Investigation 20. Theories of Shared Understanding

Gerry Stahl

Abstract

Recent research on instructional technology has focused increasingly on the potential of computer support to promote collaborative learning, shared understanding, and collaborative knowledge building. Sociocultural theories have been imported from cognate fields to suggest that cognition and learning take place at the level of groups and communities as well as individuals. Various positions on this issue have been proposed, and a number of theoretical perspectives have been recommended. In particular, the concept of common ground has been developed to explain how meanings and understandings can be shared by multiple individuals. This Investigation takes a critical look at the concept of shared meaning as it is generally used and proposes an empirical study of how group cognition is constituted in practice.

Keywords

Shared meaning · Knowledge building · Shared understanding · Common ground · Group cognition · Interpretation · Perspectives · Participation metaphor

Among those researchers working on computer-assisted learning, a community has emerged in the past decade known as computer-supported collaborative learning or CSCL (Crook, 1994; Dillenbourg, 1999; O'Malley, 1995). In an influential attempt to define this paradigm of research, Koschmann (1996) argues that previous forms of instructional technology research "approach learning and instruction as psychological matters (be they viewed behavioristically or cognitively) and, as such, are researchable by the traditional methods of psychological experimentation" (p. 10f). That is, they focus on the mind of the individual student as the unit of analysis when looking for instructional outcomes, learning, meaning-making, or cognition. By contrast, the paradigm of CSCL "is built upon the research traditions of those disciplines—anthropology, sociology, linguistics, communication science—that are devoted to understanding language, culture and other aspects of the social setting" (p. 11). This radical paradigm shifts, focusing on "the social and cultural context as the object of

G. Stahl (✉)
Chatham, MA, USA
e-mail: Gerry@gerrystahl.net

G. Stahl (ed.), *Theoretical Investigations*, Computer-Supported Collaborative Learning Series 18,
https://doi.org/10.1007/978-3-030-49157-4_20

study, produces an incommensurability in theory and practice relative to the paradigms that have come before" (p.13).

The incommensurability between CSCL and other paradigms of computer-assisted learning becomes clear if we phrase it this way: in the CSCL perspective, it is not so much the individual student who learns and thinks, as it is the collaborative group. Given that we have for millennia become used to taking learning and thinking as activities of individual minds, it is hard to conceive of them as primarily group activities. Of course, this approach does not deny that individuals often think and learn on their own, but rather that in situations of collaborative activity, it is informative to study how processes of learning and cognition take place at the group level.

Thus the question of group cognition can be viewed as largely a methodological, rather than ontological issue: it is a call to analyze case studies of collaboration at the group unit of analysis, rather than a claim that some kind of group mind exists beyond the situated and transient group discourse itself. As Stahl (2003) argued, one can identify processes of meaning-making or knowledge-building in the interaction that cannot be attributed to any individual group members, although the participation of the individuals in the group process is necessary as sources of contributed utterances and as interpreters of the shared meaning.

In fact, analysis at the group level of description often demonstrates that even when someone learns or thinks in seeming isolation, this activity is essentially conditioned or mediated by important social considerations. This was a general claim of Vygotsky (1930/1978): that intersubjective or inter-psychological or group learning generally preceded individual or intra-psychological learning, which resulted from the internalization of what took place socially. Koschmann points out that Vygotsky—one of the principle theoretical sources for CSCL—proposed the "zone of proximal development" as "a mechanism for learning on the inter-psychological plane" (p. 12).

Vygotsky (1930/1978) contrasted his conception of potential social development to the traditional psychological focus on individual learning, saying "In studies of children's mental development it is generally assumed that only those things that children can do on their own are indicative of mental abilities" (p. 85). Vygotsky's alternative social conception of development was meant to measure a child's position in the "process by which children grow into the intellectual life of those around them" (p. 88; italics in original), as opposed to their mental position in doing tasks on their own.

The italicized phrase is strikingly similar to the definition of situated learning by Lave and Wenger (1991)—another central source of CSCL's theory of learning. Related foundations of the CSCL paradigm include Hutchins' (1996) presentation of distributed cognition and Suchman's (1987) discussion of situated action. Despite the attempt by these traditions within CSCL to overcome the traditional focus of educational and psychological theories on the individual as cognitive agent, none of them have worked out a satisfactory theory of group cognition.

Stahl (2003) drew on the aforementioned and other sources to argue for taking *meaning* that is constructed in successful processes of collaboration as a shared group product, which is, however, necessarily subject to *interpretation* by the individuals involved. As much as the writings on situated action, distributed cognition, social constructivism, activity theory, social practice, etc. have foregrounded the social nature of learning and thinking, it is still hard for most people to overcome their individualistic conceptual traditions and come to terms with group learning or group cognition. This Investigation is an attempt to further that effort by considering just what is meant by shared meaning and group cognition.

The Problem of Shared Meaning

The analysis by Stahl (2003) tried to provide insight into the nature of the *group perspective*. In particular, its Chapter 16 argued for a view of both shared group *meaning* and individual *interpretation*. Shared meaning was not reduced to mental representations buried in the heads of individuals. Such mental contents could only be inferred from introspection and from interpretation of people's speech and behavior, whereas socially shared meaning can be observed in the visibly displayed discourse that takes place in group interactions, including non-verbal communication and associated artifacts. This approach does not result in a behaviorist denial of human thought in bracketing out inferred mental states and focusing on observable interaction, because of the methodological recognition of interpretive perspectives. People are considered to be interpreting subjects, who do not simply react to stimuli but understand meanings.

It is true that only individuals can interpret meaning. But this does not imply that the group meaning is just some kind of statistical average of individual mental meanings, an agreement among pre-existing opinions, or an overlap of internal representations. A group meaning is constructed by the interactions of the group's members, not by the individuals on their own. It is an emergent property of the discourse and interaction. It is not necessarily reducible to assumed personal opinions or isolated understandings of individuals.

Stahl (2004) presented an example of how this works. The discourse transcribed there is strikingly elliptical, indexical, and projective; that means that it implies and requires a (perhaps open-ended) set of references to complete its meaning. These references are more a function of the history and circumstances of the discourse than of intentions attributable to specific participants. The words in the analyzed collaborative moment refer primarily to each other, to characteristics of the artifacts discussed, and to group interactions. In fact, one can only attribute well-defined opinions and intentions to the individual students after one has extensively interpreted the meanings of the discourse as a whole.

As seen in the example transcript, the shared meaning was collaboratively created by the group as a whole. But the establishment of that meaning as shared involved a process of negotiation through which the individual group members had to interpret the meaning from their own personal perspectives, to display their understanding of the meaning, and to affirm that meaning as shared. The collaborative process itself entailed corresponding individual processes. In a sense, one can say both that the individuals learned as a result of the group learning and that the group could only learn by ensuring that the individuals learned.

Of course, the kind of "learning" that happens in a brief interaction is not the kind of learning that educators look for over months. It is perhaps better referred to as "knowledge building," in which some word or utterance takes on a new shared meaning. To understand what takes place in collaborative interactions, it seems important to become clearer about the nature of shared knowledge—how it is produced, negotiated, distributed, and internalized.

The major difficulty in understanding shared knowledge and group cognition is that it is habitual to attribute thoughts and intentions to individual actors—and to reduce group phenomena to actions of the individual group members. One typically assumes that a speaker's words are well defined in advance in the speaker's mind and that the discourse is just a way for the speaker to express some preconceived meaning and to convey it to the listeners. This reveals a conflict. If meaning is socially constructed, why do researchers feel compelled to treat it as private property; if it takes place in isolated minds, how can it ever be shared and understood collaboratively? The possibility of shared meaning must be somehow explained. This is particularly important in cases of collaborative learning, where the knowledge that is constructed must be shared among the learners (or may be shared first, before it can become part of an individual's knowledge).

The term "shared knowledge" is ambiguous. It can refer to:

- Similarity of individuals' knowledge: The knowledge in the minds of the members of a group happens to overlap, and their intersection is "shared."
- Knowledge that gets shared: Some individuals communicate what they already knew to the others, who then "share" it.
- Group knowledge: Knowledge is interactively achieved in discourse and may not be attributable as originating from any particular individual. It is part of a "shared" world.

The ambiguity of this term corresponds to different paradigms of viewing group interaction: whether it is taken to be a result of individual knowledge, reducible to knowledge held by individual thinkers, or an emergent property of the group discourse as an irreducible unit for purposes of analysis. If CSCL is to be conceived as a fundamentally new educational form, rather than just a technique for fostering individual learning, then it seems that something like the third reading of "shared knowledge" needs to be explicated.

A Conflict of Paradigms

Research on learning and education is troubled to its core by the conflict of paradigms we are considering. Sfard (1998) reviewed some of the history and consequences of this conflict in terms of the incompatibility of the acquisition metaphor (AM) of learning and the participation metaphor (PM). AM conceives of education as a transfer of knowledge commodities and their subsequent possession by individual minds. Accordingly, empirical research in this paradigm looks for evidence of learning in changes of mental contents of individual learners. PM, in contrast, locates learning in intersubjective, social or group processes, and views the learning of individuals in terms of their changing participation in the group interactions. AM and PM are as different as day and night, but Sfard argues that we must learn to live in both complementary metaphors.

The conflict is particularly pointed in the field of CSCL. Taken seriously, the term "collaborative learning" can itself be viewed as self-contradictory given the tendency to construe learning as something taking place in individual minds. Having emerged from the paradigm shift in thinking about instructional technology described by Koschmann (1996), the field of CSCL is still enmeshed in the paradigm conflict between opposed cognitive and sociocultural focuses on the individual and on the group (Kaptelinin & Cole, 2002). In his keynote at the CSCL '02 conference, Koschmann (2002a) argued that even exemplary instances of CSCL research tend to adopt a theoretical framework that is anathema to collaboration. Koschmann recommended that talk about "knowledge" as a thing that can be acquired should be replaced with discussion of "meaning-making in the context of joint activity" in order to avoid misleading images of learning as mental acquisition and possession of knowledge objects.

Although Koschmann's alternative phrase can describe the intersubjective construction of shared meanings achieved through group interaction, the influence of AM can re-construe meaning-making as something that must perforce take place in individual human minds, because it is hard for most people to see how a group can possess mental contents. Stahl (2003) argued in effect that both Koschmann's language and that of the researchers he critiqued is ambiguous and is subject to interpretation under either AM or PM. A simple substitution of wording is inadequate; it is necessary to make explicit when one is referring to individual subjective understanding and when one is referring to group intersubjective understanding—and to make clear to those under the sway of AM how intersubjectivity is concretely possible.

The problem with recommending that researchers view learning under both AM and PM or that they be consistent in their theoretical framing is that our commonsense metaphors and widespread folk theories are so subtly entrenched in our thinking and speaking. The languages of Western science reflect deep-seated assumptions that go back to the *ideas* of Plato's *Meno* (350 BCE/ 1961) and the *ego cogito* of Descartes' *Meditations* (1633/1999). It is hard for most people to imagine how a group can have knowledge, because we assume that knowledge is a substance that only minds can acquire or possess and that only physically distinct individuals can have minds (somewhere in their physical heads). The term *meaning* as in *shared meaning* carries as much historical baggage as the term *knowledge* in *knowledge building*.

The Range of Views

CSCL grows out of research on cooperative learning that demonstrated the advantages for individual learning of working in groups (e.g., Johnson & Johnson, 1989). There is still considerable ambiguity or conflict about how the learning that takes place in contexts of joint activity should be conceptualized. While it has recently been argued that the key issues arise from ontological and epistemological commitments deriving from philosophy from Descartes to Hegel (Koschmann, 2002b; Packer & Goicoechea, 2000), Stahl (2004) argued that it is more a matter of focus on the individual (cognitivist) versus group (sociocultural) as the unit of analysis.

Theoretical positions on the issue of the unit of learning (e.g., in the compilations of essays on shared cognition (Resnick, Levine & Teasley, 1991) or distributed cognition (Salomon, 1993)) take on values along a spectrum from individual to group. The following is an attempt to characterize possible positions along this spectrum, most of which have been advocated for in the literature:

- Learning is always accomplished by individuals, but this individual learning can be assisted in settings of collaboration, where individuals can learn from each other.
- Learning is always accomplished by individuals, but individuals can learn in different ways in settings of collaboration, including learning how to collaborate.
- Groups can also learn, and they do so in different ways from individuals, but the knowledge generated must always be located in individual minds.
- Groups can construct knowledge that no one individual could have constructed alone by a synergistic effect that merges ideas from different individual perspectives.
- Group knowledge can be spread across people and artifacts; it is not reducible to the knowledge of any individual or the sum of individuals' knowledge.
- Groups construct knowledge that may not be in any individual minds but may be interactively achieved in group discourse and may persist in physical or symbolic artifacts such as group jargon or texts or drawings.
- Learning is always a mix of individual and group processes; the analysis of learning should be done with both the individual and group as units of analysis and with consideration of the interplay between them.
- Individual learning takes place by internalizing or externalizing knowledge that was already constructed interpersonally; even modes of individual thought have been internalized from communicative interactions with other people.
- All human learning is fundamentally social or collaborative; language is never private; meaning is intersubjective; knowledge is situated in culture and history.

These different positions imply different answers to why CSCL is important. At one extreme of the spectrum, collaboration is only valued to the extent that it results in desirable learning outcomes for individual minds. At the other extreme, collaborative learning can benefit a whole community of practice by developing cultural artifacts like theories. Intermediate positions may acknowledge that benefits accrue at group and individual levels in parallel, through reciprocal influences.

The different positions listed above are supported by a corresponding range of theories of human learning and cognition. Educational research on small group process in the 1950s and 1960s maintained a focus on the individual as learner (Johnson & Johnson, 1989; see review in Stahl, 2000). Classical cognitive science in the next period continued to view human cognition as primarily an individual matter—internal symbol manipulation or computation across mental representations inside an individual's brain, with group effects treated as secondary boundary constraints (Simon, 1981; Vera & Simon, 1993).

In reaction to these views, a number of sociocultural theories have become prominent in the learning sciences in recent decades. To a large extent, these theories have origins in much older works that conceptualized the situatedness of people in practical activity within a shared world (Bakhtin, 1986; Heidegger, 1927/1996; Husserl, 1936/1989; Marx, 1867/1976; Schutz, 1967; Vygotsky, 1930/1978).

The following list describes some representative theories that focus on the group as a possible unit of knowledge construction. Of course, each theory is itself too complex to be summarized meaningfully in a sentence, consisting of multiple texts and redefining terms like "learning" and "knowledge" in the process of developing a theory:

- *Collaborative Knowledge Building*. A group can build knowledge that cannot be attributed to an individual or to a combination of individual contributions, but that exists as textual artifacts that can be critiqued by others (Bereiter, 2002; Donald, 1991).
- *Social Psychology*. One can and should study knowledge construction at both the individual and group unit of analysis, as well as studying the interactions between them (Fischer & Granoo, 1995; Resnick et al., 1991; Salomon, 1993).
- *Distributed Cognition*. Knowledge can be spread across a group of people and the tools that they use to solve a problem (Hutchins, 1996; Norman, 1993).
- *Situated Cognition*. Knowledge often consists of resources for practical activity in the world more than of rational propositions or mental representations (Schön, 1983; Suchman, 1987; Winograd & Flores, 1986).
- *Situated Learning*. Learning is the changing participation of people in communities of practice (Lave & Wenger, 1991; Shumar & Renninger, 2002).
- *Zone of Proximal Development*. Children grow into the intellectual life of those around them; they develop in collaboration with adults or more capable peers (Vygotsky, 1930/1978).
- *Activity Theory*. Human understanding is mediated not only by physical and symbolic artifacts but also by the social division of labor and cultural practices (Engeström, 1999; Nardi, 1996).
- *Ethnomethodology*. Human understanding, interpersonal relationships, and social structures are achieved and reproduced interactionally (Dourish, 2001; Garfinkel, 1967).

One does not have to commit to one of these theories in particular in order to gain a sense from them all of the possible nature of group knowledge.

Most of these theories hinge on the question of how it is possible for shared knowledge to be established. Despite this, none of these authors have explained how groups can learn in sufficient detail to overcome widespread resistance to thinking about learning at the group level of description.

Common Ground or Group Cognition?

Within CSCL, it is usual to refer to the theory of "common ground" to explain how collaborative understanding is possible. Baker et al. (1999), for instance, note that collaboration requires mutual understanding among the participants, established through a process of "grounding."

It is certainly clear that effective communication is generally premised on the sharing of a language, of a vast amount of practical background knowledge about how things work in the physical and social world, of many social practices implicit in interaction, and of an orientation within a shared context of topics, objects, artifacts, previous interactions, etc. Much of this sharing we attribute to our socialization into a common culture or into overlapping sub-cultures.

Most common ground is taken for granted as part of what it means to be human. The phenomenological hermeneutics of Heidegger (1927/1996) and Gadamer (1960/1988)—building on the traditions of Dilthey and Husserl—made explicit the ways in which human understanding and our ability to interpret meaning rely upon a shared cultural horizon. It emphasized the centrality of interpretation to human existence as being engaged in the world. It also considered cases where common ground breaks down, such as in interpreting ancient texts or translating from foreign languages—e.g., how can a modern German or American understand a theoretical term from a Platonic dialogue or from a Japanese poem?

The current discussion of common ground within CSCL is, however, more focused. It is concerned with the short-term negotiation of common ground during brief interactions. Such negotiation is particularly visible when there is a breakdown of the common ground, an apparent problem in the mutual understanding. A breakdown appears through the attempt of the participants to repair a misunderstanding or lack of mutuality. For instance, in the presentations of Roschelle (1996) and Stahl (2004), much of the transcribed discourse was analyzed as attempts to reach shared understandings in situations in which the group discussion had become problematic.

It is not always clear whether repairs to breakdowns in such common ground come from ideas that existed in someone's head and are then passed on to others until a consensus is established or whether the common ground might be constructed in the interaction of the group as a whole. It is possible that shared knowledge can sometimes be best explained in one way, sometimes another. At any rate, it seems that the question of the source of shared knowledge should generally be treated as an empirical question. This is what is proposed in the next section of this Investigation. But first, this alternative should be made a bit clearer.

The theory of common ground that Baker et al. (1999), Roschelle (1996), and many others in CSCL refer to is that of Clark and his colleagues. Clark and Brennan (1991) situate their work explicitly in the tradition of conversation analysis (CA), although their theory has a peculiarly mentalist flavor uncharacteristic of CA. They argue that collaboration, communication, and "all collective actions are built on common ground and its accumulation" (p. 127). The process of updating this common ground on a moment-by-moment basis in conversation is called "grounding." Grounding, according to this theory, is a collective process by which participants try to reach mutual belief. It is assumed that understanding (i.e., mutual belief) can never be perfect (i.e., the participants can never have beliefs that are completely identical). It suffices that "the contributor and his or her partners mutually believe that the partners have understood what the contributor meant to a criterion sufficient for current purposes" (p. 129). Clark and Brennan (1991) then show how various conversational moves between pairs of people can conduct this kind of grounding and achieve a practical level of mutuality of belief. They go on to show how different technologies of computer support mediate the grounding process in different ways.

Clark's contribution theory—where one participant "contributes" a personal belief as a proposed addition to the shared common ground and then the participants interact until they all believe that they have the same understanding of the original belief, at which point their common ground is “updated” to include the new contribution—is articulated in the language of individual mental beliefs, if not to say in the jargon of computer models of rational memories. Thus, it is not surprising that Schegloff (1991) responds polemically to Clark and Brennan (1991) by opposing the tradition of ethnomethodology and CA to this theory of mental beliefs: Schegloff points out that Garfinkel (1967) “asked what exactly might be intended by such notions as ‘common’ or ‘shared’ knowledge. In the days when computers were still UNIVACS, Garfinkel viewed as untenable that notion of common or shared knowledge that was more or less equal to the claim that separate memory drums had identical contents” (p. 151f). Schegloff then presented an analysis of repair in talk-in-interaction that contrasted with Clark’s by construing what took place as a social practice following social patterns of interaction. According to Schegloff’s approach, repair is a form of socially shared cognition that takes place in the medium of discourse (in the broad sense of social interaction-in-talk), following established conversational patterns, rather than a transfer and comparison of beliefs between rationalist minds.

In a later critique of Clark’s contribution theory of common ground, Koschmann and LeBaron (2003) present video data of an interaction in an operating room. A resident, an attending doctor, and an intern are discussing the location of internal organs as viewed indirectly through a laparoscopic camera. Koschmann and LeBaron argue that the discourse that takes place does not match Clark’s rubric and that the very notion of belief contributions to some kind of common ground storage space is not useful to understanding the construction of shared understanding in this situation. Although the medical operation is successful and although technology-supported collaborative learning takes place, the beliefs of the individual participants afterward do not agree in Clark’s sense. Thus, there seems to be a group shared understanding, which is effective in the practice of the operation, but which does not correspond to the understanding of any of the individual participants when considered outside their working team—as Clark’s theory of common ground would have it.

Perhaps the case of the operating room (OR) illustrates Vygotsky’s contrast between a person’s individual developmental level and their social developmental level (separated by the zone of proximal development). The intern was able to participate in the collaborative activity even though he could not correctly identify key items on his own afterward, outside the group. This might indicate that what takes place in group interactions cannot reliably be reduced to behaviors of the individuals involved. The knowledge and abilities of people in individual and group settings are quite different. The group cognition of the OR team would then not be a simple sum of the individual cognitive acts of its members; the group understanding would not be a simple intersection or overlap of individual beliefs, as identifiable outside of the group context.

Of course, the OR situation was a special case which differed in significant ways from most everyday conversation. Often, interaction can be adequately analyzed as the exchange of personal beliefs. This is particularly true of dyadic conversations, such as those in Clark’s examples, rather than in the more complex interactions of small groups of three or more in the OR—or in CSCL generally. The question for CSCL is: Can sets of students be transformed into groups that learn collaboratively in ways that encourage the emergence of collaborative group cognition in a significant sense? This is, above all, an empirical question, although it requires a clear conceptual framework for defining and interpreting the data.

Empirical Inquiry into Group Cognitive Practices

At Drexel University, an interdisciplinary group of researchers and staff of the Math Forum—a popular online site with resources and problems related to K-12 school mathematics—undertook a research project to investigate empirically whether knowledge sharing in community contexts can construct group knowledge that exceeds the individual knowledge of the group's members. Their hypothesis was that precisely such a result is, in fact, the hallmark of collaborative learning, understood in an emphatic sense, as a vision of the future. This research is based on earlier work that indicated the possibility of observing group cognition in recordings or transcripts of team discourse.

Roschelle's (1996) study of two students constructing a new (for them) conception of acceleration can be construed as an analysis of shared knowledge building. As Koschmann (2002a) pointed out, the analytic paradigm of that paper is ambiguous. Its focus on the problematic of convergence posits the conceptual change as taking place in the minds of the two individual students while at the same time raising the issue of the possibility of shared (i.e., convergent) knowledge. The study reported by Stahl (2004) was an attempt to analyze knowledge building at the group level by a group of five students. That analysis was in some respects similar to Roschelle's.

Our proposed new research at the Math Forum takes Stahl's (2004) study as a pilot study and aims to generate a corpus of group interactions in which problem-solving and knowledge building can be most effectively observed at the group level.[1] Like many studies of collaborative learning (but unlike the proposed study), the pilot study involved face-to-face interaction with an adult mentor present. Close analysis of student utterances during an intense interaction during that study suggested that the group developed an understanding that certainly could not be attributed to the utterances of any one student. In fact, the utterances themselves were meaningless if taken in isolation from the discourse and its activity context.

There were a number of limitations to the pilot study:

1. Although the mentor was quiet for the specific interaction analyzed, it might be possible to attribute something of the group knowledge to the mentor's guiding presence.
2. The digital videotape was limited in capturing gaze and even some spoken wording.
3. The data included only two sessions, too little to draw conclusions about how much individual students understood of the group knowledge before, during or after the interaction.

To overcome such limitations, in our proposed study:

1. Mentors are not active in the collaborative groups—although the groups work on problems that have been carefully crafted to guide student inquiry and advice can be requested by email from Math Forum staff.
2. The online communication is fully logged, so that researchers have a record of the complete problem-solving interaction, essentially identical to what the participants see online.
3. Groups and individuals are studied during longer, more multi-faceted problem-solving sessions—and in some cases over multiple sessions.

Despite its limitations, the pilot study clearly suggested the feasibility of studying group knowledge. It showed how group knowledge can be constructed in discourse and how discourse analysis can "make visible" that knowledge to researchers. We want to study this in more detail.

We are investigating not only whether computer-supported collaborative learning can construct novel group knowledge but also what community contexts are favorable to fostering such an outcome. We are doing this by designing and implementing an experimental service in the Math Forum. Students visiting the site are invited to join small virtual teams to discuss and solve math problems

[1]This discussion is largely drawn from an early proposal to the National Science Foundation for funding what became the Virtual Math Teams (VMT) Project from 2003 to 2015. It reflects the author's understanding of theoretical issues of CSCL in the early 2000s. For the original proposals, see (Stahl, 2010).

collaboratively online. We analyze the interactions in these teams to determine how they build shared knowledge within the Math Forum virtual community.

We are addressing the issue of the nature of shared understanding by studying online collaborative learning in the specific context of Math Forum problems, with the aim of presenting empirical examples of concrete situations in which groups can be seen to have knowledge that is distinct from the knowledge of the group members. By analyzing these situations in detail, we will uncover mechanisms by which understanding of mathematics passes back and forth between the group as the unit of analysis and individual group members as units of analysis.

One example might be a group of five middle-school students collaborating online. They solve an involved algebra problem and submit a discussion of their solution to the Math Forum. By looking carefully at the computer logs of their interactions in which they collaboratively discussed, solved, and reflected upon the problem, we can see that the group solution exceeds the knowledge of any individual group members before, during, or after the collaboration. For instance, there may be some arguments that arose in group interaction that none of the students fully understood but that contributed to the solution. Or a mathematical derivation might be too complicated for any of the students to keep “in mind” without reviewing preserved chat archives or using an external representation the group developed on an online whiteboard. By following the contributions of one member at a time, it may also be possible to find evidence of what each student understood before, during, and after the collaboration and thereby to follow individual trajectories of participation in which group and individual understandings influenced each other.

While we do not anticipate that group knowledge often exceeds that of all group members under generally prevailing conditions, we hypothesize that it can do so at least occasionally under particularly favorable conditions. We believe that we can set up naturalistic conditions as part of a Math Forum service and can collect sufficient relevant data to demonstrate this phenomenon in multiple cases. The analysis and presentation of these cases should help to overcome the AM/PM paradigm conflict by providing concrete illustrations of how knowledge can be built through group participation as distinct from—but intertwined with—individual acquisition of part of that knowledge. It should also help to clarify the theoretical framing of acts of meaning-making in the context of joint activity.

Student discourse is increasingly recognized as of central importance to science and math learning (Bauersfeld, 1995; Lemke, 1990). Discourse analysis is a rigorous human science, going under various names: conversation analysis, interaction analysis, micro-ethnography, and ethnomethodology (Garfinkel, 1967; Heritage, 1984; Jordan & Henderson, 1995; Sacks, 1965/1995; Streeck & Mehus, 2003). This method of analysis will allow us to study what takes place through the collaborative interactions. We will be looking for evidence of learning at the micro-level, where shared meanings are developed and knowledge is built up as part of solving a challenging math problem.

The focus on discourse suggests a solution to the confusion between individual and group knowledge and to the conceptual conflict about how there can be such a thing as group knowledge distinct from what is in the minds of individual group members. One way of putting it is that meaning is constructed in the group discourse. The status of this meaning as shared by the group members is itself something that must be continually achieved in the group interaction; frequently the shared status “breaks down” and a “repair” is necessary. In the pilot study, the interaction of interest centered on precisely such a repair of a breakdown in shared understanding among the discussants.

While *meaning* inheres in the discourse, the individual group members must construct their own *interpretation* of that meaning in an ongoing way. Clearly, there are intimate relationships between the meanings and their interpretations, including the interpretation by one member of interpretations by other members. However, it is also true that language can convey meanings that transcend the understandings of the speakers and hearers. It may be precisely through divergences among different interpretations or among various connotations of meaning that collaboration gains much of its creative power (Stahl, 2003).

These are questions that we will investigate as part of our micro-analytic studies of collaboration data, guided by our central working hypothesis:

- H0 (collaborative learning hypothesis): A small online group of learners can—on occasion and under favorable conditions—build group knowledge and shared meaning that exceeds the knowledge of the group's individual members.

We believe that such an approach can maintain a focus on the ultimate potential in CSCL, rather than losing sight of the central phenomena of collaboration as a result of methods that focus exclusively on statistical trends (Stahl, 2002).

Issues for Investigation

While we believe that it is possible to clarify the nature of shared knowledge and group cognition by serious reflection upon the existing theoretical discussions and case studies that touch on these concepts (many of which have been referenced here), we are convinced that significant progress and convincing arguments will require further empirical research.

Collaborative success is hard to achieve and probably impossible to predict. CSCL represents a concerted attempt to overcome some of the barriers to collaborative success, like the difficulty of everyone in a group effectively participating in the development of ideas with all the other members, the complexity of keeping track of all the interconnected contributions that have been offered, or the barriers to working with people who are not visually co-located. As appealing as the introduction of technological aids for communication, computation, and memory seem, they inevitably introduce new problems, changing the social interactions, tasks, and physical environment. Accordingly, CSCL study and design must take into careful consideration the social composition of groups, the collaborative activities, and the technological supports.

In order to observe effective collaboration in an authentic educational setting, we are adapting a successful math education service to create conditions that will likely be favorable to the kind of interactions that we want to study. We must bring together groups of students who will work together well, both by getting along with and understanding each other and by contributing a healthy mix of different skills. We must also carefully design mathematics curriculum packages that lend themselves to the development and display of deep math understanding through collaborative interactions—open-ended problems that will not be solved by one individual, but that the group can chew on together in online interaction. Further, the technology that we provide to our groups must be easy to use from the start while meeting the communicative and representational needs of the activities.

As part of our project, we will study how to accomplish these group-formation, curriculum-design, and technology-implementation requirements. This is expressed in three working hypotheses of the project: H1, H2, and H3. Two further working hypotheses define areas of knowledge building that the project itself will engage in based on our findings. H4 draws conclusions about the interplay between group and individual knowledge, mediated by physical and symbolic artifacts that embody knowledge in persistent forms. H5 reports on the analytic methodology that emerges from the project:

- H1 (collaborative-group hypothesis): Small groups are most effective at building knowledge if members share interests but bring to bear diverse backgrounds and perspectives.
- H2 (collaborative-curriculum hypothesis): Educational activities can be designed to encourage and structure effective collaborative learning by presenting open-ended problems requiring shared deep understanding.

- H3 (collaborative-technology hypothesis): Online computer-support environments can be designed to facilitate effective collaborative learning that overcomes limitations of face-to-face communication.
- H4 (collaborative-cognition hypothesis): Members of collaborative small groups can internalize group knowledge as their own individual knowledge, and they can externalize it in persistent artifacts.
- H5 (collaborative-methodology hypothesis): Quantitative and qualitative analysis and interpretation of interaction logs can make visible to researchers the online learning of small groups and individuals.

We believe that the theoretical confusion surrounding the possibility of group knowledge presents an enormous practical barrier to collaborative learning. Because students and teachers generally believe that learning is necessarily an individual matter, they find the effort at collaborative learning to be an unproductive nuisance. For researchers, too, the misunderstanding of collaborative learning distorts their conclusions, leading them to look for effects of pedagogical and technological innovation in the wrong places.

If these people understood that groups can construct knowledge in ways that significantly exceed the sum of the individual contributions and that the power of group learning can feed back into individual learning, then we might start to see the real potential of collaborative learning realized on a broader scale. This project aims to produce rigorous and persuasive empirical examples of collaborative learning to help bring about the necessary public shift in thinking.

References

Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 31–63). Oxford, UK: Pergamon.

Bakhtin, M. (1986). *Speech genres and other late essays* (V. McGee, Trans.). Austin, TX: University of Texas Press.

Bauersfeld, H. (1995). "Language games" in the mathematics classroom: Their function and their effects. In P. C. H. Bauersfeld (Ed.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 271–289). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Clark, H., & Brennan, S. (1991). Grounding in communication. In L. Resnick, J. Levine, & S. Teasley (Eds.), *Perspectives on socially-shared cognition* (pp. 127–149). Washington, DC: APA.

Crook, C. (1994). *Computers and the collaborative experience of learning*. London, UK: Routledge.

Descartes, R. (1633/1999). *Discourse on method and meditations on first philosophy*. New York, NY: Hackett.

Dillenbourg, P. (Ed.). (1999). *Collaborative learning: Cognitive and computational approaches*. Amsterdam, NL: Pergamon, Elsevier Science.

Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.

Dourish, P. (2001). *Where the action is: The foundations of embodied interaction*. Cambridge, MA: MIT Press.

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 19–38). Cambridge, UK: Cambridge University Press.

Fischer, K., & Granoo, N. (1995). Beyond one-dimensional change: Parallel, concurrent, socially distributed processes in learning and development. *Human Development, 1995*(38), 302–314.

Gadamer, H.-G. (1960/1988). *Truth and method*. New York, NY: Crossroads.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Heidegger, M. (1927/1996). *Being and time: A translation of Sein und Zeit* (J. Stambaugh, Trans.). Albany, NY: SUNY Press.

Heritage, J. (1984). *Garfinkel and ethnomethodology*. Cambridge, UK: Polity Press.

Husserl, E. (1936/1989). The origin of geometry (D. Carr, Trans.). In J. Derrida (Ed.), *Edmund Husserl's origin of geometry: An introduction* (pp. 157–180). Lincoln, NE: University of Nebraska Press.

Hutchins, E. (1996). *Cognition in the wild*. Cambridge, MA: MIT Press.

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction Book Company.
Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences, 4*(1), 39–103. http://lrs.ed.uiuc.edu/students/c-merkel/document4.HTM.
Kaptelinin, V., & Cole, M. (2002). Individual and collective activities in educational computer game playing. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *Cscl2: Carrying forward the conversation* (pp. 297–310). Mahwah, NJ: Lawrence Erlbaum Associates.
Koschmann, T. (1996). Paradigm shifts and instructional technology. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 1–23). Mahwah, NJ: Lawrence Erlbaum.
Koschmann, T. (2002a). Dewey's contribution to the foundations of CSCL research. In G. Stahl (Ed.), *Computer support for collaborative learning: Foundations for a CSCL community: Proceedings of CSCL 2002* (pp. 17–22). Boulder, CO: Lawrence Erlbaum Associates.
Koschmann, T. (2002b). *Differing ontologies: Eighteenth-century philosophy and the learning sciences.* In the proceedings of the International Conference of the Learning Sciences (ICLS'02). Seattle, WA.
Koschmann, T., & LeBaron, C. (2003). *Reconsidering common ground: Examining Clark's contribution theory in the operating room.* In the proceedings of the European Computer-Supported Cooperative Work (ECSCW '03). Helsinki, Finland. Proceedings pp. 81–98.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
Lemke, J. (1990). *Talking science*. Norwood, NJ: Ablex.
Marx, K. (1867/1976). *Capital* (B. Fowkes, Trans. Vol. I). New York, NY: Vintage.
Nardi, B. (Ed.). (1996). *Context and consciousness: Activity theory and human-computer interaction*. Cambridge, MA: MIT Press.
Norman, D. A. (1993). *Things that make us smart*. Reading, MA: Addison-Wesley Publishing Company. 290 pages.
O'Malley, C. (1995). *Computer supported collaborative learning*. Berlin, Germany: Springer Verlag.
Packer, M., & Goicoechea, J. (2000). Sociocultural and constructivist theories of learning: Ontology, not just epistemology. *Educational Psychologist, 35*(4), 227–241.
Plato. (350 BCE/1961). Meno. In E. Hamilton & H. Cairns (Eds.), The collected dialogues of Plato (pp. 353–384). Princeton, NJ: Princeton University Press.
Resnick, L., Levine, J., & Teasley, S. (Eds.). (1991). *Perspectives on socially shared cognition*. Washington, DC: American Psychological Association.
Roschelle, J. (1996). Learning by collaborating: Convergent conceptual change. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 209–248). Hillsdale, NJ: Lawrence Erlbaum Associates.
Sacks, H. (1965/1995). *Lectures on conversation*. Oxford, UK: Blackwell.
Salomon, G. (1993). *Distributed cognitions: Psychological and educational considerations*. Cambridge, UK: Cambridge University Press.
Schegloff, E. (1991). Conversation analysis and socially shared cognition. In L. Resnick, J. Levine, & S. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 150–171). Washington, DC: APA.
Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books.
Schutz, A. (1967). *Phenomenology of the social world* (F. Lehnert, Trans.). Evanston, IL: Northwestern University Press.
Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4–13.
Shumar, W., & Renninger, K. A. (2002). Introduction: On conceptualizing community. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities* (pp. 1–19). Cambridge, UK: Cambridge University Press.
Simon, H. (1981). *The sciences of the artificial* (2nd ed.). Cambridge, MA: MIT Press.
Stahl, G. (2000). Review of "professional development for cooperative learning: Issues and approaches" [book review]. *Teaching and Learning in Medicine: An International Journal, 12*(4) http://GerryStahl.net/cscl/papers/ch18.pdf.
Stahl, G. (2002). Rediscovering CSCL. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 169–181). Hillsdale, NJ: Lawrence Erlbaum Associates.
Stahl, G. (2003). *Meaning and interpretation in collaboration.* In the proceedings of the designing for change in networked learning environments: Proceedings of the International Conference on Computer Support for Collaborative Learning (CSCL '03). B. Wasson, S. Ludvigsen & U. Hoppe. Bergen, Norway. Proceedings pp. 523–532. Kluwer Publishers.
Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of CSCL. In J.-W. Strijbos, P. Kirschner, & R. Martens (Eds.), *What we know about CSCL: And implementing it in higher education* (pp. 53–86). Boston, MA: Kluwer Academic Publishers.
Stahl, G. (2010). *Proposals for research*. Philadelphia, PA: Gerry Stahl at Lulu. 626 pages. http://GerryStahl.net/elibrary/proposals/proposals.pdf

Streeck, J., & Mehus, S. (2003). Microethnography: The study of practices. In K. F. R. Sanders (Ed.), *Handbook of language and social interaction*. Mahway, NJ: Erlbaum Associates.

Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge, UK: Cambridge University Press.

Vera, J., & Simon, H. (1993). Situated action: A symbolic interpretation. *Cognitive Science, 17*(1), 7–48.

Vygotsky, L. (1930/1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation of design*. Reading, MA: Addison-Wesley.