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Theories of CSCL

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Abstract. This chapter examines collaborative learning as cognition at the small-group unit of analysis, and highlights theoretical questions concerning interrelationships among individual, collective and cultural cognition. CSCL is a theory- and research-based pedagogical vision of what collaborative learning could be like, thanks to innovative computational supports and new ways of thinking about learning. Theories of CSCL are shaped by rapidly evolving digital technologies, pedagogical practices and research methods. Relevant theories can be categorized as: subjective (individual cognition and learning), intersubjective (interactional meaning making) and inter-objective (networks of learners, tools, artifacts and practices). Theoretical insights suggest ways of enhancing, supporting and analyzing cognition and learning by individuals, groups and communities. The emerging ecology of socio-digital participation—involving students' daily use of computers, mobile devices, social media and the Internet—requires extending and synthesizing CSCL theories to conceptualize connected learning at multiple levels.

Introduction & Scope: Theory of Theories

Educational research and practice should be informed by theory. However, CSCL has adopted and spawned a variety of competing theories. How should CSCL researchers and practitioners react to the current situation and what should they expect in the future?

Theories of CSCL are important to define what is unique about CSCL and to counter misunderstandings about the nature and aims of CSCL as an evolving research field. CSCL is a theory- and research-based pedagogical vision of what collaborative learning could be like, given the development of innovative computational supports and new ways of conceptualizing knowledge (epistemology), thought (cognition) and (collaborative) learning—largely influenced by contemporary and emerging philosophical approaches and theories. Hence, CSCL is not simply the study of the use of existing technologies in conventional educational settings, as analyzed by traditional methods and theories. The new theories have implications for designing CSCL technologies, associated pedagogic practices and analytic methods.

To examine the role of theory, we need to examine 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. From this perspective CSCL can involve learning either “through” or “around” CSCL technology (Lehtinen et al., 1999). The former involves CSCL environments mediating—or providing a medium for—learners’ synchronous or asynchronous online interaction, whereas the latter engages learners interacting face-to-face and co-creating knowledge or artifacts around digital devices. Technological development is, however, blurring boundaries of such activities, as all knowledge work increasingly involves socio-digital technologies. 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 joint pursuit of knowledge objects (Knorr-Cetina, 2001), which learners seek to understand by co-authoring texts or other products incorporating evolving shared meaning and common understanding. CSCL is also contrasted with CSCW, where adults collaborate on professional work using computer support.

Still others focus on the intersubjective aspects of collaboration that involve real-time interaction in small groups and associated efforts of meaning making. Post-humanist approaches highlight the active role of digital and other artifacts and physical, virtual or mixed environments in which enacted collaborative activity is embedded. Such an “inter-objective” (Latour, 1996) framework guides one to examine how multiple people learn as a group, community or network by building joint meaning and constructing shared artifacts within technologically rich.

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 philosophical and methodological underpinnings. This chapter’s discussion of theories of CSCL is anchored to an examination of interrelations and mutual shaping among the technologies, practices and research methods of CSCL (Figure 1), characterized as follows.

*** INSERT FIGURE 1 ABOUT HERE ***

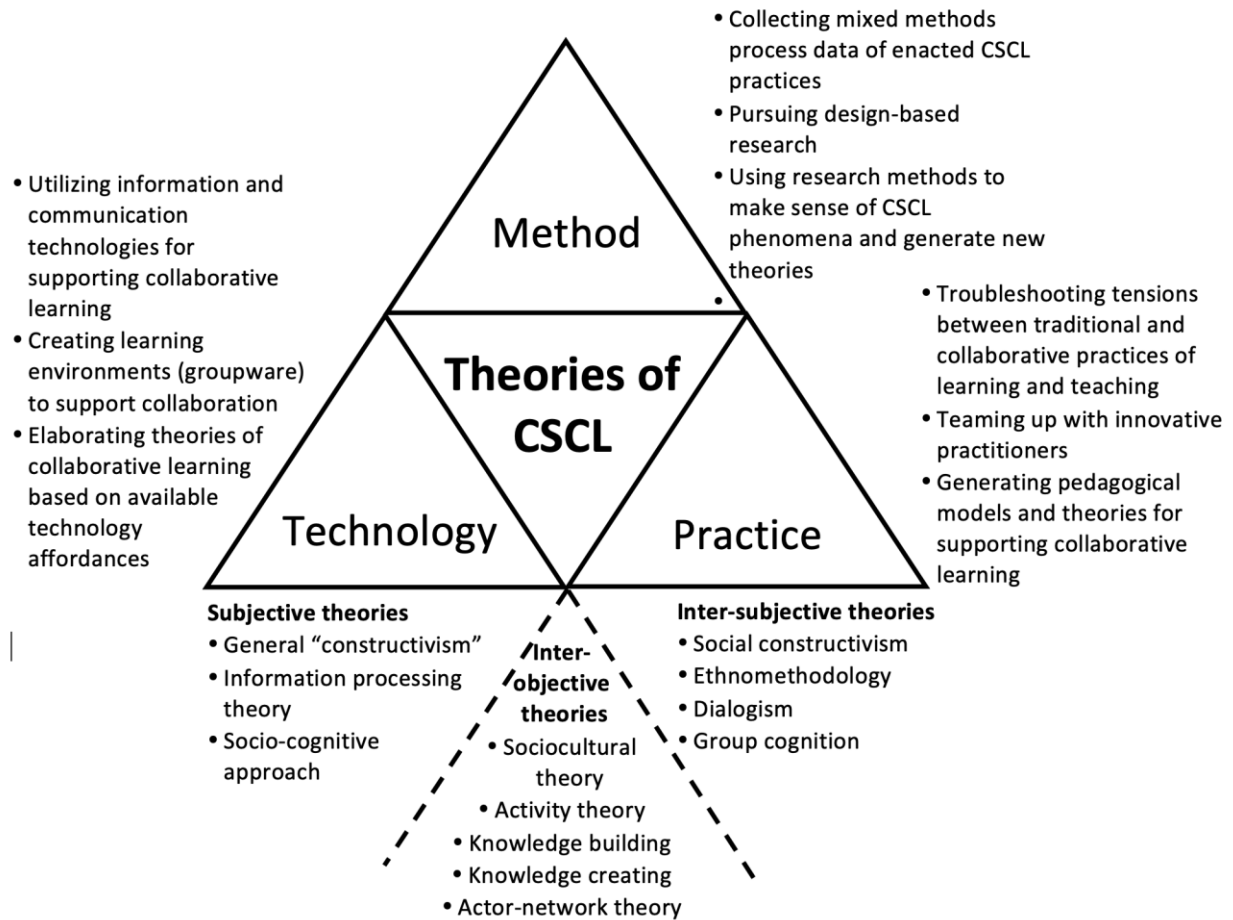


Figure 1. Framework for examining theories of CSCL.

- *Technologies*: The emergence of the CSCL field was associated with the development of information and communication technologies or groupware systems that enabled synchronous and asynchronous interaction and collaboration among learners. They inspired environments and theories for collaborative learning. The future of CSCL will also be mediated by rapid development of socio-digital technologies. The use of social media apps is in tension with CSCL's traditional focus on specialized applications for collaboration. Generic social media promote exchange of personal opinions (including flaming and fake news) rather than supporting intersubjective processes of knowledge building in domains like argumentation, sciences and mathematics.
- *Practices*: Educational use of CSCL technologies is a systemic phenomenon anchored in social practices of students, teachers and educational institutions. The impacts of CSCL technologies are mediated both by prevailing educational practices and enacted practices of using these technologies in learning and instruction. CSCL investigators have developed pedagogic frameworks and guidelines for supporting innovative CSCL implementations, together with developing theories for understanding practices of CSCL and its transformative dynamics. The socio-political agenda of CSCL to improve the quality of learning, democratize knowledge and promote educational

equality requires CSCL researchers to work closely with educators in iterative design experiments to implement CSCL in context.

- *Methods:* With their research methods, investigators analyze CSCL processes and practices, contributing to redesign of CSCL technologies and pedagogic models, as well as refining theories of CSCL. Analyses of CSCL in practice have motivated theories of cognition that is socially and materially distributed, temporally and socially emergent, and embodied, enactive, embedded and extended. The field has developed specific methods and investigative practices for studying collaborative learning at multiple levels: from the individual and small group to classroom/community/cultural/societal units of analysis.

What kind of theory is appropriate and useful for deepening understanding, explanation and advancement of CSCL?

The theory of science has morphed considerably in recent decades (see e.g., Latour & Woolgar, 1979) from former positivist conceptions of theory and of science. Today, the theory of CSCL is a controversial moving target, not an established canon of universally accepted principles. We will be less concerned with predictive theory typical for the natural sciences, and more with theory as a tool for understanding and transforming learning and education. A number of theories have been prominent in CSCL during the past 25 years due to the trans-disciplinary nature of the field; researchers trained in specific fields—such as education, design, psychology, computer science, anthropology or linguistics—brought with them theories, methodologies and philosophies of science from these quite different enterprises.

This has resulted in a confusing variety of incommensurate, competing theories influential within CSCL research. For instance, the most common theories identified in recent content meta-analyses of CSCL (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 grouped based on loose author self-identification rather than looking at the approaches actually applied in the reported research. Difficulties in comprehensively characterizing CSCL theories reflect the complexity of the evolving field, where different research questions require distinct kinds of investigation.

To clarify the range of traditional and emerging theories, we have categorized them under these headings: *subjective* (foregrounding individual cognition and learning), *intersubjective* (foregrounding interactional meaning making) and *inter-objective* (post-humanist emphasis on building of heterogeneous networks of learners, tools, artifacts and practices). These overlapping categories of theories have been crucial for understanding the field of CSCL, its developmental history and envisioned future.

In the following sections, we will review the role of CSCL technologies, practices and methods, as tied to the subjective, intersubjective and inter-objective theories that seem critical for advancement of the field. Finally, we will suggest elements of a more integrated theory of CSCL.

History & Development

Interdependence of Theory and Method

Shifts in theory both influenced and responded to changes in 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 psychologists like Brown (1992) highlighted the importance of pursuing field case-studies in actual classrooms, the psychological sciences generally prioritize controlled laboratory experiments and statistical measures of collected data.

Because implementation of CSCL in education calls for systemic change in social practices that individualistic psychological theories are unable to account for, subjective approaches have been critiqued, complemented, expanded and partially replaced by approaches that emphasize materially and socially distributed aspects of thinking and learning, rather than mental models or symbolic representations. Such development has been critical for the development of CSCL, given its 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. Controlled experiments to measure individual learning gains have been either complemented or replaced with in-depth case studies or longitudinal ethnographies, without which emerging CSCL practices could not have been fully understood, adequately explained or deliberately fostered.

The recognition of the complexity of learning in CSCL settings necessitate extending the theory and bringing in conceptualizations and methods from related fields. Hence, CSCL theories increasingly invoke and adapt methods from other social sciences, including linguistics and anthropology. The resulting contextualized approaches to analyzing cognition address thinking and learning as involving people situated in dialog with others, within a world of language, artifacts and culture. Such CSCL studies often use interaction analysis or design-based research to understand and explore how groups of students interact using technological artifacts and systems. 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 often reflect on how theoretical frameworks affect the analysis methods of investigators. However, available technologies and methods can provide access to specific kinds of empirical phenomena and data, in turn inspiring the refinement of CSCL theory. In human sciences, methods and tools can create the very phenomena (research objects) of investigation, so that theories, methods or technologies are interdependent (Gigerenzer, 1994). 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 (Scardamalia, this volume), 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 (Hillman & Säljö, 2016). CSCL research addresses complex and often messy efforts of implementing collaborative practices in education and, therefore, usually uses mixed methods for reaching robust understanding of CSCL processes. Although design-based and interventionist approaches appear to dominate CSCL, it is also important to continue pursuing controlled experiments for testing the impact of well understood practices of using technology, possibly within the cycles of design-based research.

There is 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. One could use different methods at each unit of analysis and then identify links between them. A central open question involves how the levels interact. This must become a vital concern of further development of theories of CSCL.

Diversity of Theories & Traditional Oppositions

The distinction between different theoretical frameworks depends on the focal unit of collaboration. *Subjective* theories focus 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. *Intersubjective* and *inter-objective* theories are more oriented to social, community and cultural levels of analysis, the former emphasizing linguistic interactions and the latter embeddedness of learning on networks of people and artifacts. Both are concerned with analyzing and cultivating the social practices in which learning is embedded and the social institutions that structure learning activities. The collaborative group then stands in the middle, between the individuals who participate in the group, tools and artifacts used, and the community or larger network whose practices the group adopts and adapts as it learns collaboratively. One can focus on the group itself as the unit of analysis. Collaborative learning, which takes place in CSCL primarily at this unit, can have consequences at the other levels, leading to learning outcomes for the individuals or transformation of community social practices (Lave & Wenger, 1991).

The array of theories has evolved 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, 2020, 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 deduce 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 logical reasoning (Chomsky, 1959). Cognitive science's computational theory of mind assumed encapsulated mind with internal representations, memory storage and information processing analogous with those of early computers (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 is in some vague sense constructed).

Alternative socio-historically motivated theories then developed based on the dynamic philosophy of Hegel (1807) and Marx (1867), which shaped Vygotsky’s, Bakhtin’s and other investigators’ theories of the social mind and mediated cognition. From the perspective of the emerging socio-cultural framework, cognitive development and learning were results of dialectics between personal tool-mediated activities, group interactions, social practices and “cognitive-cultural macro-structures” (Donald, 1991). 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 approach.

“Mediation” is a concept developed in Hegel’s dialectical philosophy and central for CSCL. Notice that the word has connotations of media and middle. It can refer to a variety of processes that take place in the middle of two related phenomena. For cognitivism, the human mind plays a mediating role in transforming perceptions of the world into mental knowledge. In CSCL, technologies provide the tools and media through which interactions between people, groups and artifacts take place; they mediate both interaction and materially embodied activity. In CSCL contexts, interaction is not directly between minds, but is mediated by language, gesture, symbol, technology and context (including school practices, background knowledge, previous interactions).

Development and Learning in Vygotsky

Vygotsky (1930) 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 mediated, group, social cognition. Thereby, they offer an important starting point for CSCL theory.

Collaborative learning, as the source of cognitive development, may be considered a basis of all human learning, not just an optional and rare mode of instruction. That is, group cognition is 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 base for individual cognition. By incorporating language, external symbols and other cultural artifacts, this process 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 (1930, pp. 86f) 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.” 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.

In his “Problems of Method,” Vygotsky (1930, pp. 58-75) called for a new paradigm of educational research almost a century ago. Arguing that one cannot simply look at post-test results of an experiment, he proposed a method of “double stimulation” where a child is confronted by a learning challenge and a potential artifact to mediate that work. Instead of proposing an experimental study for comparing learning outcomes with and without some furnished artifact, Vygotsky suggests that “the experimenter waits until they spontaneously apply some new auxiliary method or symbol that they then incorporate into their operations.” Taking this inter-objective research approach on collaboration requires attention to the children’s interaction, the object-related activity 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 extended processes of co-creating artifacts for transforming problem situations and re-mediating their learning processes (Ritella & Hakkarainen, 2012); see also (Paavola & Hakkarainen, this volume). Such investigation involves tracing the *unique trajectories* of distinct *groups’ object-related activities*, which could not be understood if sorted into statistically aggregated or standardized categories.

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 support 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 popular in his time, Vygotsky sketched a vision of the ties between individual, group and community (social, cultural) cognition that CSCL researchers can now elaborate.

State of the Art

Recent Theories Influential in CSCL

CSCL is distinguished by its pedagogic, analytic and technological focus on collaboration. Popular socio-cultural theories in CSCL build on Vygotsky’s initiative. Most traditional and socio-cognitive theories of learning, by contrast, focus on the individual mind as the learner and the repository of learned knowledge. The theories presented in this section consider how learning (cognition) and knowledge (epistemology) can be considered at larger units of analysis than the individual human, such as the small group and various social or cultural levels, including artifacts and other contextual referents.

Socio-cognitive Research on CSCL

Socio-cognitive theories of CSCL, which build on conceptions of individual learning, cognition and motivation, typically 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. Investigators may focus on cognitive and motivational gains of personal and collaborative learning or measure the impact of various scripting strategies on collaborative-learning processes and individual-learning outcomes (e.g., Weinberger et al., 2005). Studies of regulation in CSCL have expanded from self-regulation to peer assisted co-regulation and group regulation (e.g., Panadero & Järvelä, 2015). Although

socio-cognitive studies often rely on laboratory experiments and quasi-experimental designs, many use mixed methods and collect data from field studies. Each approach has appropriate rigorous standards of evidence that it can follow (Methods section, this volume).

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 based on the adoption of social practices or “member methods” shared through participation in 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 embodied activity how their actions should be understood. Sacks studied this in transcripts of ordinary conversation, founding Conversation Analysis (Garfinkel & Sacks, 1970; Sacks, 1965). Investigations showed how people design their speech to open and close new topics, to respond to each other and to repair misunderstandings (Schegloff, 2007). As a sociological approach, ethnomethodology shifts the view of learning to the community, social or cultural level.

Dialogism

Bakhtin’s (1981) theory has affected CSCL research by guiding investigators in analyzing dialogic interaction processes. The dialogic approach guides students in sustained interaction that enables them to explore and build on their own and peers’ ideas (Wegerif, 2007). From the dialogic nature of thinking and meaning, it follows that a person’s utterance in conversation, writing or thinking should not necessarily be interpreted as an expression of private mental representations or beliefs, but as an interactive response to on-going communication, designed to evoke future responses. Furthermore, speech incorporates countless standard elocutions that are part of a literary genre and language. Often, specific words that someone else used are repeated and taken up in the new utterance. Accordingly, utterances should be analyzed and understood as dialogical moves within a social setting, not just as personal expressions.

Knowledge Building

Pioneering CSCL work of Scardamalia and Bereiter (1996) 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, as distinguished from individual learning. They propose that schools can be developed into “knowledge-building” communities that engage students in expert-like creative work with knowledge, appropriating disciplinary methods of advancing knowledge. Toward that end, students are engaged in “design mode” activities of creating, improving, sharing and advancing ideas, understood as improvable conceptual artifacts (i.e., results of knowledge building, such as texts, reports, designs, theories, symbols, tools, usable objects). Knowledge building is an emergent, nonlinear process that cannot be rigidly scripted or pre-determined. The knowledge-building framework has been developed in close collaboration with teachers committed to implementing Scardamalia’s (2002) knowledge-building principles in practice (e.g., anchoring learning on real issues and authentic problems, promoting idea diversity and engaging in efforts of reflecting upon earlier investigations or proposals).

Knowledge-Creating Learning

Paavola and Hakkarainen (2014) expanded the conceptually oriented knowledge-building theory by also taking into consideration materially embodied aspects of artifacts (see Paavola & Hakkarainen, this volume). Their knowledge-creating learning approach is distinguished both from the knowledge-acquisition metaphor and the participation metaphor (Sfard, 1998). While the acquisition view represents a “mono-logical” (subjective, mental) view on human learning and the participation view represents a “dia-logical” (intersubjective) view, the knowledge-creation perspective may be understood as “tria-logical” in nature because of its foregrounding interaction between individuals, communities *and shared epistemic objects being developed*. Knowledge creation is anchored by deliberately cultivated knowledge practices, i.e., social practices of working with knowledge artifacts and media (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. Social practices are anchored in dynamic activity systems, which must be transformed to make significant changes happen. Expansive learning starts by criticizing, questioning and analyzing contradictions arising within the system or its external relations. CHAT studies often promote community development by engaging students and teachers in solving vital real-world problems in collaboration with networks of local stakeholders, such as community organizations and workplaces (Engeström, 2002; Roth, 2007).

Actor-Network Theory

Actor-Network Theory (ANT) (Latour, 2007) builds on science and technology studies showing how complex human activity relies on networks of people, artifacts and practices. Such networks diverge from CHAT activity systems in terms of having diverse kinds of actors exerting causal influences, including non-human agents such as tools, technology-rich environments or knowledge objects. This framework is characterized by “inter-objectivity” (Latour, 1996) in terms of treating humans and artifacts symmetrically and highlighting the active roles of the various actors. ANT has been applied more often in CSCW and workplace situations than in educational or CSCL contexts but appears to have potential here as well (Fenwick & Edwards, 2011). Learning takes place in increasingly complex socio-material environments, which intertwine enacted local practices with virtual and distributed activities. Technological artifacts have a dynamic dual role as agents that oscillate between structuring and constraining as well as directing and expanding activity. ANT examines social engineering involved in negotiating conflicting interests of stakeholders—such as researchers, technology developers, educational administrators, teachers and students—that successful CSCL projects must align.

Group Cognition and Adopting Group Practices

The theory of group cognition (Stahl, 2006; 2020, Investigation 16) is primarily concerned with building knowledge and epistemic artifacts through artifact-mediated processes of group interaction. It focuses on the small-group unit of analysis, as the level at which social and cultural phenomena and artifacts influence the interaction, which, in turn, may produce group,

individual and community learning. 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, for instance, in the context of learning geometry (Stahl, 2013; 2016); see (Medina & Stahl, this volume). One can refine CSCL curriculum and *pedagogy* to promote the adoption of key group practices. CSCL *technology* can support the presentation, exploration and adoption of identified group practices. *Analysis* of group interaction in CSCL settings 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.

Dealing with Diversity

It is appropriate that a field like CSCL, which is still an exploratory vision, allows a diversity of theories, from subjective to intersubjective and inter-objective. This inspires innovative research agendas. However, because theory has consequences for methodology, a researcher should be explicit about what theoretical framework guides a specific research project or analysis. One's research question should determine the unit of analysis and associated methods. While all established theories capture some truth, their corresponding methodologies may be both limiting and mutually incompatible. For instance, validated self-report questionnaires are useful tools, but participants' individual responses are not likely to adequately reveal contextual factors and intersubjective learning processes. The current situation of the theory of CSCL affords flexibility to the researcher but requires careful respect for the diverse approaches.

The Future

Toward an Integrated Theory of CSCL

CSCL theory during recent decades has increasingly broadened the phenomena of interest—from learning impacts on individual students to forms of interaction within small groups and communities, involving various forms of artifacts and interactions among levels. Central theoretical concepts have been reconceptualized. Investigation of the phenomena related to these concepts will continue to stimulate theory building and may allow an integrated framework to emerge for understanding collaborative learning and for guiding technological and pedagogical support.

In this section, we review themes and concepts that seem central to continuing to develop CSCL theory—from a collection of concerns from related fields to a framework specific to what is unique to CSCL (see Figure 2). Finally, we turn from theory to practice and consider the implications of this chapter's discussion for pursuing CSCL in the classroom.

*** INSERT FIGURE 2 ABOUT HERE ***

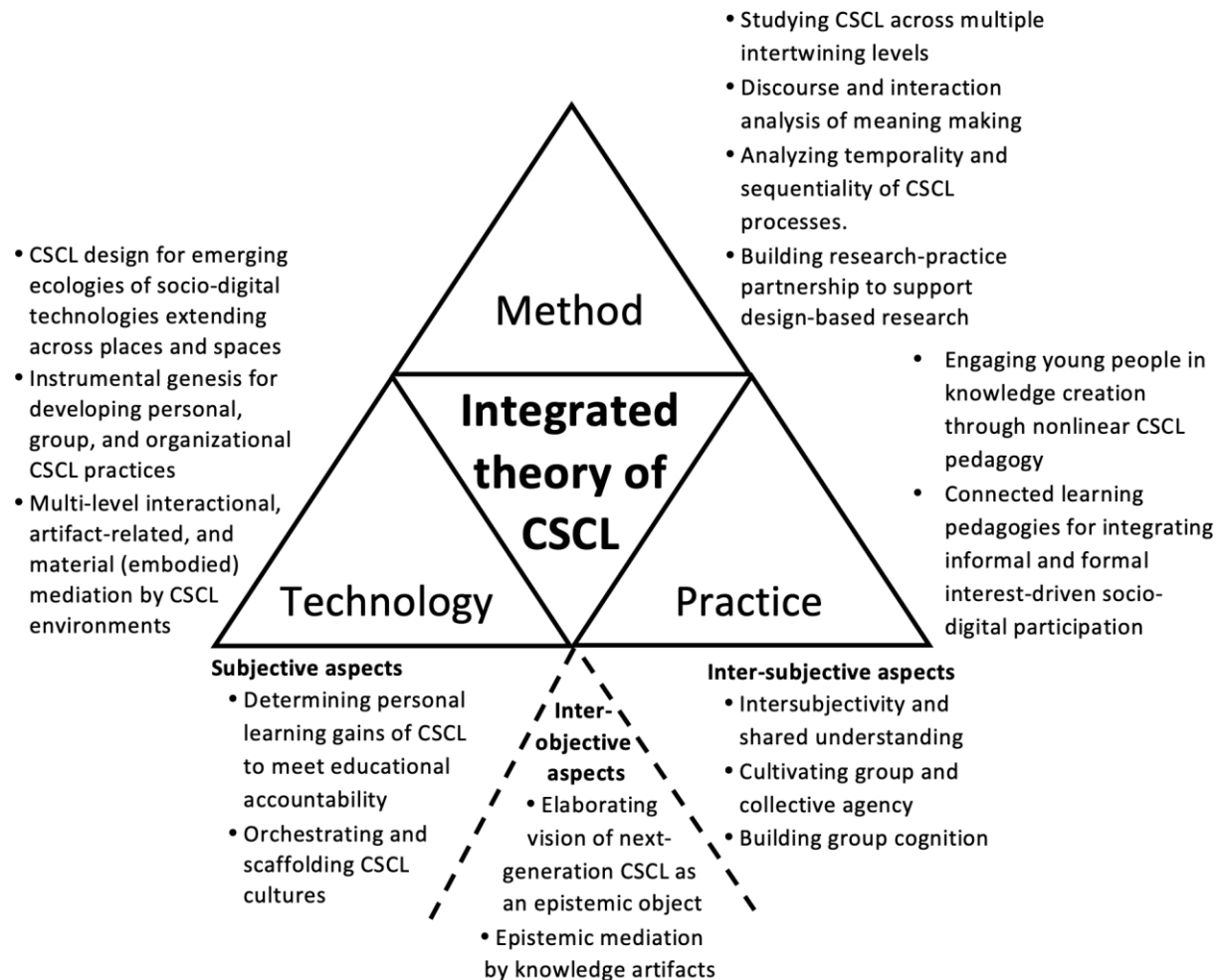


Figure 2. Framework for integrated CSCL theory.

Elements of an Integrated Theory of CSCL

Discourse and Interaction

Collaborative learning proceeds through knowledge-creating discussion within a group of learners. The group learns by building and sharing knowledge and by interacting in non-verbal ways within the CSCL environment (e.g., highlighting, sketching, modeling, prototyping, gesturing, producing knowledge artifacts). Analysis of collaborative interaction usually involves investigating transcripts of the discourse and multimodal interaction. It may consist of understanding the flow of conversational moves and embodied actions and the meaning making that took place by the group, perhaps adapting Conversation Analysis (Schegloff, 2007) or Interaction Analysis (Jordan & Henderson, 1995).

Interactional Mediation by CSCL Environments

CSCL provides multi-faceted socio-technical environments that mediate collaborative interaction and learning in multi-faceted ways. The rapidly evolving ecology of socio-digital technologies is distributed across formal and informal spaces of learning, so that technology mediation is

increasingly mashed up to take place through and “around” socio-digital tools. Theory should account for such mediation and inform the design of media to support specific, identified aspects of collaborative learning, as well as interconnecting informal and formal technology-mediated learning.

Epistemic Mediation by Knowledge Artifacts

CSCL environments offer learning communities shared spaces and scaffolding for creating, building, visualizing, sharing, organizing and advancing knowledge artifacts. Socio-digital technologies enable cognitive augmentation that CSCL builds on: By technologically extending the mind, digital devices foster new forms of collaborative working and engagement in successive refinement of complex ideas (Donald, 1991). The “epistemic mediation” involved in such extended thinking processes refers to a deliberate process of deepening inquiry by creating external epistemic artifacts (e.g., shared written notes, visual representations, material artifacts, simulations and discourse media) that crystallize and promote evolving understanding and collective inquiry. Problems and solutions in CSCL processes can be understood as epistemic objects; such objects represent what the participants are seeking to understand and create but do not yet know or understand. These objects are defined by their openness, incompleteness and capacity to unfold indefinitely through successive thought- and affect-laden instantiations as textual or other artifacts (Knorr-Cetina, 2001).

Temporality and Sequentiality

CSCL takes place over time and through language use embedded in technology-mediated activity. Interaction takes place through the sequential ordering of actions, utterances and gestures. A given oral or written utterance typically responds to previous activity and discourse, generally designed to provoke a response and to propel the discourse and inquiry. The analysis of collaborative learning as a group meaning-making process may need to interpret the temporality and sequentiality of captured discourse and related activity (Medina & Stahl, this volume). Although utterances may be analyzed statistically to answer specific research questions, the enacted collaboration itself is an inherently sequential process, which cannot be fragmented without losing its meaning. Further, temporality and sequentiality also structure the non-linguistic activity. CSCL activity is embedded in unfolding social (group work) and material (technological) processes, which are entangled in temporal emergent assemblages, analysis of which may reveal development of key group, social and epistemic practices.

Intersubjectivity and Shared Understanding

A fundamental theoretical question for CSCL is that of intersubjectivity (Stahl, 2020, Investigation 18): How is it possible (both in the abstract and in practical terms) for participants in a group to understand each other? This is a problem for cognitivism: 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? Socio-cultural theory answers this by noting that people share language, activity context and cultures laden with mutually understood meanings. Of course, in a situation of collaborative learning there are ample opportunities for misunderstanding each other. Fortunately, our languages and embodied activity include shared practices for repairing misunderstandings. Intersubjectivity is the result of specific aspects of human interaction, beginning in prehistory (Tomasello, 2014) and continuing in successful CSCL sessions today (Schneider & Pea, 2013). The need to constantly maintain intersubjective shared understanding

is a major reason that CSCL requires special supports, training and effort in order to be successful.

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 (Hutchins, 1996) 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 artifact actors, bringing in a cultural-historical unit of analysis. CSCL theory should account for agency and other phenomena at multiple units of analysis.

Orchestrating and Scaffolding the CSCL Culture

CSCL aims at cultivating nonlinear pedagogy, characterized by open-ended, emergent and inventive educational practices (Ng, 1995). Although nonlinear knowledge-creation processes cannot be rigidly scripted (Scardamalia & Bereiter, 2014), it is necessary to guide and scaffold student learning for productive collaborative learning, interaction and knowledge creation.

Flexible teacher orchestration and CSCL structuring is necessary to cultivate local practices of working with knowledge and media (Zhang, 2018). A delicate balance is needed for guiding, scaffolding, orchestrating, structuring and facilitating collaborative knowledge creation.

Theoretical Perspectives on Implementing CSCL

Implementing the Vision of CSCL in Classrooms

CSCL has been criticized for having failed to transform education (e.g., Wise & Schwarz, 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. We all seriously underestimated the challenges of transforming technological infrastructure, cultivating CSCL practices and changing associated educational accountability regimes. The preceding theoretical perspectives indicate why implementation of CSCL will take longer:

- CSCL is a *vision* of a future involving technologies, practices and research methods that guide investigators' theory-building and intervention efforts. CSCL is an incomplete epistemic object (Knorr-Cetina, 2001), which constantly raises new questions and becomes more complex as technologies, practices and methods develop unpredictably.
- CSCL is embedded in rapidly expanded *ecologies of socio-digital participation* that involve young people using technology intensively. Many young people use digital technologies for pursuing their interests together with their peers (Ito et al., 2010), experimenting with digital tools and making personal media productions. The challenge of CSCL is to promote connected learning in terms of also engaging students at school in creative and academic collaborative use of technology.

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, So, Toh & Chen, 2011), 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 remain elusive and prone to failure (Hakkarainen, 2009; Ritella & Hakkarainen, 2012). Advancement of the CSCL field requires a more comprehensive theoretical and practical understanding of the complex and dynamic relations between digital technologies, social practices and educational-transformation processes.

Despite transformative CSCL visions, new digital tools tend to be initially used to promote traditional practices of teaching or learning; radical innovative possibilities emerge only through sustained transformation of social practices (Hakkarainen, 2009). Successful implementations of CSCL practices rely on systematic participatory transformations taking place through intensive research-practice partnerships. To effectively utilize CSCL practices, teachers and students must undergo “instrumental genesis” (Rabardel & Bourmaud, 2003), integrating the CSCL tools into learning/teaching activities. This involves shaping, adapting and tailoring the CSCL tools and practices according to local needs and requirements by participants, as well as cultivating novel 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 participants.

As students increasingly rely on technology in their everyday interaction, cognition and learning practices, approaches explored in CSCL research and theory may promote connected learning practices and, thereby, overcome the limitations of simplistic social-media apps. The result may be quite different from the experimental prototypes of classic CSCL research projects. Despite the complexity of the challenges, that is what it means to understand the CSCL vision as an epistemic object of global inquiry, rather than as a summative evaluation of a well-defined object of study. Theories of CSCL should comprehend, envision and guide the targeted transformations and emergent technologies, practices and methods for achieving it.

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) – 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 evolution and extends the theory of learning to include external memories provided by digital technology.

(Stahl, 2020) – *Theoretical Investigations* brings together many of the past articles in the *International Journal of CSCL* and recent essays by the journal’s editor that are most relevant to this chapter. Together, they point in the direction of CSCL theory indicated here for the future. See also (Medina & Stahl, this volume) and essays available at: <http://gerrystahl.net/elibrary>.

(Hakkarainen, 2009) – This article generalizes research experiences implementing CSCL in educational practices, expands knowledge building toward the dialogic approach to knowledge-creating learning and works out the notion of knowledge practices. See also (Paavola & Hakkarainen, this volume).

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