Virtual Math Teams: Explorations of Group Cognition
Gerry Stahl

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Gerry Stahl teaches, publishes and conducts research in human-computer interaction (HCI) and computer-supported collaborative learning (CSCL). His recent book, Group Cognition: Computer Support for Building Collaborative Knowledge was published by MIT Press. He is founding Executive Editor of the International Journal of Computer-Supported Collaborative Learning (ijCSCL), published by Springer. He has contributed chapters to two edited volumes of the Springer CSCL series. He is the Principal Investigator of the Virtual Math Teams Project, a large 5-year research effort in collaboration with the Math Forum @ Drexel. He served as Program Chair for the international CSCL ’02 conference, Workshops Chair for CSCL ’03, CSCL ’05, ICCE ’06 and CSCL ’07. He teaches undergraduate, masters and PhD courses in HCI, CSCW and CSCL at the I-School of Drexel University in Philadelphia. See CV for more details, at: http://www.cis.drexel.edu/faculty/gerry/resume.html.

2. Title:
Virtual Math Teams: Explorations of Group Cognition

3. Description:
This book presents a coherent research agenda that has been pursued by the author and his research group at Drexel University from 2003 to the present. The motivation and background of this research was extensively compiled in the author’s recent and well received book on Group Cognition (Stahl, 2006b). The proposed volume picks up where that book left off, presenting five concrete analyses of group interactions in different phases of the Virtual Math Teams research project. It precedes these analyses with descriptions of the project and its methodology, as well as situating this research in the past and present context of the CSCL research field. The studies are followed by discussions of their implications for the theory of group cognition and for the methodology of the learning sciences. The proposed monograph will include analyses based upon previous publications by the author (peer-reviewed journal articles, book chapters and conference papers), in addition to new introductory and concluding chapters. The analyses based on previous publications will be thoroughly rewritten to provide for smooth continuity of the book as a whole. The narrative of the book will be written from scratch, to provide for an engaging flow that follows the progression of the research.
The nature of group cognition and shared meaning making in collaborative learning is an important research issue in CSCL. More generally, perhaps, the theme of sense making is a central topic in information science. While many authors pay lip service to these topics, few have provided much detailed analysis of the mechanisms of intersubjective meaning making as a foundation for understanding processes involved in collaborative learning and knowledge building. This book centers on detailed empirical studies of how students in small online groups make sense of math issues and how they solve problems by making meaning together. These studies are woven together with materials that describe the online environment and pedagogical orientation, as well as reflections on the theoretical implications of the findings in the studies.

The VMT project has dual goals: (a) to provide a source of experience and data for practical and theoretical explorations of group cognition and (b) to develop an effective online environment and educational service for collaborative learning of mathematics. The book will reflect these twin orientations, reviewing the intertwined aims and development of the research and the service. The final third of the book will abstract from the lessons of the VMT project specifically to discuss more generally implications for CSCL pedagogy, technology, methodology and theory.

4. Audience:
The central market is the readers of the CSCL book series. Readers of the author’s previous book, *Group Cognition*, should also be very interested. More generally, students and researchers in the learning sciences, cognitive sciences and information sciences—including education and psychology—should provide a significant target audience.

5. Table of Contents:

“Virtual Math Teams: Explorations of Group Cognition”

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7. Case D: Disembodied Meaning Making
8. Case E: A Knowledge Community
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*Index of Authors*
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*Series List*
6. Monograph.

7. NA

8. Chapters 1-7 will incorporate material from detailed analyses in recent publications by the author during 2006 and 2007—after the writing of *Group Cognition*.

9. The author has permission to republish his writings in this format.

10. Approximate length: 200-250 pages.

11. Approximately 20 tables and 20 screen images will be included.

12. No color plates are required.

13. See table of contents above. All references will be collected at the end.

14. The manuscript will be submitted in December 2007.

15. The author will prepare a formatted manuscript.

16. **Competition:**
The proposed book will complement the existing CSCL book series. It will be different from the edited volumes in that it will present a coherent monograph by one author. It will be different from the Wegerif volume as well as from the author’s previous book by concentrating on a single extended research effort from various perspectives. It will build on the author’s theories presented in *Group Cognition* and *What We Know about CSCL*, but will not duplicate them.

17. **Uniqueness:**
The literature of CSCL is scattered and fragmentary. The edited volumes of the CSCL book series and the issues of the *International Journal of CSCL* have helped to make this literature more accessible and better organized, but there are still few published monographs that bring together an extended research agenda or that provide a more comprehensive theory. The few monographs that do exist in the field—e.g., by Lave or Bereiter—have proven to be highly influential. The proposed book would complement well the author’s *Group Cognition* and Wegerif’s new offering in the CSCL series.

18. **Classroom usage:**
The proposed book will be written for advanced undergraduates and graduate students. It will be suitable for usage in courses on HCI, CSCL, CSCW, Education, Psychology, and the Learning Sciences generally.

19. **Past publication:**
*Group Cognition* was published in March 2006 by MIT Press in its series on Acting with Technology. The author met all deadlines for manuscript preparation, reading edits, reading proofs, preparing indices, etc. That book was approximately twice as long as the proposed book. The author contributed chapters to the Springer CSCL
series books on What We Know about CSCL and Scripting in CSCL. He has published about a hundred academic papers and chapters.

20. Suggested reviewers:
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21. Chapter summaries:

“Virtual Math Teams: Explorations of Group Cognition”

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1. Vision: Explorative Learning
The book takes seriously the notion of “explorations”. The opening chapter provides a vision of explorative learning on three main levels:

a. The idea of students learning through experiential exploration or inquiry dates back at least to (Dewey, 1938/1991). According to (Vygotsky, 1930/1978), individual learning is grounded in dialogic exploration with other people (see also Wegerif, 2007). CSCL envisions the use of networked computers to provide new opportunities for such learning (Scardamalia & Bereiter, 1996), building on a theory of situated learning in communities (Lave & Wenger, 1991).

b. According to the approach of design-based research (Design-Based Research Collective, 2003) which is extensively used in the learning sciences, educational research can effectively be conducted through iterative processes of exploration. Experimental situations are set up to allow testing of an approach and to provide for collecting of data on what transpires. Based on analyses of student behaviors in the designed context, adjustments are made to the pedagogic intervention, to the supporting technology and to the research hypotheses.

c. The book itself will follow an explorative trajectory, leading to successively abstract reflections on the research project’s path of exploration and its findings. It begins with a vision of learning and of research; it then looks closely at case studies of cognitive accomplishments and their analysis; it concludes with general implication for pedagogy and theory.

This chapter provides an introduction to the Virtual Math Teams project, directed by the author over a five year period. It describes the project’s vision and provides an overview of its stages, incorporating material from (Stahl & Zhou, 2006).

2. Approach: Iterative Explorations
The VMT project has evolved through many phases of exploration. The technology gradually changed from simple chat to a complex online environment. The math content grew from isolated problems to math worlds and math domains. The sessions became scaffolded session sequences. The programmatic changes and their motivations will be traced in this chapter. The research method also evolved: from coding chat utterances to analyzing group cognition to investigating meaning making.
This evolution will be presented in relation to the history of CSCL as presented in (Stahl, Koschmann, & Suthers, 2006).

3. Analysis: Online Social Practices
The central analytic focus is on the social practices of the teams of students in the online VMT sessions. How do students interact, communicate and problem solve within the VMT situation? How do they make sense of their technical environment and use its functionality to mediate their work? This chapter defines the concept of social practices through a preview of the case studies of VMT to follow, using material from (Stahl, 2007b).

4. Case A: Greater than the Sum
The first case study makes the transition from individual problem solving to group cognition. A specific SAT problem is solved by a team of students, none of whom could solve it individually. Although the solution at first appears to be the accomplishment of one student, closer consideration shows how it results from the group interaction, building on material from (Stahl, 2006d). Social practices—including the use of humor, teasing and flirtation—allow participants to build on each other’s efforts, producing a solution as a group achievement.

5. Case B: A Failed Proposal
Progress in group problem solving is made largely through the bid and acceptance of proposals. This was already observed in Case A. In Case B, a failed proposal is analyzed to see through a breakdown case what would be necessary for the interactional success of a math proposal (see Stahl, 2006a). The effective constitution of the team as a working group is achieved through the structure of a proposal, which is taken up on behalf of the group and which structures the temporality of the sustained group effort.

6. Case C: Pointing in Virtual Spaces
Deictic reference is crucial to the grounding of discourse in its situation. However, pointing to specific objects by disembodied online team participants is difficult. In this case study, two participants coordinate their activities in chat and in a shared whiteboard over an extended interaction to establish a shared being-together-at-something-with-others. The students fluidly create a subtle social practice taking advantage of the unique configuration of functionality in their technical environment. The analysis incorporates material from (Stahl, 2006c).

7. Case D: Disembodied Meaning Making
Since prehistory, people have been socialized from infancy to make sense of their social world in face-to-face settings. Gesture, expression, intonation, bodily orientation and physical environment are taken for granted. In the online VMT environment, participants confront each other under quite different circumstances and must adapt their sense-making practices to understand each other and to create shared meaning. This chapter, building on materials in (Stahl, 2007a), explores the conditions that surround sense making in VMT. The log of interactions makes these otherwise taken-for-granted conditions visible. Considerations of the design of the technical environment point to preconditions for group cognitive activity as well.

8. Case E: A Knowledge Community
The final phase of the VMT project shifts the focus from individual cognition and team problem solving to knowledge building within a community spanning multiple teams over an extended time period. Case study E looks at how a specific team interacts with textual artifacts from other teams to build knowledge about math in a Wikipedia-like environment. This raises research questions about how participants
establish and identify shared interests, practices, language, artifacts and knowledge in order to form and foster collaborative group efforts.

9. Pedagogy: Collaborative Knowledge Building
This chapter will present an understanding of the social practices through which computer-supported collaborative learning takes place, as observed in the VMT project. Collaborative learning is here operationalized as the co-construction of knowledge artifacts, which can be observed in the record and results of VMT sessions. Implications for pedagogy and the development of scripted curriculum will be drawn.

10. Technology: Collaboration Support
The VMT project has included the evolution of many technological supports to meet the gradually revealed needs of online math teams. The fluid support of knowledge-building efforts at the individual, group and community levels has required special emphasis on integration of interdependent activities. In particular, the chat, whiteboard and wiki functionality have been integrated in multiple ways, with social awareness cues to indicate where activity is taking place, both synchronously and asynchronously. The discussion of integration of chat and whiteboard incorporates material from (Mühlpfordt & Stahl, 2007). Additionally, support for group formation, proposals, deixis, persistent knowledge building and other social practices is reviewed.

11. Methodology: Chat Interaction Analysis
Research in the VMT project has required the development and refinement of a methodology for chat interaction analysis. Largely foreshadowed in (Stahl, 2006b), the methodology parallels the ethnomethodologically-inspired approach of conversation analysis, although with many significant differences due to the disembodied, technology-mediated nature of interaction in VMT. This methodology has itself required the development of support technology, primarily in the form of a VMT replay application. Focusing frequently on the rich interactions that occur during breakdowns in shared understanding, this chat analysis necessarily differs from conventional statistical modeling; it eschews attempts at automated coding, although it benefits from computer-generated log representations.

12. Paradigm: Case Studies & Design Explorations
The VMT project suggests a different philosophic or scientific paradigm from that underlying much educational research since (Thorndike, 1914). It does so in terms of its design-based approach, its chat-analytic methodology and its emergent view of collaborative interaction. The traditional focus on individual agency and factual knowledge shifts to a concern with social interaction (grounded in cultural-historical context and community) and the co-construction of meaningful artifacts and practices. A view of interacting systems at the individual, small group and community level replaces models of individual causation based on mental representations. Correspondingly, a methodology oriented to detailed case studies of interaction replaces statistical modeling, with exploratory research predominating over hypothesis testing.

13. Theory: Group Cognition
For some time, educational visionaries have called for alternatives to traditional schooling, such as dialogic liberation problem-solving (Freire, 1970), learning webs (Illich, 1970) and experiential learning (Dewey, 1938/1991). Broad-scale implementation of their ideals have proven elusive, presumably because the nature of collaborative learning and the requisite technical support were not sufficiently well understood. With the intervening progress in the learning sciences and in CSCL, as
well as with broad cultural shifts to online social networking (e.g., email, Wikipedia),
it may now be possible to implement something like the VMT model. This concluding
chapter will pull together the lessons from the VMT research for scaling up the
project as a public service at http://mathforum.org/vmt. In doing so, the chapter will
particularly present what has been learned for the theory of group cognition that goes
beyond (Stahl, 2006b) and that can deepen thinking about online social networking.

Endnotes

References

Design-Based Research Collective. (2003). Design-based research: An emerging
Cambridge, UK: Cambridge University Press.
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on Computer Support for Collaborative Learning (CSCL 2007), New Brunswick, NJ. Retrieved from
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Ludvigsen, Lund, A. & Säljö, R. (Ed.), *Learning in social practices. ICT and


The Virtual Math Teams (VMT) Project (vmt.mathforum.org) at the Math Forum enables K-12 math collaborative learning, professional development of educators, and group cognition research. VMT is now integrated with GeoGebra (http://www.geogebra.org/).

In a Nutshell, Virtual Math Teams No recognizable code. Open Hub computes statistics on FOSS projects by examining source code and commit history in source code management systems. The Virtual Math Teams (VMT) research group at Drexel University has developed a methodology for chat analysis that is tuned to the exploration of group cognition in a chat environment. This approach is inspired by ethnomethodologically-informed conversation. The VMT research team is exploring through the use of chat analysis and other empirical methodologies such topics as: group cognition, group meaning making, the self-constitution of small groups, the nature of online co-presence, group agency, virtual deixis, the adoption of the VMT system, the virtual co-construction of math objects, bridging online discontinuities, negotiation of meaning and online group information. The Virtual Math Teams Project explores the potential of the Internet to link learners with sources of knowledge around the world, including other learners, information on the Web and stimulating digital or computational resources. It offers opportunities for engrossing mathematical discussions that are rarely found in most schools (Boaler, 2008; Lockhart, 2009). The traditional classroom that relies on one teacher, one textbook and one set of exercises to engage and train a room full of individual students over a long period of time can now be supplemented through small-group experiences of V...