need to analyze interaction at the group level, rather than just the individual as the cognitive subject. It also

highlights the critical role of artifacts (including symbols and language), as arising in shared group interaction.

Furthermore, the key role of mediation of group cognition by artifacts—as stimulants to working on a primary learning object—suggests the importance of computer supports in CSCL. CSCL environments can be designed with a wide variety of artifacts (scripts, models, manipulatives, graphics, prompts, etc.) to stimulate collaborative learning. Vygotsky’s brief career began in the context of stimulus/response behaviorism. Through critiquing with a dynamic lens the theories of learning that were then popular, Vygotsky managed to sketch a vision of the ties between individual, group and community (social, cultural) cognition that CSCL researchers can elaborate. There have been a number of significant advances in theory since Vygotsky, although most of them focus on a single level, rather than on the interactions among levels.

Recent Theories Influencing CSCL (1653)

Socio-cognitive research on CSCL

Many investigators examine well-understood aspects of CSCL by relying on socio-cognitive theories of CSCL, which build on conceptions of individual learning, cognition and motivation from cognitive, educational and social psychology. Socio-cognitive studies aim at examining (a) how collaborative learning affects advancement of individual learning and (b) how manipulations of controlled independent variables affect the success of students’ collaborative learning. Socio-cognitive research may focus on cognitive and motivational gains of personal and collaborative learning. It may, for instance, measure self-regulation, co-regulation or shared regulation of learning, or the impact of various scripting strategies on collaborative-learning processes and outcomes. Although many socio-cognitive studies rely on rigorous experimental and quasi-experimental designs, hypothesis testing, quantitative methods and pre/post-test designs, others use mixed methods and collect data from field studies. Rigorous methodological standards of these approaches assist the field as a whole to uphold the quality of investigations and standards of evidence as defined in psychology.

Ethnomethodology

Ethnomethodology contrasts with socio-cognitive approaches in that it does not seek to analyze psychological processes in the minds of individuals, but studies social, interactional and linguistic practices that can be observed directly, for instance in detailed transcripts of conversation. Garfinkel (1967) argued that human behavior is largely based on the adoption of social practices or “member methods” shared by members of a given culture. It is because everyone is familiar with these practices that people can make sense of each other’s behavior. Furthermore, people display in their behavior how their actions should be understood (Garfinkel & Sacks, 1970; Sacks, 1965/1995). Sacks studied this in transcripts of ordinary conversation, founding Conversation Analysis. He and his colleagues showed how people design their speech to open and close new topics, to respond to each other, to repair misunderstandings, etc.

Dialogism

Bakhtin’s (1981) theory has affected CSCL research by guiding investigators in analyzing dialogic interaction processes (Wegerif, 2007). The aim of the dialogic approach is to engage students in sustained interaction that enables learners to explore and build on their own and peers’ ideas. From the perspective of Bakhtin’s theory, thinking and meaning making are dialogic in nature: “the word in language is half

someone else's." This implies that a person's utterance in conversation or writing or even thinking is not simply an expression of some individual mental representation that is strictly that person's private belief, but that it is an interactive response to an interactional context involving other people. Often, specific words that someone else used are literally repeated and taken up in the new utterance. Spoken and written statements are generally responses to on-going communications and are designed to evoke future responses. Furthermore, speech incorporates countless standard elocutions that are part of a particular literary genre and language. Accordingly, utterances should be analyzed and understood as dialogical moves within a social setting, not just as personal expressions.

Bakhtin's theory has also inspired investigations of chronotopes, i.e., temporal and spatial implications of CSCL (Ritella & Hakkarainen, 2012). The temporal structure of activity is transformed by changing participants' intangible ideas to shared epistemic artifacts and, thereby, bringing results of past inquiries to the present. The spatial transformation involves (a) sharing inquiries regardless of location and making remote knowledge resources immediately accessible, and (b) interacting with qualitatively different semiotic spaces organized in multiple ways. Following Bakhtin, these spatial and temporal processes may be fused to create a novel chronotope of technology-mediated collaborative learning.

Knowledge Building

Pioneering work of Scardamalia and Bereiter (1993) created a knowledge-building framework that engages young students in the collaborative pursuit of knowledge advancement. Their groupware system for mediating knowledge-building processes evolved into Knowledge Forum. They consider knowledge building to be a collaborative effort of advancing communal knowledge, and, thereby, separate it from individual learning. Bereiter and Scardamalia proposed that schools could be developed into "knowledge-building" communities that elicit expert-like creative working with knowledge. Such communities are engaged in creating, sharing and advancing students' ideas understood as improvable epistemic artifacts. The knowledge-building framework has been developed in close collaboration with teachers committed to implementing Scardamalia's (2002) principles in practice.

Knowledge-Creating Learning

Paavola and Hakkarainen (2014) developed their knowledge-creating learning framework for expanding the conceptually oriented knowledge-building theory by also taking into consideration materially embodied aspects of artifacts (see Paavola & Hakkarainen chapter in this volume). Knowledge-creating learning is distinguished both from the knowledge-acquisition metaphor and the participation approach (Sfard, 1998). While the acquisition view represents a "monological" (subjective, mental) view on human learning and the participation view represents a "dialogical" (intersubjective) view, the knowledge-creation perspective may be understood as "trialogical" in nature because of its foregrounding interaction between individuals, communities *and shared epistemic objects being developed*. Knowledge creation is anchored on deliberately cultivated knowledge-laden social practices of working with knowledge artifacts and media, i.e., knowledge environments and practices (Hakkarainen, 2009).

Cultural-Historical Activity Theory

Relying on Cultural Historical Activity Theory (CHAT) developed by Vygotsky's colleagues, Engeström (1987) investigated CSCL from the perspective of expansive learning. CHAT guides researchers to examine CSCL as an integral part of the contradiction-laden historical development of educational activity, calling for profound transformation of social practices prevailing at school as well as renegotiation of relations between schools and the surrounding community. Social practices are anchored in dynamic activity systems, which have to be transformed to make significant changes happen. Analysis

of activity systems is focused on the object-oriented character of human activity, tool mediation and contradictions emerging between system elements. A collective activity has its own motive under which individual actions are subsumed and which they serve according to the division of labor and communal rules. Expansive learning starts by criticizing, questioning and analyzing contradictions arising within the system or its external relations. Rather than examining school learning as an isolated sphere of human activity, CHAT addresses historically changing relations between educational and other activities students take part in. Investigations promote community development through solving real-world problems in hybrid activities with local representatives of productive work (Engeström, Engeström & Suntuio, 2002; Roth & Lee, 2007).

Actor-Network Theory

Actor-Network Theory (ANT) (Law, 1999; Latour, 2005) builds on science and technology studies showing how complex human activity relies on heterogeneous networks of people, artifacts and practices. Such networks diverge from CHAT activity systems in terms of having actors from completely diverse social communities and institutions exerting causal influences. This framework is characterized by “inter-objectivity” (Latour, 1996) in terms of treating humans and artifacts symmetrically, and highlighting the active role of the diverse actors in the contexts examined. ANT has been applied more often in CSCW and workplace situations than in educational or CSCL contexts, but appears to have potential there as well (Fenwick & Edwards, 2010). ANT guides the examination of social engineering, such as the building of coalitions, which is needed for making educational transformation. The stakeholders—such as researchers, technology developers, educational administrators, teachers and students—are likely to have conflicting interests that successful projects temporally align within contexts mediated by educational and technological artifacts.

ANT conceptualizes the dynamic dual role of CSCL artifacts as agents that oscillate between structuring and constraining as well as directing and expanding activity. Social and material agency is entangled in CSCL experiments. Currently, learning takes place in increasingly complex socio-technological environments, which integrate local socio-material practices with virtual and distributed activities shaped by rapidly developing digital instruments and methods.

Group Cognition and Adopting Group Practices

The theory of group cognition grew out of CSCL research, primarily associated with the Virtual Math Teams project, as documented in a series of books (see Stahl, 2019, Introduction). It focuses directly on the small-group unit of analysis, as the level at which social and cultural phenomena and artifacts influence the interaction, which, in turn, influences individual learning. It uses a variation on Conversation Analysis—adapted to the online, educational, small-group context—to analyze discourse automatically captured in transcripts. It is primarily concerned with the building of knowledge and epistemic artifacts through the artifact-mediated dialogic processes of group interaction. The theory elaborates concepts of cognition, knowledge, interaction, sequentiality, intersubjectivity, shared understanding, artifact mediation, practice, agency and joint attention appropriate to the small-group level of description.

The interpenetration of the social, group and individual cognitive levels can be observed, analyzed and studied in processes involving the adoption of group practices (Stahl, 2019, Investigation 16). One can identify this adoption process taking place repeatedly in adequate transcripts of successful CSCL sessions. Typically, a social practice will be introduced into the group interaction. For instance, an instructional task in a geometry class might introduce a theorem or a construction step from Euclid. The group of students will discuss this, experiment with it and try to make sense of it for themselves as a group. Then they may agree—either explicitly or by incorporating it into their behavior—to accept it in

some form as a group practice shared by their group. The practice will likely show up in subsequent group interaction, but now as a tacit practice, which does not require discussion but has been learned by the group. The group practice may, moreover, be adopted by some of the group members as a personal practice, contributing to their individual learning. (See “Analyzing Group Practices” in this volume.)

The design of CSCL technology and of educational interventions can be conceived and refined in relation to the analysis of the adoption of group practices. An academic subject like geometry can be characterized in terms of a large set of practices (e.g., for interpreting, constructing and discussing geometric figures). A CSCL environment can support the presentation, exploration and adoption of these practices by collaborative small groups. Analysis of group interaction can reveal successes and barriers to adoption of such practices and point to needed improvements as well as documenting successful learning at group and individual levels.

The Future: Toward a Theory of CSCL

Elements of a Theory of CSCL (1235)

Discourse and Interaction

Collaborative learning generally proceeds through discussion within a group of learners. The group learns by building knowledge in the group discourse and by interacting in non-verbal ways within the CSCL environment (e.g., highlighting, drawing, altering models, making moves in games). Analysis of collaborative interaction usually involves investigating transcripts of the discourse and interaction that took place. This may consist of coding individual utterances and conducting statistical analysis of the results. It may also consist of understanding the flow of conversational moves or the meaning making that took place by the group, perhaps using a version of conversation analysis or interaction analysis (Henderson).

Mediation by CSCL Environments

CSCL provides multi-faceted socio-technical environments that mediate personal and collaborative interaction and learning in multi-faceted ways. Collaboration “through” CSCL involves mediated synchronous or asynchronous interaction. The former involves mediated interaction of face-to-face community and the latter interaction of physically distributed community. The rapidly evolving ecology of wireless and mobile socio-digital technologies is distributed across formal and informal spaces of learning so that technology mediation is increasingly mashed up to take place through as well as “around” CSCL tools and social media apps.

Epistemic Mediation by Knowledge Artifacts

CSCL environments provide learning communities shared spaces and scaffolding for creating, building, visualizing, organizing, sharing and advancing knowledge. CSCL environments provide External Memory Fields (Donald, 1991) for production of knowledge, and enable collaborative working and refining of complex ideas. By “epistemic mediation” we refer to a deliberate process of deepening inquiry by creating external epistemic artifacts (e.g., shared written notes, visual representations, material artifacts) that crystallize and promote evolving understanding, or provide stepping stones for directing and guiding further personal or collective inquiry efforts. Problems and solutions being refined in CSCL processes can be understood as epistemic objects (artifacts); such objects represent what the participants

are seeking to understand and create but do not yet know or understand at the beginning of the inquiry process. Such objects are defined by their incompleteness and their capacity to unfold indefinitely through successive imperfect but affect-laden instantiations as text, visual models, prototypes and other artifacts (Knorr Cetina, 2001).

Temporality and Sequentiality

Learning takes place over time and through language. Interaction takes place through the sequential ordering of utterances and gestures. A given utterance typically responds to previous discourse, often using pronouns to reference immediately preceding or earlier topics and events. It (the previous utterance) also generally is designed to provoke a response and to create an opportunity in the discourse for a specific range of responses. The analysis of collaborative learning as a group meaning-making process may need to interpret the temporality and sequentiality of captured discourse. Of course, research questions involving testing specific hypotheses concerning individual learning that took place in a collaborative setting can proceed at the unit of individual utterances, ignoring their sequential ties.

Intersubjectivity and Shared Understanding

Perhaps the most fundamental theoretical or philosophical question for CSCL is that of intersubjectivity: How is it possible (both in the abstract and in practical terms) for participants in a group to understand each other? If one person's mind expresses a thought in a spoken utterance, how can another person's mind know what that utterance meant to the speaker? A socio-cultural theory might answer this by claiming that both people share a meaningful language (with its extensive set of understood linguistic practices). Furthermore, the spoken utterance occurred within a world (possibly including previous utterances, a CSCL environment, a classroom setting and the wider physical and historical world) that is shared by everyone in the group. Of course, in a situation of collaborative learning there are ample opportunities for misunderstanding each other. Fortunately, our languages include shared practices for dealing with misunderstandings. Intersubjectivity is the result of human interaction, beginning in prehistory (Tomasello) and continuing in every successful CSCL session (Schneider & Pea).

Personal, Distributed and Group Agency and Units of Analysis

Theories based on individual minds locate the agency that causes events like expressing opinions or learning at the individual unit of analysis, looking to personal motivations and beliefs. Theories of distributed cognition (e.g., Hutchins) or group cognition locate collaborative agency at the group unit. CHAT looks as well at tensions or contradictions among social factors in the setting and ANT goes further to bestow agency on an open-ended universe of (past and present) human and artifactual actors, bringing in a cultural-historical unit of analysis.

Pedagogy of CSCL: Open-ended and Nonlinear Knowledge-Creation Projects

Bransford (xxxx) distinguishes linear and nonlinear pedagogy. Traditional educational practices are characterized by "linear" pedagogy, which involves highly scripted, closed and repeated educational practices. Such linear practices tend to reduce the complexity of epistemic objects and lead to an emphasis on task completion rather than idea improvement (Ng & Bereiter, 1995) and to student reproduction of pre-given textbook knowledge. CSCL and other progressive educational programs aim, in contrast, at cultivating "nonlinear" pedagogy that is characterized by open-ended, emergent and inventive educational practices. Such practices expand epistemic objects, encourage inquiry and emphasize refining knowledge from diverse sources. This requires building of knowledge through intensive discourse. Genuine collaborative pursuit of novelty is an emergent and nonlinear process where the actual goals,

objects, stages, tools and end results cannot be pre-determined or the flow of creative activity rigidly scripted (Bereiter & Scardamalia, 2014). The complex nature of such inquiries may not be predictable by students, teachers or researchers (see Zhang et al., 2009; 2018). Pursuit of nonlinear CSCL pedagogy is not only challenging for students, but also for their teachers and for researchers.

Epistemic Games as a Metaphor for CSCL

The rationale for having academic investigators take active part in designing, assessing and improving CSCL processes at schools is in providing the students and teachers an access to cutting-edge practices of research and creative knowledge work. Appropriating creative learning practices may be understood in terms of adopting innovative features of epistemic games (Markauskaite & Goodyear, 2017; Shaffer & Gee, 2007; Bielaczyc & Own, 2014), i.e., identifiable but partially hidden patterns and structures of collaborative activity that professional and academic epistemic cultures have cultivated. Meaning-making interaction, learning by arguing, learning by design, knowledge building, dialogical inquiry, maker-centered learning may be understood as multiplayer epistemic games. All of these are “thick” epistemic games as distinguished from shallow online learning applications. Markauskaite and Goodyear (2017) understand epistemic fluency as a capability of taking part and practicing many different epistemic games involved in CSCL for solving complex problems, carrying out deepening inquiries that cross domains, going beyond the information given, integrating informal and academic knowledge, and inventing something new.

Orchestrating and Scaffolding the CSCL Culture

Fundamental issues of CSCL are involved when determining the level of structuring, scaffolding and scripting that is needed for making CSCL successful. Scripting may be seen as one perspective on cultural mediation—i.e., creating artifacts and structures for mediating activity. Although nonlinear knowledge creation processes cannot be rigidly scripted, it is necessary to guide and scaffold student learning for productive collaborative learning, interaction and knowledge creation. Teacher orchestration plays a crucial role; the teacher sets the CSCL culture. A great deal of flexible orchestration and structuring is necessary to cultivate local practices of working with knowledge and media (Zhang et al., 2018). There is a delicate continuum of scripting, scaffolding, orchestration, structuring – from explicit to more tacit, implicit and embodied facilitation of knowledge creation.

Theoretical Perspectives on Implementing CSCL (1709)

Implementing the Vision of CSCL in Classrooms

CSCL is often criticized for having failed to transform education (Schwarz & Wise, 2017). Critics assume that once students had computers and became accustomed to networking with other students, the incorporation of collaborative learning and CSCL in classrooms should have spread rapidly. They see little difference between students learning as individuals and groups of students learning collaboratively once they have communication media. Many think that CSCL can be implemented by simply using popular social media apps to support student communication and collaboration. The characterizations of CSCL and the theoretical perspectives presented in this chapter, however, provide grounds for understanding why the broad implementation of CSCL is more complicated and will take longer:

- CSCL is a *vision* of a future involving technologies, pedagogies, research methods and social practices that have not yet been adequately developed or understood.

- Learning is not a simplistic transfer of factual propositions through passive communication channels into student minds, but a *multi-level* matter of collaborative teams building shared knowledge and group practices, mediated by epistemic artifacts and social influences, and eventually appropriated as personal skills.
- *Social media apps*, by contrast, are designed to reduce users to consumers, gossips and emotional defenders of pre-existing personal opinions.
- *Recent theories* relevant to CSCL suggest that widespread acceptance of CSCL will require students, teachers, politicians and other stakeholders to dispense with many commonsense assumptions about learning and transform innumerable practices currently defining education.

A theoretical and practical challenge is to determine what processes, methods and practices are needed for CSCL to penetrate deeply into educational systems. A handful of systematic efforts have produced promising results (e.g., Chan, 2011; Looi et. al., 2001), but they have been rare. Although there have been isolated CSCL classrooms sustained by committed teachers, the establishment and dissemination of rich collaboration cultures in schools remains mysterious and prone to failure (Hakkarainen, 2009; Ritella & Hakkarainen, 2012). Advancement of the CSCL field requires a more comprehensive understanding of the complex and dynamic relations between digital technologies, social practices and educational-transformation processes.

Social Artifacts, Group Practices and Individual Understanding

The core focus of CSCL is to facilitate the development of personal, group and social cognition through collaborative technological supports: “Small groups are the engines of knowledge building. The knowing that groups build up in manifold forms is what becomes internalized by their members as individual learning and externalized in their communities as certifiable knowledge” (Stahl, 2006, p.56).

Groups in CSCL settings adopt group practices that contribute to their ability to effectively engage in cognitive activities such as problem solving. The adoption process typically proceeds through discussion, negotiation and enactment. Once adopted, the group can henceforth follow the practice tacitly. Group practices are often introduced from cultural or community practices (such as school subject matter, teacher presentations, readings) or from individual practices of one of the group members. Subsequently, group members often incorporate practices derived from adopted group practices in their individual repertory of cognitive skills and habits. Through such related processes of adoption, enactment, dissemination and transformation, practices that constitute the cognitive abilities of individuals, small groups and communities transfer between levels, evolve and influence each other. They may gradually become preserved on the various levels as individual skills, group processes and cultural artifacts.

CSCL research has the potential to explore the interactions between levels of description by capturing interaction data and analyzing it at multiple, interdependent units of analysis. Tasks can be defined for student groups that exceed the abilities of the individual members but lie in the group’s zone of proximal development. The learning environment can be seeded with relevant cultural artifacts. Then the interaction can be analyzed to document the adoption of group practices and their eventual influence on the enactment of the cultural artifacts and on the individual learning of the students. CSCL methodology must be extended and integrated to support such multi-level analysis with a focus on the interplay of individual, group and social practices. An integrated theory incorporating multiple levels of description can inform the design and testing of CSCL technologies. Affordances can be designed to support the adoption of specific group practices central to a targeted realm of learning. The effectiveness of the technology can then be evaluated by analyzing the extent to which it supports the adoption of important group practices (Stahl, 2019, Investigation 16).

The complaint that CSCL has not yet had much impact on educational practice may assume an overly simplistic notion of causality. According to ANT, scientific research does not lead by itself to social

change. Science results primarily in publications, which may have a gradual impact on language and thinking in a culture. Over time and in untraceable ways, new models of technology, new pedagogical practices and new conceptualizations may interact with the innumerable factors, ideas, constraints, artifacts and influences that influence what happens in classrooms. Social change, like learning, involves subtle and complex inter-level transformations.

Contrast Between CSCL and Social Media Apps

Although today's socio-digital technologies could enable interest-driven participation (Ito et al., 2010), most young people use them only to pursue shallow practices of hanging out with an extended network of peers. Moreover, intensive use of rapidly developing social-media technology involves unforeseen cognitive risks, such as constant interruptions (Carr, 2007) and excessive multi-tasking (Moisala et al., 2016) that corrupt development of attentional capabilities. Many people become addicted to frequent use of online sources (Salmela et al., 2016), and potentially subject to deliberately spread misinformation, advertising, targeting and bias. CSCL can play a balancing role because of its sustained focus on systematic and critical reflection in personal and collaborative learning. Creative and academic practices using socio-digital technologies do not emerge spontaneously, but require the support of well-designed and tested CSCL interventions. In order to become cognitively and culturally socialized to in-depth learning, young people need CSCL environments and practices that build on extensive research advancements, which have only just begun.

During the history of CSCL research, digital tools and instruments have been radically transformed. While collaborative learning originally required specifically designed groupware systems, current digital technologies are already social in nature in terms of enabling sharing of digital activities. We use the term socio-digital technologies to refer to integrated systems of digital technological tools, social media and global knowledge networks that support sharing of activities, media and knowledge (Hakkarainen et al., 2015). From a future-oriented CSCL perspective, it may be important that the boundary between specifically designed CSCL environments and regular socio-digital technologies is blurring. Although there are now very sophisticated CSCL environments, they may appear monolithic and isolated; they are not easily integrated with popular, freely available social media apps. It is not currently clear how to adapt, incorporate or extend commercial apps and online information sources in association with CSCL tools, curriculum and pedagogy to support teachers' agentic efforts of building local information ecologies, while avoiding the anti-intellectual consequences of social media.

Contemporary Theory and Research for the Future

Due to its trans-disciplinary agenda, CSCL has been involved in close collaboration with teacher practitioners from the very beginning of the research field. CSCL may be seen as expansive research in the context of application. Accordingly, the targeted CSCL phenomena occur in "Pasteur's quadrant" (Stokes, 1997), characterized by high levels of knowledge creation and application, as separated from pure basic research or mere practical application. CSCL appears, further, to be a paradigmatic example of "mode2" knowledge production (Novotny 2003; Novotny et al., 2002), which focuses on multi-disciplinary efforts of solving significant practice-related educational problems in close collaboration with practitioners. This is very different from a model of knowledge production that involves basic disciplinary research in the laboratory separated from societal interests. In order to have an impact on educational practices, CSCL researchers build extended expert communities, consisting of researchers, technology developers, teachers, students, parents and school administrators, for supporting educational change. Working with such an extended expert community—and integrating their knowledge competence—enables CSCL researchers to generate socially robust know-how needed for educational transformation.

Toward that end, CSCL studies rely on design-based research (DBR) methodology. The design-experiment approach is highly regarded in the learning sciences and involves co-designing and analyzing CSCL interventions in the field with teacher practitioners, iteratively refining pedagogic implementation of the experiments, and expanding creative CSCL practices (Bielaczyc, 2013; Brown, 1992; see also van der Akker et al., 2006). Working in the field inspires CSCL research and assists anchoring interventions and validity assessments of practicalities in schools. Collaboration with researchers gives teachers new perspectives and fosters professional development. Without researchers' support, teachers tend to reduce disruptive digital innovations to activities sustaining prevailing educational practices (Christiansen, Horn, & Johnson, 2011). Successful implementations of CSCL practices rely on systematic participatory transformations taking place through intensive research-practice interaction. Socio-culturally oriented researchers have developed a whole family of related intervention methodologies, including design-based implementation research (Fishman et al., 2011), research-practice partnership (Coburn & Stein, 2010), social design experiments (Bang & Vossoughi, 2016; Gutierrez & Jurow, 2016) and educational improvement science (Bryk et al., 2015).

Despite researchers' and educators' transformative visions, new digital tools tend to be initially used to promote traditional practices of teaching and learning. Radical transformative possibilities start emerging only through transformed social practices (Hakkarainen, 2009). In order to make CSCL practices effective, the use of CSCL technologies by teachers and students must go through a developmental process known as "instrumental genesis" (Rabardel & Bourmaud, 2003) of integrating the tools into learning/teaching activities. This involves shaping, adapting and tailoring the CSCL artifact according to local needs and requirements by participants (Nardi & O'Day, 2000), as well as cultivating personal and group practices. The process iteratively evolves the design of the tools to better facilitate intended practices and the creation of novel practices, tool usages and understandings by the users.

As students increasingly rely on technology in their social interaction, cognition and learning practices, approaches explored in CSCL research may exert an influence—especially as people become concerned about the harmful effects of simplistic social media apps. The result may be quite different from the experimental prototypes of current CSCL research projects. But that is what it means to understand CSCL as a vision and a process of global inquiry, rather than as a summative evaluation of a well-defined object of study. Theories of CSCL should conceptualize that vision and the effort to achieve it.

References (incomplete)

- Bakhtin, M. (1981). *The dialogic imagination. Four essays by M. M. Bakhtin*. University of Texas Press.
- Bang, M. & Vossoughi, S. (2016). Participatory design research and educational justice: Studying learning and relations within social change making. *Cognition and Instruction*, 34, 173-193.
- Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Erlbaum.
- Bereiter, C. & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. Chicago: Open Court.
- Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. In E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merriënboer (Eds.), *Powerful learning environments: Unraveling basic components and dimensions* (pp. 55). Oxford, UK: Elsevier Science.
- Bielaczyc, k. (2013). Informing design research: Learning from teachers' design of social infrastructure. *The Journal of the Learning Sciences*, 22, 258-311.
- Bielaczyc, K. & Own, J. (2014). Multi-player epistemic games: Guiding the enactment of classroom knowledge building community. *International Journal of Computer-Supported Collaborative Learning*, 9, 33-62.68).
- Blikstein, P. (2013). Digital fabrication and "making" in education: The democratization of innovation. In J. Walter-Herrmann & C. Buching (Eds.), *FabLabs: Of machines, makers, and inventors*. Bielefeld: Transcript.

- Brown, A. N. (1992). Design experiments: Theoretical and methodological challenges of creating complex interventions in classroom settings. *Journal of the Learning Sciences*, 2, 141-178.
- Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How American schools can get better at getting better*. Cambridge, MA: Harvard Education Press.
- Buckingham Shum, S. & Ferguson, R. (2011). *Social learning analytics. Technical report KMI-11-01*, Knowledge Media Institute, The Open University, UK.
- Buckingham Shum, S & Deakin Crick, R. (2016). Learning analytics for 21st century competencies. *Journal of Learning Analytics*, 3, 6-21.
- Carr, N. (2010). *The shallows: How the Internet is changing the way we think, read, and remember*. London: Atlantic.
- Chan, C. K. K. (2011). Bridging research and practice: Implementing and sustaining knowledge building in Hong Kong classrooms. *International Journal of Computer-Supported Collaborative Learning*. 6(2), 147-186.
- Chen, B., & Hong, H. Y. (2016). Schools as knowledge-building organizations: Thirty years of design research. *Educational Psychologist*, 51(2), 266-288.
- Chen, B & Zhang, J. (2016). Analytics for knowledge creation: Towards epistemic agency and design mode thinking. *Journal of Learning Analytics*, 3, 139-163.
- Chi, M. T. H. (2009). Active-constructive-interactive: a conceptual framework for differentiating learning activities. *Topics in Cognitive Science*, 1, 73-105.
- Chomsky, N. (1959). Review of verbal behavior, by B. F. Skinner. *Language*. 35(1), 26-57.
- Cress, U. (2008). The need for considering multilevel analysis in CSCL research-an appeal for the use of more advanced statistical methods. *International Journal of Computer-Supported Collaborative Learning*. 3(1), 69-84.
- Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.
- Donald, M. (2001). *A mind so rare: The evolution of human consciousness*. New York, NY: W. W. Norton.
- Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. New York, NY: Basic Books.
- Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.
- Garfinkel, H., & Sacks, H. (1970). On formal structures of practical actions. In J. Mckinney & E. Tiryakian (Eds.), *Theoretical sociology: Perspectives and developments*. (pp. 337-366). New York, NY: Appleton-Century-Crofts.
- Hakkarainen, K. (2009). A knowledge-practice perspective on technology-mediated learning. *International Journal of Computer-Supported Collaborative Learning*. 4(2), 213-231.
- Hegel, G. W. F. (1807). *Phenomenology of spirit* (J. B. Baillie, Trans.). New York, NY: Harper & Row.
- Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences*. 4(1), 39-103.
- Kant, I. (1787). *Critique of pure reason*. Cambridge, UK: Cambridge University Press.
- Koschmann, T. (Ed.). (1996). *CSCL: Theory and practice of an emerging paradigm*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Latour, B. (1996). On interobjectivity. *Mind, Culture and Activity*. 3(4), 228-245.
- Latour, B., & Woolgar, S. (1979). *Laboratory life*. Thousand Oaks, CA: Sage Publications.
- Marx, K. (1867/1976). *Capital* (B. Fowkes, Trans. Vol. I). New York, NY: Vintage.
- Packer, M., & Goicoechea, J. (2000). Sociocultural and constructivist theories of learning: Ontology, not just epistemology. *Educational Psychologist*. 35(4), 227-241.
- Sacks, H. (1965/1995). *Lectures on conversation*. Oxford, UK: Blackwell.
- Sawyer, R. K. (Ed.). (2014). *Cambridge handbook of the learning sciences*. (2nd ed.). Cambridge, UK: Cambridge University Press.
- Schwarz, B., & Wise, A. (2017). Visions of CSCL: Eight provocations for the future of the field. *International Journal of Computer-Supported Collaborative Learning*. 12(4), 423-467.

- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
- Stahl, G. (2019). *Theoretical investigations: Philosophical foundations of group cognition*. New York, NY: Springer.
- Vygotsky, L. (1930/1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Additional Readings

(Koschmann, 1996) – This edited volume defined the beginnings of CSCL theory. It includes Koschmann’s discussion of the CSCL paradigm, Roschelle’s model of CSCL interaction analysis and Scardamalia & Bereiter’s argument for supporting collaborative learning, among other seminal papers.

(Vygotsky, 1930/1978) – Vygotsky’s most important writings and notes collected here present a vision of the theory of learning most influential in CSCL.

(Donald, 1991; 2001) – In these books, Donald presents culture as a rapid form of human evolutions and extends the theory of learning to include external memory provided by digital technology.

(Stahl, 2019) - *Theoretical Investigations* brings together many of the past articles in the *International Journal of CSCL* and recent essays by the editor that are most relevant to this chapter. Together, they point in the direction of CSCL theory indicated here for the future. See also the chapter on “Analyzing Group Practices” in this volume.

(Hakkarainen, 2009) – This paper proposes the dialogic approach to knowledge practices. See also the chapter on “Dialogic Knowledge” in this volume. See also the chapters on “?” and “?” in this volume.