Theories of CSCL

Abstract   There are many theories useful for framing CSCL research and they may in principle be irreducible to a single theory. CSCL research explores questions involving numerous distinct—though interacting—phenomena at multiple levels of description. The useful approach may be to clearly distinguish levels such as individual, small-group and community units of analysis, and to differentiate terminology for discussing these different levels. Theory in general has evolved dramatically over the ages, with a trend to extend the unit of cognition beyond the single idea or even the individual mind. Seminal theoretical works influential within CSCL suggest a post-cognitive approach to group cognition as a complement to analyzing cognition of individuals or of communities of practice.

There is no one theory of CSCL. Research in CSCL is guided by and contributes to a diverse collection of theories. Even the word *theory* means different things to different researchers and plays various distinct roles within CSCL work. The reading of the history of theory presented here is itself reflective of one theoretical stance among many held, implicitly or explicitly, by CSCL researchers.

The nature and use of theory have changed over history and continue to evolve. The theories most relevant to CSCL—in the view developed in this paper—concern the nature of cognition, specifically cognition in collaborating groups. Through history, the analysis of cognition has broadened, from a focus on single concepts (Platonic ideas) or isolated responses to stimulae (behaviorism), to a concern with mental models (cognitivism) and representational artifacts (post-cognitivism). More recent theories encompass cognition distributed across people and tools, situated in contexts, within small groups, involved in larger activities and across communities of practice. For CSCL, theory must take into account interaction in online environments, knowledge building in small groups and cognition at multiple units of analysis.

A brief history of theory

CSCL is multi-disciplinary by its nature and because of its origins (see Stahl, Koschmann & Suthers, 2006, for a history of CSCL from a perspective similar to the one here). Consider the name, *Computer-supported Collaborative Learning*: it combines concerns with *computer* technology, *collaborative* social interaction and *learning* or education—very different sorts of scientific domains. CSCL grew out of work in fields like informatics and artificial intelligence, cognitive science and social psychology, the learning sciences and educational practice—domains that are themselves each fundamentally multidisciplinary. Theory in these fields may take the form of predictive mathematical *laws*, like Shannon's (1949) mathematical theory of information or Turing's (1937) theory of computation; of *models* of memory and cognition; or of *conceptions* of group interaction and social practice. They may have very different implications for research: favoring either laboratory experiments that establish statistical regularities or engaged case studies that contribute to an understanding of situated behaviors.

In the European tradition, theory begins with the ancient Greeks—especially Socrates, Plato and Aristotle—and continues through the 2,500-year-long discourse of philosophy. In recent times, theory has veered into unexpected directions as it has morphed into sciences based more on empirical research than on intellectual reflection. For instance, the work of Freud, Darwin and Marx replaced traditional philosophic assumptions about fixed natures of minds, organisms and societies with much more dynamic views. Theory always transcended the opinions of common sense—so-called *folk theories* based on the everyday experience of individuals—to synthesize broader views. But folk theories have also changed over time as they adopt popularized pieces of past theories; thus, a trained ear can hear echoes of previous theories in the assumptions of common-sense perspectives, including in current CSCL research literature.

After the dogmatic centuries of the medieval period, philosophy took some significant turns: the rationalism of Descartes, the empiricism of Hume, the Copernican revolution of Kant, the dialectical development of Hegel, the social situating of Marx, the existential grounding of Heidegger and the linguistic turn of Wittgenstein. These all eventually led to important influences on theory in CSCL.

In particular, the field of educational research followed this sequence of philosophic perspectives. Empiricism and positivism in philosophy of science culminated in behaviorism in biology and the human sciences. The central metaphor was that of *stimulus* provoking *response*, all objectively observable and unambiguously measurable (as critiqued in Chomsky, 1959). The major theoretical move of the generation before ours was to assert the necessity of taking into account cognitive processes in studying human behavior, from Chomsky's (1969) theories of language based on deep grammar and brain mechanisms to the mental models and internal representations modeled by artificial intelligence programs. Human-computer interaction, the part of computer science dealing with designing for usage, has gone through a similar sequence of behaviorist and cognitivist theories (see Carroll, 2003, for numerous examples). More recently, post-cognitive theories have been influential in CSCL, as will be discussed later.

The unit of analysis

The history of theory can be tracked in terms of the following issue: At what unit of analysis should one study thought (*cognition*)? For Plato (340 BC/1941), in addition to the physical objects in the world, there are concepts that characterize those objects; philosophy is the analysis of such concepts, like goodness, truth, beauty or justice. Descartes (1633/1999) argued that if there is thought, then there must be a mind that thinks it, and that philosophy should analyze both the mental objects of the mind and the material objects to which they refer, as well as the relation between them. Following Descartes, rationalism focused on the logical nature of mental reasoning, while empiricism focused on the analysis of observable physical objects. Kant (1787/1999) re-centered this discussion by arguing that human understanding was the source of the apparent spatio-temporal nature of observed objects and that critical theory's task was to analyze the mind's structuring categories. Up to this point in the history of theory, cognition was assumed to be an innate function of the individual human.

Hegel (1807/1967) changed that. He traced the logical/historical development of mind from the most primary instinct of a living organism through stages of consciousness, self-consciousness and historical consciousness to the most developed trans-national spirit of the times. To analyze cognition henceforth, it is necessary to follow its biological unfolding through to the ultimate cultural understanding of a society. Figure 1 identifies Hegel's approach to theory as forming the dividing line between philosophies or theories oriented on the individual and those oriented to a larger unit of analysis.
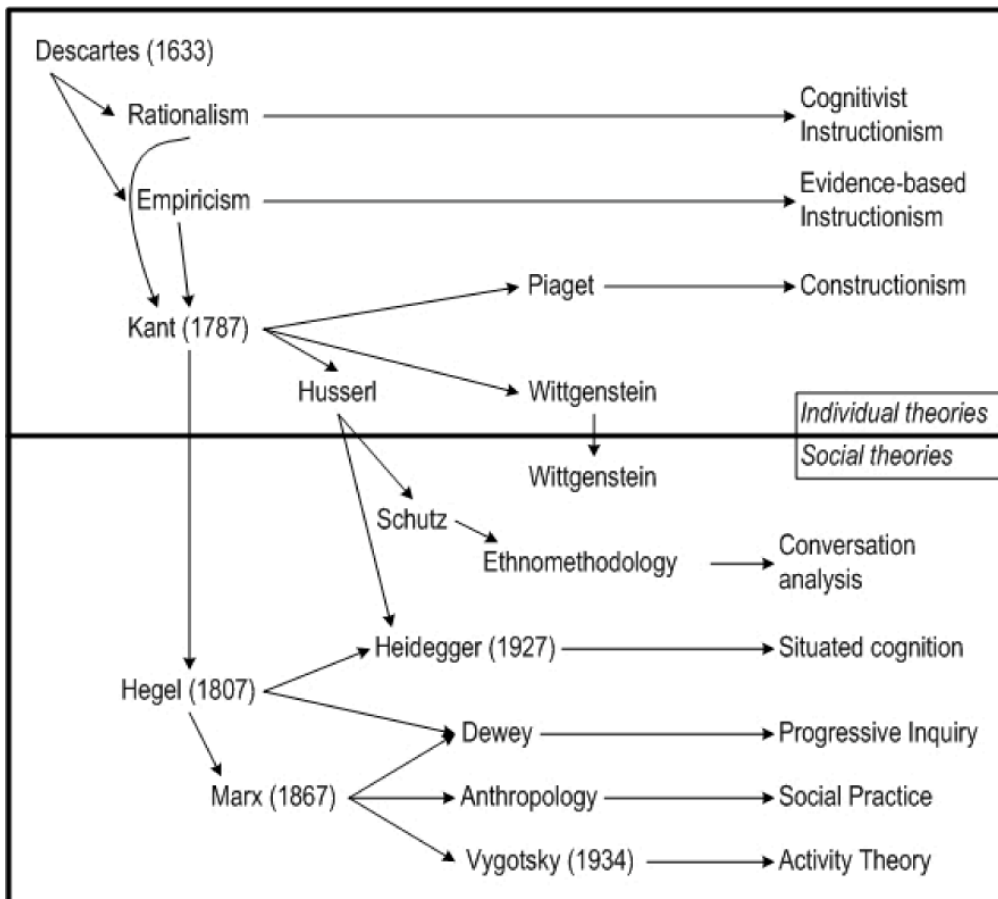

Figure 1. From (Stahl, 2006, p. 289, Fig 14-1).

Philosophy after Hegel can be viewed as forming three mainstreams of thought, following the seminal approaches of Marx (critical social theory), Heidegger (existential phenomenology) and Wittgenstein (linguistic analysis). As taken up within CSCL, one can say these approaches established expanded units of analysis.

Marx (1867) applauded Hegel's recognition of the historical self-generation of mankind and analyzed this historical process in terms of the dialectical development of the social relations of production and the forces of production. His analysis took the form of historical, political and economic studies of the world-historical processes by which human labor produces and reproduces social institutions. Here, the study of the human mind and its understanding of its objects becomes focused at the epochal unit of analysis of social movements, class conflicts and transformations of economic systems.

Heidegger (1927/1996) radicalized the Hegelian dialectic between man and nature by starting the analysis of man from the unified experience of *being-in-the-world*. The problem of a distinction between an observing mind and an objective world was thereby reversed. Heidegger, instead, had to show how the appearance of isolated minds and an external world could arise through abstraction from the primary experience of being-there, human existence inseparable from the worldly objects that one cares for and that define one's activity. The primordial unit of analysis of cognition is the involvement of people in their world.

Wittgenstein (1953) focused increasingly on language as it is used to accomplish things in the world through interpersonal communication. He rejected his own early view (Wittgenstein, 1921/1974), which reduced a rationalist conception of propositional, logical language to a self-contradictory position. Now, linguistic meaning no longer dwelt in the heads of users or the definitions of the words, but in communicational usage. Echoing the *lived world* of phenomenology, Wittgenstein acknowledged the role of the human *form of life*. He also conceptualized language as the playing of *language games*, socially established forms of interaction. The unit of analysis shifted from mental meanings to interpersonal communications in the context of getting something done together.

Marx, Heidegger and Wittgenstein initiated the main forms of post-Kantian, post-Hegelian philosophy and scientific theory (Stahl, 2010c). Kant represents the culmination of the philosophy of mind, in which the human mind is seen as the active constructor of reality out of its confrontation with the objects of nature, which are unknowable except through this imposition of human structuring categories. With Kant—over two hundred years ago—the human mind is still a fixed unit consisting of innate abilities of the individual person, despite how much his philosophy differs from naïve realist folk theories, which accept the world as fundamentally identical with its appearance to the human observer. Hegel overthrows the Kantian view of a fixed nature of mind by showing how the mind has itself been constructed through long sequences of processes. The Hegelian construction of mind can be understood in multiple senses: as the biological development of the brain's abilities as it grows from newborn to mature adult; as the logical development from simple contrast of *being* and *non-being* to the proliferation of all the distinctions of the most sophisticated understanding; or as the historical development from primitive homo sapiens to modern, civilized, technological and cultured person. After Hegel, theory shifted from philosophy to science, to explore the biological, logical and historical processes in more detail and to verify them empirically. Followers of Marx, Heidegger and Wittgenstein

adopted approaches to this that can be referred to as *social*, *situated* and *linguistic*. They are all constructivist, following Kant's insight that the structure of known objects is constructed by the knowing mind. They all focus on a unit of analysis broader than the isolated individual mind of Descartes.

Seminal theories for CSCL

The social, situated and linguistic theories of Marx, Heidegger and Wittgenstein entered the discourse of CSCL literature with researchers coming from the various scientific traditions that went into forming CSCL as a research domain, including psychology, education, social science, design studies, computer science and artificial intelligence (e.g., Dourish, 2001; Ehn, 1988; Floyd, 1992; Schön, 1983). Although these fields each introduced various theoretical perspectives, we can see the major philosophic influences largely through several seminal texts: *Mind in Society* (Vygotsky, 1930/1978), *Situated Learning* (Lave & Wenger, 1991), *Lectures on Conversation* (Sacks, 1962/1995) and *Understanding Computers and Cognition* (Winograd & Flores, 1986).

Mind in Society is an edited compilation of Vygotsky's writings from the early 1930s in post-revolutionary Russia, which has been influential in the West since it appeared in English in 1978. Critiquing the prevailing psychology as practiced by behaviorists, Gestaltists and Piaget, Vygotsky did not try to fit psychology superficially into the dogmatic principles of Soviet Marxism, but rather radically rethought the nature of human psychological capabilities from the developmental approach proposed by Hegel and Marx. He showed how human perception, attention, memory, thought, play and learning were products of developmental processes—in terms of both maturation of individuals and the social history of cultures. He proposed a dynamic vision of the human mind in society, as opposed to a fixed and isolated function. The Hegelian term, *mediation*, was important for Vygotsky, as it is for CSCL. Even in his early years still talking about stimulus and response, he asked how one stimulus could mediate the memory of, attention toward or word retrieval about another stimulus (p. iii). In Hegelian terms, this is a matter of mediating (with the first stimulus) the relation (memory, attention, retrieval) of a subject to an object (the second stimulus). This is central to CSCL because there the learning of students is mediated by technological networking as well as by collaborative interaction. Another popular term from Vygotsky is the *zone of proximal development* (pp. 84-91). This is the learning distinction and developmental gap between what individuals can do by themselves (e.g., on pre- and post-tests) and what they can do in collaboration (e.g., situated in a small group). A group of children may be able to achieve cognitive results together that they will not be able to achieve as individuals for a couple more years. This is consistent with Vygotsky's principle that people develop cognitive abilities first in a social context—supported or mediated by peers, mentors or cognitive aids like representational artifacts—and only later are able to exercise these cognitive abilities as individuals. Vygotsky's theory, if carried beyond where he had time to develop it, implies that collaborative learning provides the foundation upon which all learning is built. Methodologically, it argues against judging the outcomes of collaborative learning by testing individuals outside of their collaborative settings.

Situated Learning went beyond Vygotsky in expanding the unit of analysis for learning. For Vygotsky and his followers, analysis must include the mediating

artifact (tool or word) and the mentor or group. For Lave and Wenger, the unit of analysis is a larger community of practice. Adopting the theoretical and analytical centrality of social practices in Marx, they focused on learning as the development of processes and relationships within the community in which individuals participated. Learning was viewed on the model of apprenticeship, in which an individual gradually—and primarily tacitly—adopts the practices that are established within the community in which the individual is becoming a member. Within CSCL, this approach can be seen in the idea that one learns mathematics by adopting the practices of mathematicians, such as using mathematical symbolisms, making conjectures about mathematical objects and articulating deductive arguments (Sfard, 2008). The CSILE project (Scardamalia & Bereiter, 1996), a pioneering CSCL effort, tried to support the communicative practices seen in professional research communities within the learning communities of school classrooms; the unit of analysis for knowledge building mediated by the CSILE discussion software was the discourse of the classroom as a whole.

Lectures on Conversation laid the cornerstone of Conversation Analysis (CA). It was based on the ethnomethodological (Garfinkel, 1967) perspective, grounded in both Wittgenstein's linguistic analysis and Heidegger's (1927/1996) and Husserl's (1936/1989) phenomenological approach. Like Wittgenstein, CA analyzed language at a unit larger than the isolated word or speech act. CA focuses on *adjacency pairs* used in conversation—see (Schegloff, 2007) for a systematic presentation of 40 years of research by the CA community on adjacency-pair structure. An adjacency pair is a sequence of two or three utterances that elicit or respond to each other, such as a question and answer. The significance of the adjacency pair as a unit of analysis is that it includes contributions by both people involved in an interaction, and thereby avoids treating speech as an expression of an individual mind. What is important is the mode of interaction carried out by the adjacency pair situated in its on-going, sequential discourse context. This should be contrasted with approaches that code isolated utterances based on assumptions about mental models inside the individual mind of the speaker. A CA analysis explicates how a dyad or small group builds upon and solicits each other's contributions, thus providing insight into patterns of collaboration.

Understanding Computers and Cognition presented a Heideggerian critique of the rationalist foundations of artificial intelligence by a leading AI researcher. The book reviews three theories that endorse contextual analysis: Heidegger's (1927/1996) being-in-the-world, Gadamer's (1960/1988) historically grounded conception of interpretation and Maturana's (1987) ecological version of cognition. These theories emphasize the inseparability of the mind from its larger context: human being engaged in the world, interpretation oriented within the horizon of history and the organism bound in a structural coupling with its environment. In contrast, AI software represents mental functions as isolatable units of rational computation, which in principle cannot capture the richness and complexity of situated human cognition and collaboration. The larger, primarily *tacit* (Polanyi, 1966) unit of context cannot be adequately represented in a computer system (Stahl, 2010d). Accordingly, the role of computer software should be to support human interaction and collaboration, rather than to replace or fully model human cognition.

The writings of Vygotsky, Lave and Wenger and Sacks further develop the perspectives of Marx, Heidegger and Wittgenstein that cognition is social, situated and linguistic. Winograd—like others, including Ehn and Dourish—reviews the

foundational post-cognitive theories and considers the implications for computer-supported collaboration. But these theories can be—and have been—taken in different directions by CSCL researchers when it comes time to following implications for research conceptualizations and methods. These directions can perhaps best be seen in terms of theories of individual, small-group and community cognition in CSCL research.

Theories of individual cognition in CSCL

Many research questions within CSCL involve individual cognition. CSCL research is often treated as a sub-discipline of educational or psychological research, oriented to the mind of the individual student. Such research can follow traditional scientific research paradigms based on pre-Kantian empiricism and/or rationalism. However, CSCL research tends to adopt a constructivist approach, based on the Kantian principle that the student constructs his or her own understanding of reality. Constructivist theory is cognitivist, in that it involves assumptions about cognitive processes in the mind of the student underlying the student's observed behaviors. For instance, a student's responses in a test situation are assumed to be reflective of the student's mental models of some knowledge content, as construed by the student.

Work within CSCL generally acknowledges the importance of the larger social, historical and cultural context. However, it often treats this context as a set of environmental variables that may influence the outcomes of student cognition, but are separable from that cognition. In this way, cognition is still treated as a function of an individual mind. This approach may be called *socio-cognitive*. It acknowledges social influences, but tries to isolate the individual mind as a cognitive unit of analysis by controlling for these external influences.

Followers of Vygotsky are considered *socio-cultural*. They recognize that cognition is mediated by cultural factors. Yet, they still generally focus on the individual as the unit of analysis. They investigate how individual cognition is affected by cultural mediations, such as representational artifacts or even by collaborative interactions. Vygotsky himself—who was after all a psychologist—generally discussed the individual subject. For instance, the zone of proximal development measured the individual's ability when working in a group, not the group's ability as such. Vygotsky was trying to demonstrate that individual cognition was derivative of social or intersubjective experiences of the individual, and so his focus was on the individual rather than explicitly on the social or intersubjective processes in which the individual was involved.

In this sense, much CSCL research investigates individual cognition in settings of collaboration. In fact, if the research is based on testing of the individual before and after a collaborative interaction and does not actually analyze the intervening interaction itself, then it is purely an analysis at the individual unit of analysis, where the collaboration is merely an external intervention measured by presumably independent variables.

If one looks closely at most studies that claim to be about small-group collaboration, one finds that they adopt this kind of focus on the individual within a group setting and treat the group interaction as an external influence on the individual. This is particularly clear in the writings of *cooperative learning* that preceded CSCL (e.g., Johnson & Johnson, 1989). As defined within CSCL

(Dillenbourg, 1999), in cooperative learning students divide up group work and then put the individual contributions together, whereas in collaborative learning students do the work together. Similarly on the methodological level, in cooperative learning the analyst distinguishes the contributions to the work and focuses on the learning by the individuals as a result of the cooperative experience, whereas in collaborative learning the analyst may chose to focus on the group processes. The same is true for small-group studies of sociology and social psychology: they usually treat the group process as a context and analyze the effects on the individual.

A final example of a theory of individual cognition is psycho-linguistic contribution theory (Clark & Brennan, 1991). This particular paper is often cited in CSCL literature. Although the paper claims to be in the Conversation Analysis tradition, it translates the adjacency-pair structure of grounding shared understanding into the contributions of the individuals. It analyzes the individual contributions as expressions of their mental representations or personal beliefs and treats the resultant *shared understanding* as a matter of similar mental contents or acceptance of pre-conceived beliefs rather than as a negotiated group product of collaboratively co-constructed meaning making. Clark (1996) tries to unite cognitivism with Conversation Analysis, but he analyzes the situated, engaged interaction as an exchange of signals between rationally calculating minds, who identify deliberate actions based on "knowledge, beliefs and suppositions they believe they share" (p. 12). Interestingly, Clark (1996) concludes in favor of recognizing two independent theories with different units of analysis: "The study of language use must be both a cognitive and a social science" (p.25).

Theories of community cognition in CSCL

In striking contrast to the steadfast focus on the individual as the unit of analysis is the social science perspective on social processes. Marx provided a good example of this. Where economists of his day analyzed economic phenomena in terms of rational choices of individual producers and consumers, Marx critiqued the ideology of individualism and analyzed sweeping societal transformations such as urbanization, the formation of the proletariat and the rise of the factory system. Lave and Wenger (1991) brought this approach to educational theory, showing for instance how an apprenticeship training system reproduces itself as novices are transformed into experts, mentors and masters. Learning is seen as situated or embedded in this process of the production and reproduction of structures of socially defined knowledge and power.

The theoretical importance of the *situation* in which learning takes place is widely acknowledged in CSCL. Suchman (1987) demonstrated its centrality for human-computer interaction from an anthropological perspective heavily influenced by both Heidegger (via Dreyfus) and Garfinkel, leading to conclusions similar to Winograd's. Suchman and Nardi have helped to establish ethnographic methods—oriented to community phenomena—as relevant to CSCL research. Unfortunately, even perspectives like situated cognition can take a reductive turn: Recent commentaries on situated cognition (Robbins & Aydede, 2009) and distributed cognition (Adams & Aizawa, 2008) frame the issues at the individual level, to the extreme of reducing all cognitive phenomena to neural functions.

Building on Vygotsky and his Russian colleagues, Activity Theory (Engeström, 1987; Engeström, 1999; Kaptelinin & Nardi, 2006) insists on taking an entire activity system as the unit of analysis. In his triangular analysis rubric, Engeström extends Vygotsky's mediation triple of subject, mediator and object to include mediating dimensions from Marx's theory: the division of labor, the rules of social relations and the community of productive forces. Like discourse analysis (Gee, 1992), activity theory is repeatedly looking at small-group interactions but only seeing the larger, societal issues. For instance, when activity theory addresses the study of teams in the most detail in Chapter 6 of (Engeström, 2008), it is mostly concerned with the group's situation in the larger industrial and historic context; rather than analyzing how groups interactionally build knowledge it paraphrases how they deal politically with organizational management issues.

There is something of this avoidance of the small group as the scientific focus in other theories popular in CSCL as well, for instance in distributed cognition. In defining statements of post-cognitivist theory, Hutchins has explicitly pointed to group-cognitive phenomena:

- "Cognitive processes may be distributed across the members of a social group" (Hollan, Hutchins & Kirsh, 2000, p. 176).
- "The cognitive properties of groups are produced by interaction between structures internal to individuals and structures external to individuals" (Hutchins, 1996, p. 262).
- "The group performing the cognitive task may have cognitive properties that differ from the cognitive properties of any individual" (Hutchins, 1996, p. 176).

However, rather than focusing on these group phenomena in detail, he analyzes socio-technical systems and the cognitive role of highly developed artifacts (airplane cockpits, ship navigation tools). Certainly, these artifacts have encapsulated past cultural knowledge (community cognition), and Hutchins' discussions of this are important. But in focusing on what is really the community level—characteristically for a cultural anthropologist—he does not generally analyze the cognitive meaning making of the group itself (but see his analysis of group or organizational learning in Chapter 8 of Hutchins, 1996).

Even ethnomethodology (Garfinkel, 1967; 2006) and conversation analysis (Sacks, 1962/1995; Sacks, Schegloff & Jefferson, 1974; Schegloff, 2007) consider themselves social sciences, versions of sociology or communication studies, but not sciences of the small-group unit of analysis. They aim to analyze social practices, defined across a whole society or linguistic community. This may be a quibble over words, for they do in fact define many important processes at the group unit, even if they call them *social*. Even Vygotsky used the term *social* in an ambiguous way when he said that learning takes place socially first and then later individually. *Socially* can refer to two people talking as well as to transformations of whole societies. But for the sake of distinguishing levels of description or units of analysis in CSCL, it seems important to make clear distinctions. Table 1 suggests sets of different terms for referring to phenomena at the individual, small-group and societal levels. The distinction of these three levels is argued for by (Rogoff, 1995), (Dillenbourg et al., 1996), (Stahl, 2006) and others in CSCL. We start with these three levels, which seem particularly central to much of CSCL work, although other levels might also usefully be distinguished, such as "collective intelligence" at the classroom level or "collective practices" at the school level (Guribye, 2005; Jones, Dirckinck-Holmfeld & Lindström, 2006; Looi et al., 2011). Perhaps

consistent usage of such terminological distinctions would lend clarity to the discussion of theories in CSCL.

Table 1. Terminology for phenomena at the individual, small-group and community levels of description. From (Stahl, 2010a, p. 27, Table 2.1).

Level of description	Individual	Small group	Community
Role	Person / student	Group participant	Community member
Adjective	Personal	Collaborative	Social
Object of analysis	Mind	Discourse	Culture
Unit of analysis	Mental representation	Utterance response pair	Socio-technical activity system, mediating artifacts
Form of knowledge	Subjective	Intersubjective	Cultural
Form of meaning	Interpretation	Shared understanding, joint meaning making, common ground	Domain vocabulary, artifacts, institutions, norms, rules
Learning activity	Learn	Build knowledge	Science
Ways to accomplish cognitive tasks	Skill, behavior	Discourse, group methods, long sequences	Member methods, social practices
Communication	Thought	Interaction	Membership
Mode of construction	Constructed	Co-constructed	Socially constructed
Context of cognitive task	Personal problem	Joint problem space	Problem domain
Context of activity	Environment	Shared space	Society
Mode of Presence	Embodiment	Co-presence	Contemporary
Referential system	Associations	Indexical field	Cultural world
Form of existence (Heidegger)	Being-there (*Dasein*)	Being-with (*Mitsein*), Being-there-together at the shared object	Participation in communities of practice (*Volk*)
Temporal structure	Subjective experiential internal time	Co-constructed shared temporality	Measurable objective time
Theory of cognition	Constructivist	Post-cognitive	Socio-cultural
Science	Cognitive and educational psychology	Group cognition theory	Sociology, anthropology, linguistics
Tacit knowledge	Background knowledge	Common ground	Culture
Thought	Cognition	Group cognition	Practices
Action	Action	Inter-Action	Social praxis

Theories of small-group cognition in CSCL

As suggested above, the CSCL-related literature on small groups and on post-cognitive phenomena provide some nice studies of the pivotal role of small groups, but they rarely account for this level of description theoretically. They are almost always in the final analysis based on either a psychological view at the individual level or a sociological view of rules at the community level. They lack a foundational conception of small groups as a distinct level of analysis and description. They confuse analysis at the small-group level and at the societal level,

and they lack a developed account of the relationships among the individual, small group and community of practice. Yet there are distinct phenomena and processes at each of these levels, and analyses at different levels of description reveal different insights.

If group phenomena are treated seriously as first-class objects of theory, then one can study how small groups engage in cognitive activities such as: interpersonal trains of thought, shared understandings of diagrams, joint problem conceptualizations, common references, coordination of problem-solving efforts, planning, deducing, designing, describing, problem solving, explaining, defining, generalizing, representing, remembering and reflecting as a group. In CSCL studies of text chat or discussion forums, for instance, analysis can show group-cognitive accomplishments emerging from the network of meaningful references built up by postings, demonstrating how the group's self-formation and its cognitive accomplishments are enacted in situated interaction.

The small-group level is, of course, particularly central to CSCL theory, because CSCL is explicitly concerned with supporting collaborative learning, knowledge building or group cognition. There are few other domains in which this is such a central concern. Even computer-supported cooperative work (CSCW) is less concerned with the small-group phenomena because the work is often divided up among individuals and is usually more directly affected by societal issues like economic competition—so CSCW is more concerned with communicating and coordinating ideas than with building them together. We have seen this, for instance, in the case of activity theory—which could profitably be used to investigate group processes—where Engeström (2008) argued against a focus on small groups because workplace teams tend to come and go quickly, forming changing *knots* of co-workers around ephemeral tasks.

A theoretical approach that does focus on small-group interaction is that of dialogicality (Linell, 2001; 2009; Mercer, 2000; Wegerif, 2007). Dialogical theory goes back to Bakhtin (1986), a contemporary of Vygotsky. It stresses the linguistic nature of interaction. It also reiterates the idea that a person's identity as an individual arises through the confrontation with ones partners in dialogue—a view that goes back beyond Mead (1934/1962) to Hegel's (1807/1967) master-slave dialectic (Stahl, 2006, p. 333f). The notion of dialogue partners coming from different perspectives and negotiating from these is an important contribution of dialogic inquiry (Wells, 1999). Another key concept is that of a *shared dynamic dialogic space*, within which knowledge building can take place (Kershner et al., 2010). This is similar to the *joint problem space* of (Teasley & Roschelle, 1993), but now developed in an unambiguously post-cognitive manner.

 The idea of an interactional *space* for interaction within a small group is central to group cognition theory (Stahl, 2006) as well. The term *group cognition* was coined to stress the goal of developing a post-cognitive view of cognition as the possible achievement of a small group collaborating so tightly that the process of building knowledge in the group discourse cannot be attributed to any individual or even reduced to a sequence of contributions from individual minds. For instance, the knowledge might emerge through the interaction of linguistic elements, situated within a sequentially unfolding set of constraints defined by the group task, the membership of the group, and other local or cultural influences, as well as due to the mediation of representational artifacts and media used by the group.

The theory of group cognition absorbs many ideas from the theories discussed above, including that of a shared dynamic dialogical space. Despite some scattered

case studies by the authors already mentioned and their colleagues, there is yet not much documentation and analysis of empirical instances of effective group cognition. The analysis of group cognition needs not only specially focused methods to track its occurrence, but even prior to that are required special technologies, pedagogy and guidance to structure and support groups to effectively build knowledge that can be shown to be a group product not reducible to individual mental representations. The Virtual Math Teams Project was launched to generate a data corpus that would allow for the analysis of group cognition. This project and some analyses by a number of researchers is documented in (Stahl, 2009). Group-cognition theory focuses on the sequential team interaction within case studies of small-group collaboration. This takes place within an interaction space or a *world* in the Heideggerian sense, which opens up to allow the production of group-cognitive accomplishments. The interaction that takes place within such a world—whether face-to-face or online—is subject to a variety of constraints, as pictured in Figure 2.
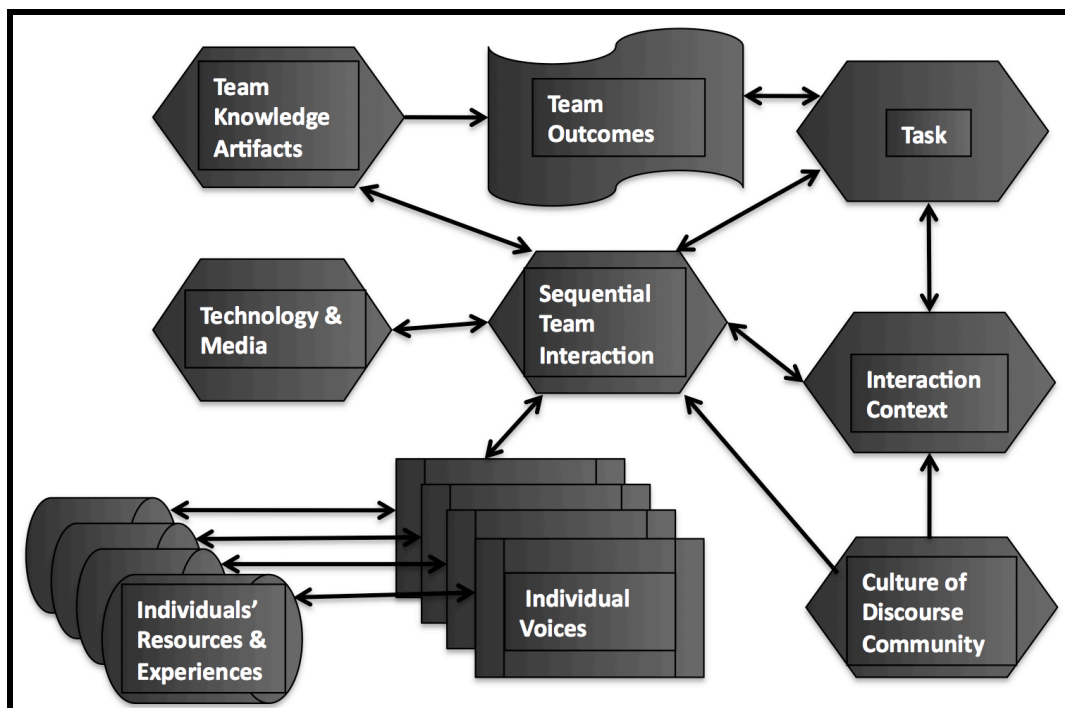

Figure 2. A diagram of constraints on sequential team interaction. From (Stahl, 2010b, p. 256, Figure 1).

Note that Figure 2 is not intended to be a model of objects and processes. Rather it tries to present some of the complex constraints on the discourse through which group cognition might be achieved. Neither the physical individuals nor their group are represented here as such; the dialogical (Bakhtinian) voices of the individuals enter into the sequential team interaction and respond to it. Over time, the sequential team interaction forms the central shared dynamic dialogic space within which the group-cognitive constraints interact. Behind the individual voices that enter into this interaction are not so much minds containing mental representations, as a fluid background of past experiences and developed resources for action, which surface based on relevance to the interaction. The team discourse is situated in the shared dialogical context generated by the on-going interaction itself; the culture and history associated with the group's community of practice;

and the socio-technical environment including the media of communication. The interaction is goal-oriented toward the task—as given externally but as enacted by the group—and mediated by a variety of kinds of artifacts, including codifications of knowledge products previously generated by the group. These artifacts might end up among the team outcomes, in relation to the guiding task. Of course, other constraints and influences are possible as well, coming for instance from the guidance of a teacher or the motivations of a reward system. The point is that one can picture the whole system producing cognitive accomplishments without having to postulate mental representations in individual minds, let alone to reduce the whole system to rational mental decisions or to regulation by social institutions.

The term *constraint* in Figure 2 is chosen to be a neutral term, not implicating a notion of mechanistic causality. While it is clear that the traditional conception of causality is inadequate—stemming back to Aristotle and metaphors of physical mechanics—it is less obvious how to think about the working of the constraints upon group cognition. Folk theory adopts a mechanistic worldview, or even an anthropomorphic view of nature combined with a mechanistic view of causality. Observable behavior of people is taken to be the result of rational decision making in the heads of individuals causing the people to behave as a result of the minds acting as the agency for causing words to be produced and limbs to be moved. But the *linguistic turn* of Wittgenstein (Wittgenstein, 1953) and even more so the recent *practice turn* (Schatzki, Knorr Cetina & Savigny, 2001) have veered radically away from such a view.

Latour (1992) seems to be working toward a post-cognitive notion of causality, perhaps relying heavily on Hegel's notion of mediation. Interestingly, he not only argues against the hegemony of individual minds as agents in the social world, but he also argues against the adequacy of our notion of the *social* (Latour, 2007). History is made neither by rational decisions of individual minds nor by the workings of *society*. Rather, it is the result of a complex network of mediating actors, including all kinds of artifacts as well as human actors. Thus, Latour seems to be advocating an analytic approach that steers clear of both cognitive minds and social institutions to focus on a middle ground. Figure 2 may illustrate the kind of network that he would endorse for picking apart and then reassembling instances of group cognition.

A multiplicity of theories in CSCL

In general, CSCL raises many fundamental questions for traditional theories, oriented as CSCL is to small groups and to online interaction. The accustomed characteristics of the physical world, in which interlocutors are embodied and visible to each other, are missing in CSCL settings, and that brings into question numerous assumptions of folk theories and traditional approaches. The group itself has no identity as a physical body and has no brain to possess its knowledge; it relies on external memories, which differ essentially from personal memories (Donald, 1991). The online world—shared dialogical space—has no location or extension. Group members can come from around the world and do not necessarily share local connections and culture. CSCL involves students in qualitatively different social relations of production, modes of being in the world or forms of life; even Marx, Heidegger and Wittgenstein's foundational philosophies of post-cognitive theory need to be rethought for virtual groups. Concepts of causality,

world, knowledge, cognition, intersubjectivity, interaction and presence need to be reconceptualized for theories in CSCL.

There are many avenues for developing theories in CSCL, as reviewed in this article. Although there are some similarities among these alternatives—often in terms of their critiques of earlier theories—there are strong differences of position and perspective. This is not necessarily a problem. There is a huge assortment of processes taking place in successful CSCL events: at multiple time scales and involving different aspects of interaction. It is possible to raise innumerable research questions, each requiring possibly different methods of investigation at different levels of analysis. It is likely that CSCL requires multiple theories, which are not reducible to one grand unifying theory and that even seem incommensurate with each other. This goes essentially beyond the common notion of *mixed methods*, in which two or more methods of analysis are used to triangulate a single phenomenon from different angles. There are distinct phenomena at different levels of description—and they interact with each other in complex ways.

In CSCL, there are many phenomena of interest and they are largely defined by the theories that conceptualize them. So different theories in CSCL can be talking about quite different phenomena (although they may unfortunately be calling them by the same name). In order to avoid confusion and arguments about pseudo-problems, we need to be clear about the theories behind research questions, assumptions, methodologies, analysis tools, findings and claims in the field of CSCL.

This article has sketched some of the theoretical landscape underlying CSCL research. Progress in further developing theories of CSCL will require careful analysis of case studies and experimental results guided by theoretical perspectives that are clearly enunciated.

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