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Group-Cognition Factors in Socio-Technical Systems

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Abstract

Objective: This commentary on the special issue suggests a focus on group-cognition factors in investigations of teamwork involving socio-technical systems. **Background:** The author has conducted research in Computer-Supported Collaborative Learning and has found the need to re-think the theory and methodology of that field to take account of its defining characteristics of small-group interaction and socio-technical mediation. **Method:** A brief literature review is undertaken of major findings in post-cognitive theory and Conversation Analysis. This suggests a methodological priority to group phenomena as sources for the genesis of individual phenomena and for understanding of processes of coordination and communication in small groups. **Results:** It is seen that many recent studies of teams take place within traditional disciplinary frameworks that analyze phenomena primarily at the individual unit of analysis, reducing group phenomena to additive sums of individual phenomena. For instance, processes of coordination and communication are treated as secondary to the expression of individuals' mental models or external expressions of internal representations. **Conclusion:** The commentary calls for development of a new science of groups, with the development of appropriate theory, conceptualizations of core phenomena, experimental methods, analytic analyses and presentational formats. Examples are: focus on discourse analysis, use of design-based research, conceptualization of mediation rather than causation and publication of case studies. **Application:** A focus on the group unit of analysis can shed new light on the topics addressed in this special issue.

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Keywords

Collaborative learning, post-cognitive theory, group cognition, conversation analysis, group unit of analysis.

The articles in this special issue illustrate impressively the application of a widely diverse set of theoretical perspectives, experimental approaches, analytic methodologies and disciplinary concerns. In terms of subject matter as well, the variety of coordination strategies, communication media and socio-technical contexts investigated is no less daunting. Many of the papers express the feeling that they are partaking in a grand beginning of investigating this vast new territory; that they have just begun to peek into a realm that is still quite unexplored. At the same time, one repeatedly finds familiar categories, computations and theoretical moves borrowed uncritically from well-established domains. One wonders if the brave new world of socio-technical systems and ubiquitous teamwork might require a more radical re-tooling of the machinery of research than such facile re-application. Sure, one can extend analyses of human factors from the situation of an individual computer user staring at the screen of a desktop computer in a sterile lab to that of teams of people interacting with extensive and messy networks of robots, software, communication systems and other teams. But it may also be true that there may be much to be gained from thinking about what is new and essentially different here, and what the implications of that might be for the methods of the science(s) that we pursue.

Coming from the field of computer-supported collaborative learning (CSCL), I have been led to view socio-technical systems primarily from the perspective of the small-group unit of analysis. CSCL explores how networked computers can support collaborative learning not only through the design of socio-technical systems that include communication support for students learning together, but also through innovative teacher/facilitator roles, scaffolded pedagogy and effective peer coordination. Many CSCL researchers come from education, psychology, cognitive science and computer science and still tend to focus on learning as an individual process involving mental processes, internal representations and mental models. Rather than assuming that the categories of traditional approaches still get at the fundamental phenomena in an essentially transformed educational practice, I have tried to identify what is at the root of collaborative learning—such as group processes of coordination and communication.

In CSCL, learning takes place as group discourse. Coordination and communication are not accidental secondary factors, but the primary interaction through which everything else happens. Discourse—which can include speech, text, gesture, intonation, gaze, etc., even in an online environment in which these are indicated in various ways on a computer screen—is the shared world in which participants are engaged as contributors to a joint meaning-making process (Stahl, Koschmann & Suthers, 2006).

Taking the lead from various post-cognitive theories—from mediated cognition (Vygotsky, 1930/1978) to distributed (Hutchins, 1996), situated (Lave, 1991; Suchman, 2007) and embodied cognition (Dourish, 2001)—I try to push the theoretical viewpoint that focuses on the small group as the unit of analysis, as opposed to the many researchers who try to reduce group phenomena to the psychological individual as the ultimate basis of all cognition. I was driven to this approach by my empirical work designing and deploying socio-technical systems for collaborative learning in the 1990s (Stahl, 2006). In the past decade, I have explored what I call “group cognition” through design-based research developing support for virtual math teams (Stahl, 2009).

In his seminal work on distributed cognition, Hutchins (1996) critiques the foundations of traditional cognitive science (Newell & Simon, 1972) along Vygotskian lines by arguing not only that cognition can extend beyond the individual mind, but that group-cognitive processes have a micro-genetic priority and that there are some group-cognitive processes that cannot be internalized by individuals. For instance, the navigational skills that sailors on large naval ships have, they originally learned from their apprenticeship in navigation teams; furthermore, although they have internalized these skills enough to accomplish some navigational tasks as individuals, there are certain group-cognitive tasks that are too complex to be internalized by any one individual.

In our world of global economics and large socio-technical systems, there must be more such irreducibly group-cognitive tasks than we realize. Just as the Navy trains its navigators to work in teams that accomplish joint cognitive tasks—tasks evidencing a high level of computational complexity that cannot be reduced to the cognitive functions of individuals—so society generally must educate the work force and leadership of the next generation to think collaboratively as effective, innovative, knowledge-producing teams.

To radically re-think group cognition requires more than minimal extensions of traditional information-processing theories. That approach in some ways modeled human cognition on a model of computer computation and adopted an image of science based on the advances of natural sciences as opposed to human sciences. Group cognition involves meaning making and interpretation; it requires a new scientific paradigm, replacing mechanistic causal notions of statistical results under reproducible conditions with a notion of mediation under unique situations (Stahl, 2010). It must be grounded in detailed case studies of group interactions “in the wild.” Hutchins, Lave, Suchman and Dourish approach this through ethnography. I approach it through an adaptation of Conversation Analysis (Sacks, 1962/1995; Schegloff, 2007) to the online context. Just as the tape recorder and then video technology once made it possible for the first time to document face-to-face conversation in enough detail to support detailed analysis, so computer logs in carefully designed interventions can now capture everything at the group level of interaction and make it available for rigorous, situated detailed analysis. Group cognition is an emergent phenomenon, but it emerges from the semiotic interactions within the group discourse observed at the group unit of analysis, not directly from some

hypothesized comparison or agreement of mental models or computations among internal representations at the individual unit of analysis.

While it may initially seem that naturalistic online interaction mediated by complex socio-technical systems would be much harder to analyze than the cognitive efforts of an individual in a controlled lab setting, the opposite can be true. That is because everything that is shared in the group interaction must by definition be made visible for the multiple participants, whereas individual cognition is posited as not directly accessible. Once it is visible in a computer system, group cognition may be captured and made visible to analysts in a persistent form that can be studied in depth. For instance, a group's trains of thought and references to various concepts, images or experiences are displayed by the participants and these aspects of the group cognition are thereby made available for analysis. Whereas psychological or educational analyses of collaboration generally "black-box" key cognitive processes—e.g., by hypothesizing mental models or internal representations whose details cannot be explored empirically, but only inferred—these processes can be observed at work in the group discourse. For instance, an analyst can follow how a concept develops as it is successively used by different participants building on each other's utterance. One can see precisely what references are made to specific artifacts in the discourse context. Drawings—which often ground mathematical thinking—can be shared in the whiteboard, which then functions as part of the external memory of the group, its common ground or its joint problem space (Çakır, Zemel & Stahl, 2009; Sarmiento & Stahl, 2008). All this interactional data can be captured without interrupting cognition with think-aloud protocols or removing individuals from their interactive group context to administer surveys or interviews.

In particular, fine-grained analysis of discourse can reveal group-cognitive processes of communication and coordination—but also of argumentation, deduction, problem solving, explanation, etc. Conversation Analysis (CA) as a field has built up an impressive analysis of how everyday conversations work: what the rules are by which people take turns talking, how they respond to each other, what kinds of linguistic maneuvers they make to accomplish interpersonal moves, and so on. Specifically, CA looks at "adjacency pairs" as the elementary building blocks of face-to-face informal interaction. Because an adjacency pair includes an interchange between at least two people, it is irreducibly a group phenomenon.

For virtual math teams, we must adapt the CA approach to our context of online quasi-synchronous, text-based chat and whiteboard drawing. Rather than transcribing speaking and listening, we analyze typing and reading. Rather than observing socially enforced sequential turn taking, we reconstruct an implied sequential threading. Rather than studying social conversation we follow problem solving and mathematical exploration. Rather than tracking adult behavior, we examine novice learning of new math-discourse skills. So, in addition to the normal communication processes of interpersonal interaction, we can analyze effects of technological mediation; progressions attributable to learning; reasoning or explanation processes specific to math discourse; and coordination practices for collaborative problem solving.

Our approach to the study of group cognition in socio-technical systems involves a design-based research (Design-Based Research Collective, 2003) process that drives a co-evolution of technology, theory, intervention and analysis methodology—as can be seen in the diverse themes of the chapters of (Stahl, 2009). Our technology for virtual math teams has grown to support cognition and learning at the individual, small-group and community units, as required by our multi-level theory. Our analysis—focused for practical and theoretical reasons on the small-group unit of analysis—has resulted in many case studies that motivated new technical functionality as well as new pedagogical theories and interventions. We believe we have just begun to understand group cognition mediated by socio-technical systems and that there is much more to be learned by pursuing analysis that takes seriously the priority of the group unit of analysis.

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Biography

Gerry Stahl teaches, publishes and conducts research in information science, human-computer interaction and computer-supported collaborative learning at Drexel University in Philadelphia. He has PhDs in philosophy from Northwestern (1975) and in computer science from Colorado (1993). His books are *Group Cognition: Computer Support for Building Collaborative Knowledge* (2006, MIT Press) and *Studying Virtual Math Teams* (2009, Springer). He is founding Executive Editor of the *International Journal of Computer-Supported Collaborative Learning (ijCSCL)* and directs the Virtual Math Teams Project.