Studying Virtual Math Teams

COMPUTER-SUPPORTED COLLABORATIVE LEARNING

VOLUME 11

The *Computer-Supported Collaborative Learning Book Series* is for people working in the CSCL field. The scope of the series extends to 'collaborative learning' in its broadest sense; the term is used for situations ranging from two individuals performing a task together, during a short period of time, to groups of 200 students following the same course and interacting via electronic mail. This variety also concerns the computational tools used in learning: elaborated graphical whiteboards support peer interaction, while more rudimentary text-based discussion forums are used for large group interaction. The series will integrate issues related to CSCL such as collaborative problem solving, collaborative learning without computers, negotiation patterns outside collaborative tasks, and many other relevant topics. It will also cover computational issues such as models, algorithms or architectures which support innovative functions relevant to CSCL systems.

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Studying Virtual Math Teams

Springer

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Part I
Introducing Group Cognition in Virtual Math Teams

Introduction to Part I

Virtual math teams are small groups of learners of mathematics who meet online to discuss math. They encounter stimulating math problems and engage in intense discussions of math issues among peers. It is now technologically possible for students from around the world to gather together in these teams and to share mathematical experiences involving deep conceptual relationships that invoke wonder—the kinds of experiences that can lead to a lifetime fascination with mathematics, science and other intellectual pursuits. The online meeting of students from different backgrounds can spark interchanges and collaborative inquiry that lead to creative insight. The accomplishments of such groups can have productive consequences for the students involved. The meeting can also produce records of the interactions, which researchers can study to understand the group processes involved in collaborative math exploration.

Beginning in 2002, a group of researchers and online-math-education-service providers began the Virtual Math Teams (VMT) Project, which is still active in 2009 as this book goes to press. The mission of the VMT Project is to provide a new opportunity for students to engage in mathematical discourse. We have three primary goals in this project:

- As service providers, we want to provide a stimulating online service for use by student teams from around the world.
- As educational-technology designers, we want to develop an online environment that will effectively foster student mathematical discourse and collaborative knowledge building.
- As researchers, we want to understand the nature of team interaction during mathematical discourse within this new environment.

The VMT Project was launched to pursue these goals through an iterative, cyclical process of design-based research at the Math Forum at Drexel University in Philadelphia, USA. This book reports on some of our progress to date in this effort.

Studying Virtual Math Teams is a diverse collection of chapters about various aspects of the VMT Project and about the group interactions that take place in the VMT environment. Researchers who have been involved with the project in different

ways contributed chapters on their findings. Because of the deeply collaborative nature of the project, all the chapters are, at heart, group products. Most of them are written by core members of the VMT research team, which has met together weekly over the years of the project to analyze logs of student interaction in detailed group data sessions. Others are written by researchers who visited the project for several months or who used the VMT environment or data for investigations in their own collaborative research groups.

The collecting of the chapters was initiated at an all-day workshop at the CSCL 2007 international conference, where drafts of many of the chapters were presented and discussed. Early versions of these presentations had been previously critiqued through online sessions conducted within the VMT environment. The researchers involved have profoundly influenced each other's thinking/writing. Furthermore, all chapters have been heavily edited to form a coherent volume with manifold connections and tensions.

The motivation behind the VMT Project and the historical background for this book is provided at length in *Group Cognition: Computer Support for Building Collaborative Knowledge* (Stahl, 2006b). That book covered the author's work for the decade preceding the VMT Project, in which he and his colleagues developed a number of computer systems to support knowledge building, analyzed the interactions that took place by users of those systems and explored theoretical aspects of such group interaction. The book argued for a need to investigate what it termed *group cognition*: the interactive processes by means of which small groups of people can solve problems, build knowledge and achieve other cognitive accomplishments through joint effort. In particular, it proposed studying this in online environments, in which a complete record of the shared interaction could be captured for replay and detailed study. The chapters of *Group Cognition*—mostly written before the VMT Project began—envisioned a research agenda that could elaborate and support its theory of group cognition. The chapters of *Studying Virtual Math Teams* report on the results of implementing that research agenda with the VMT Project and confirm the conjectures or fulfill the promises of the earlier work. They also extend the theory of group cognition substantially with the detail of their empirical findings and the corresponding analyses by the VMT team and its collaborators.

This volume is meant to display the methodology that we have developed through our group interaction with the project data. The Editor and his colleagues have in the past made claims about what microanalysis of chat logs could provide, and it is now time to document this. We do not claim to have invented a completely new approach, having learned enormously from the many social-science researchers referenced in our chapters. However, we have adapted existing approaches to fit the context of our situated work through the inter-animation of our own diverse perspectives on the scientific enterprise. Many of these perspectives will shine through in the individual chapters authored by different people or small groups. As the history of the project emerges from the consecutive pages that follow, the influence of project personnel and visitors will become evident.

In terms of analysis method, our first visiting researchers—Strijbos and Xhafa—introduced us to both the rigors and the limitations of coding. Zemel then provided expertise in the alternative approach of conversation analysis. However, conversation analysis did not quite fit our undertaking, because it is oriented toward physical (rather than virtual) co-presence of participants and because it aims to reveal the interactional methods of participants (rather than assess educational designs). So we gradually adapted conversation analysis, which is traditionally based on a particular style of video transcriptions of informal talk, to replayable chat logs of students doing goal-directed problem solving. Weimar's sensitivity to educational interactions, Shumar's perspective from social theory and ethnographic practice as well as Stahl's focus on design-based research processes all helped to sculpt this into an effective practice. Our gradually emerging findings also modified our approach, such as Sarmiento's research into how students sustain longer episodes than are usually studied in CA, Çakir's analyses of the dialectic between visual/graphical reasoning and symbolic/textual group cognition, and Zhou and Toledo's studies of questioning and resolving differences as drivers of collaborative problem solving.

Despite the sequential development of themes as this book unfolds, the chapters retain the self-contained character of individual essays. The reader is welcome to skip around at will. However, we have also tried to provide some coherence and flow to the volume as a whole, and the ambitious reader may want to follow the over-arching narrative step by step:

- *Part I* provides a gentle introduction to the perspective, vision, technology, theory, methodology and analysis of the VMT Project.
- *Part II* digs deeply into the data, analyzing specific aspects of group interactions that take place in the VMT environment.
- *Part III* investigates higher-level issues of the team discourse, such as small-group agency, problem solving, creativity and reasoning.
- *Part IV* turns to design issues of the online technology that supports the student communication: how to integrate different media and how to structure important functionality.
- *Part V* explores various ways of analyzing and representing the foundational response structure of small-group interaction in chat.
- *Part VI* concludes with the implications of the preceding chapters for a science of group cognition.

Introducing Group Cognition in Virtual Math Teams

Part I offers an introduction to the study of group cognition in virtual math teams. It consists of four chapters written by the Editor on independent occasions (see Notes at end of book) and in varying literary genres (interview, user manual, book review,

methodological reflection and case study). They should provide entry for the reader into the orientation and intricacies of the book's material:

- *Chapter 1* is an informal discourse on the Editor's views about how to think about computer support for collaborative learning. It was written at the request of an Italian journal about knowledge building, and is structured as an interview by the journal.
- *Chapter 2* was written for teachers who are interested in using the VMT service with their students. It describes technological and pedagogical aspects. Although the details of the environment have evolved from year to year, the general description in this chapter provides good background for most of the later analyses of student interactions. It is written for potential users—or their teachers—to give a sense of the practical instructional uses of the service.
- *Chapter 3* reproduces a review of a recent book that conceptualizes mathematical learning in terms of discourse. The position elaborated there motivates the VMT orientation to math learning through discursive problem solving. The review then extends the book's approach to apply it to small-group interactions, such as those in the VMT Project. Extended this way, the book's theory of mathematics provides a way of understanding group cognition in collaborative math work.
- *Chapter 4* presents the methodology of the VMT Project analyses: to describe the group practices that the student teams use in doing their collaborative intellectual work. Specifically, this chapter introduces several analyses that appear in later parts of the volume to illustrate the analytic approach. In giving a glimpse of concrete analyses that will follow, it situates them in one way of understanding their significance.
- *Chapter 5* goes into detail on one of the analyses in Chapter 4, providing two competing analyses of the same interaction: one in terms of an individual solving a tricky math problem and the other understanding the solution as a group achievement. The subtle interplay between individual and group phenomena/analyses provides a pivotal theme for the VMT Project, for the theory of group cognition and for the present volume. Without trying to be conclusive, this chapter at least makes explicit the issue that is perhaps the most subtle and controversial in the theory of group cognition.

These essays and the subsequent studies of the VMT Project in Parts II through VI are intended to help you, the reader, to initiate your own studying of virtual math teams (or similar phenomena) and to further your reflections on the associated theoretical and scientific themes.

Chapter 1
A Chat About Chat

Gerry Stahl

Abstract This is an informal discussion from my personal perspective on computer-supported collaborative learning (CSCL). I envision an epical opportunity for promising new media to enable interpersonal interaction with today's network technologies. While asynchronous media have often been tried in classroom settings, I have found that synchronous text *chat* in small workgroups can be particularly engaging in certain circumstances—although perhaps chat can often be integrated with asynchronous hypermedia to support interaction within larger communities over longer periods. More generally, building collaborative knowledge, making shared meaning, clarifying a group's terminology, inscribing specialized symbols and creating significant artifacts are foundational activities in group processes, which underlie internalized learning and individual understanding no matter what the medium. Therefore, I look at the online discourse of small groups to see how groups as such accomplish these activities. This has consequences for research and design about learning environments that foster knowledge building through group cognition, and consequently contribute to individual learning.

Keywords CSCL · group cognition · text chat · math education

Interviewer: **Prof. Stahl, can you chat with us a little about your view of research in computer-supported collaborative learning today?**

For me, CSCL stands at an exciting turning point today. The field of computer-supported collaborative learning (or, "CSCL") started in the early 1990s as an interdisciplinary effort to think about how to take advantage of the availability of computers for education. In particular, social constructivist ideas were in the air

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and people thought that personal computers in classrooms could help to transform schooling. Researchers arrived at CSCL from different disciplines and brought with them their accustomed tools and theories. Education researchers and psychologists administered surveys and designed controlled experiments, which they then analyzed statistically to infer changes in mental representations. Computer scientists and AI researchers built systems and agents. Everyone who put in the required effort soon discovered that the problem was a lot harder than anyone had imagined. Progress was made and a research community grew, but existing conceptualizations, technologies and interventions ultimately proved inadequate. Today, I think, people are working at developing innovative theories, media, pedagogies and methods of analysis specifically designed to deal with the issues of CSCL. I feel that we are now poised just at the brink of workable solutions. Perhaps as editor of the *ijCSCL* journal, I have a special view of this, as well as a peculiar sensitivity to the fragility of these efforts.

Of course, I do not want to give the impression that previous work in CSCL was not significant. Certainly, the pioneering work of Scardamalia and Bereiter, for instance, broke crucial new ground—both practical and theoretical—with their CSILE system for collaborative knowledge building. I want to come back to talk about that later. Nevertheless, I think that even the successes like those also demonstrated that the barriers were high and the tools at hand were weak.

Interviewer: **What do you think is the #1 barrier to widespread success of CSCL?**

As someone interested in philosophy, I see a problem with how people conceive of learning—both researchers and the public. The philosophical problem is that people focus on the *individual learner* and conceive of learning as the accumulation of *fixed facts*. But I think that the evidence is overwhelming that social interaction provides the foundation upon which the individual self is built, and that knowledge is an evolving product of interpersonal meaning making. We often cite Vygotsky as the source of these ideas, but there is a rich philosophical literature that he drew on, going back to Vico, Hegel, Marx, Gramsci, Mead, Dewey and many others.

There is an "ideology of individualism" prevalent in our society, with negative consequences for politics, morality, education and thought generally. We need to recognize that the individual is a product of social factors, such as language, culture, family and friends. Even our ability to think to ourselves is an internalized form of our ability to talk with others and of our identity as an inverted image of the other; the mental is a transformed version of the social. When I learn as an individual, I am exercising skills that are based on social skills of learning with others: collaborative learning is the foundation for individual learning, not the other way around.

Standard assumptions about learning are, thus, misleading. Researchers strive to get at the mental representations of individual subjects—through pre/post tests, surveys, interviews, think-aloud protocols and utterance codings—that they assume

are driving learning behaviors. But, in fact, learning behaviors are constructed in real time through concrete social interaction; to the extent that the learning is reflected mentally, that is a trace in memory or a retrospective account of what happened in the world. To foster learning, we need to pay more attention to collaborative arrangements, social actors and observable interactions.

Interviewer: **Then do you feel there is a problem with the very concept of learning?**

Yes, the traditional concepts of learning, teaching and schooling carry too much baggage from obsolete theories. If we try to situate thought and learning in groups or communities, then people complain this entails some kind of mystical group spirit that thinks and learns, in analogy with how they conceive of individual thinking and learning as taking place by a little homunculus in the head. That is why I prefer Bereiter's approach of talking about knowledge building. Unfortunately, he was caught up using Popper's terminology of "third world" objects that belong neither to the physical nor mental worlds. What he was really talking about—as he now realizes—was knowledge-embodying *artifacts*: spoken words, texts, symbols or theories. Artifacts are physical (sounds, inscriptions, visible symbols, carved monuments), but they are also meaningful. By definition, an artifact is a man-made thing, so it is a physical body that incorporates a human intention or significance in its design. Knowledge artifacts belong simultaneously in the physical and meaning worlds. Through their progressive reification in physical forms, symbols come to have generalized meanings that seem to transcend the experiential world.

If we now situate knowledge building in groups or communities, we can observe the construction and evolution of the knowledge in the artifacts that are produced—in the sentences spoken, sketches drawn and texts inscribed. There is no mystery here; these are common things whose meanings we can all recognize. They are so familiar, in fact, that we take them for granted and never wonder how meanings are shared and knowledge is created in group interactions or how it spreads through communities. When you consider it this way, the strange thing is to think about learning taking place inside of brains somehow, rather than in the interplay between linguistic, behavioral and physical artifacts. If one carefully observes several students discussing a mathematical issue using terminology they have developed together, drawings they have shared and arguments they have explained, then the learning may be quite visible in these inscriptions. One can assume that each member of the group may go away from the group process with new resources for engaging in math discourses (either alone or in new groups) in the future.

Interviewer: **But can't students learn by themselves?**

Of course, I can also build knowledge by myself, as I am now in typing this text on my laptop. However, that is because I have discussed these and similar issues

in groups before. I have had years of practice building ideas, descriptions and arguments in interaction with others. Even now, in the relative isolation of my study, I am responding to arguments that others have made to my previous presentations and am designing the artifact of this text in anticipation of the possible reactions of its potential audiences. The details and significance of this artifact are ineluctably situated in the present context of discourse in the CSCL research community and the scientific world generally. That is why I have chosen a classic dialog genre for its form, in which my utterances partake in a community discourse.

The idea that thoughts exist primarily inside of individual heads is deeply misguided. The ideology of individualism is accompanied by an objectivistic worldview. There is an assumption that stored in the minds of individuals are clear and distinct thoughts ("ideas" or propositions), and that it is the goal of scientific research to discover these thoughts and to measure how they change through learning episodes. However, when knowledge is truly constructed in social interactions, then the thoughts do not exist in advance. What individuals bring to the group is not so much fixed ideas, already worked out and stored for retrieval as though in a computer memory, but skills and resources for understandingly contributing to the joint construction of knowledge artifacts.

Interviewer: **What would be the consequences of rejecting this ideology of individualism?**

Given a view of learning as the increased ability to engage in collaborative knowledge building rather than as an individual possession, CSCL researchers may want to develop new methods to study learning. The old methods assumed that thoughts, ideas and knowledge lived in the heads of individuals and that researchers should find ways to access this fixed content. But if knowledge is constructed within situations of interaction, then (a) there is no ideal (God's-eye-view, objective) version of the knowledge that one can seek and (b) the knowledge will take essentially different forms in different situations. A student's skills of computation will construct very different forms of knowledge in an interactive group discourse, a written test, a visit to buy items in a store, a job adding up customer charges, a laboratory experiment or an interview with a researcher.

If we conceive of learning as situated in its specific social settings and as a collaborative knowledge-building process in which knowledge artifacts are constructed through interaction among people, then we need to give up the idea that learning can be adequately studied in settings that are divorced from the kinds of situations in which we want the learning to be useful. Studying knowledge in laboratories, questionnaires and interview situations will not necessarily reveal how learning takes place in social settings like school and work.

To make matters worse, the traditional methods that are brought to CSCL from other disciplines are often based on theories of causation that arose with the laws of mechanics in physics, dating back to Galileo and Newton. In order to deal with

the complexity of nature, early physicists simplified matter into ideal, inelastic billiard balls whose actions and reactions followed simple equations. We cannot simplify the complexity and subtlety of human interaction, of interpersonal gesture, of linguistic semantics and of social strategies into equations with a couple of linear variables without losing what is most important there. Each utterance in a knowledge-building discourse is so intertwined with the history, dynamics and future possibilities of its situation as to render it unique—irreducible to some general model. In phenomena of a human science like CSCL, researchers must treat events as unique, situated, over-determined, ambiguous case studies—rather than as instances of simplistic, deterministic, linear causative general laws—and interpret their meanings with the same sorts of social understanding that the "subjects" or participants brought to bear in constructing the meanings. Too many research hypotheses presume a model of knowledge as pre-existing individual opinions causing group interactions, rather than viewing knowledge as an emergent interactional achievement of the group interactions—subsequently assimilated and retroactively accounted for by individuals.

Interviewer: **How can you have a rigorous science without laws, laboratories, equations, models and quantified variables?**

Let me give you a recent example that I take as a guide for my own research agenda. During the past 50 years, a new discipline was created called conversation analysis (CA). It set out to study informal, everyday conversation and to discover how speakers constructed social order through common, subtle discourse practices that everyone is familiar with and takes for granted. The pioneers of the field took advantage of the latest tape-recording technology and developed forms of detailed transcription that could capture the details of spoken language, like vocal emphasis, timing and overlap. Although meaning making takes unique twists in each conversation, it turned out that there are interesting regularities, typical practices and preferred choices that researchers can identify as being consequential for face-to-face interactions. For instance, they outlined a set of conventional rules that people follow for taking turns in conversations.

In CSCL, we are particularly interested in computer-mediated communication, often among students discussing some subject matter. This is very different in form and content from informal conversation. First, in a medium like text chat people cannot take advantage of vocal emphasis, intonation, facial expression, accent, gesture, pauses or laughter. One does not observe a chat utterance being constructed in time; it appears as a sudden posting. Consequently, postings can never overlap each other, cut each other off or fluidly complete each other's thoughts. Several people can be typing simultaneously—and they cannot predict the order of appearance of their postings. So the whole system of turn taking discovered by CA no longer applies in the same form.

However, chat text has some advantages over speech in that utterances are persistently visible and can be designed with special visual features, such as punctuation,

capitalization, emoticons and other symbols. People in chat rooms take advantage of the new affordances for interaction to create their social order. CSCL could study the methods that small groups use to communicate in the new media that we design. The understanding of how people interact at this level in various CSCL environments could inform the design of the technologies as well as influencing the kinds of educational tasks that we ask students to undertake online in small groups.

CSCL researchers can take advantage of the detailed computer logs that are possible from chat rooms just as the CA researchers used meticulous transcripts of tape recordings or videos to study interaction at a micro-analytic level never before possible. Depending upon one's research questions, these logs may allow one to finesse all the issues of videotaping classroom interactions and transcribing their discourse. Of course, one should not get carried away with hoping that the computer can automate analysis. The analysis of human interaction will always need human interpretation, and the production of significant insights will require hard analytic work. The pioneers of CA were masters of both those skills.

Interviewer: Can you give some examples of text chat analysis that you have conducted?

First, I have to explain that I do not conduct analysis of text chat on my own—as an individual. I am part of the Virtual Math Teams (VMT) research team that is trying to build the analog of CA for CSCL. When we analyze some chat log, we hold a "data session" with about eight people, so that our interpretations of meanings constructed in the chat have some intersubjective validity. We have been working on a number of different themes, including how small groups in online text chat:

- Propel their discourse with math proposal bid/uptake pairs,
- Coordinate drawing on a shared whiteboard with chat postings to make deictic references,
- Design texts and other inscriptions to be read in specific ways,
- Collaboratively construct math artifacts,
- Bridge back to previous discussions with group memory practices,
- Engage in information questioning and
- Resolve differences between multiple perspectives or alternative proposals.

With each of these themes, we have been discovering that it is possible to uncover regular social practices that recur from group to group, even though most groups have never used our CSCL system before. In each case, the achievements of the groups are constructed interactively in the discourse situation, not premeditated or even conscious. To determine which of these activities the group is engaging in at any given time requires interpretation of the activity's meaning. It cannot be determined by a simple algorithm. For instance, a question mark does not always correspond with an information question; there are many ways of posing a question and many uses of the question mark in chat.

Interviewer: **Why are you focused so much on text chat?**

Actually, I have not always favored chat. My dissertation system was a shared database of design rationale. Next, I developed a CSCL system to support multiple perspectives in threaded discussion. When I later worked on a European Union project, I helped design a system that again featured threaded discussion. It was not until a few years ago that my students convinced me that synchronous chat was a much more engaging online medium than asynchronous forums. I still think that asynchronous media like Knowledge Forum or wikis may be appropriate for longer-term knowledge building in classrooms or communities. But we have found that text chat can be extremely powerful for problem solving in small groups.

The CSCL research community now has a lot of experience with discussion forums. Studies have clearly documented the importance of the teacher's role in creating a knowledge-building classroom. To just tell students in a traditional class to post their ideas in a regular threaded discussion system like Blackboard is doomed to failure: there will be little activity and what gets posted is just individual opinions and superficial agreements rather than knowledge-building interactions.

Chat is different. Although teenagers are used to superficial socializing using instant messaging and texting, they can readily be encouraged to participate in substantive and thoughtful exchanges in text chat. Our studies show that students in our chat rooms are generally quite engaged in knowledge-building activities.

Group size has an enormous impact on the effectiveness of different media. Unfortunately, there is not much research on, for instance, math collaboration by different size groups. Most math education research is still focused on individual learning. Studies of collaboration in math problem solving tend to use dyads. Dyad communication is easy to study because it is always clear what (who) a given utterance is responding to. In addition, the two participants often fall into relatively fixed roles, often with one person solving the problem and the other checking it or asking for clarifications.

Perhaps one of our most interesting findings is that math problem solving can, indeed, be accomplished collaboratively. When we started the VMT Project, we had no idea if the core work of mathematical thinking could be done by a group. The tradition has always pictured an isolated individual deep in silent reflection. Even the studies of dyads generally found that one student would solve the problem and then explain the solution to the other. We found that participants in virtual math teams spontaneously began to explore their problems together, discussing problem formulations, issues, approaches, proposals and solutions as a group. Moreover, students generally found this interaction highly engaging, stimulating and rewarding.

Small groups of three or four active students chatting become much more complex and interesting than an individual thinking aloud or a dyad answering each other. The response structure of postings is still critical to interpreting meaning, but in groups it can become tricky, often leading to interesting confusions on the part of the participants. Roles still surface, but they are often fluid, disputed and emergent, as participants try to position themselves and others strategically in the collaborative-learning dynamic. Here, the construction of knowledge becomes much

more of a group achievement, resulting from the intricate semantic intertwining of postings and references rather than being attributable to individuals.

Interviewer: Is that what you mean by your concept of group cognition?

Exactly! Cognition (thinking) is a semantic process, not necessarily a mental—silent, in the head—affair. An idea is a knowledge artifact, like a sentence, that gathers together in a complicated way a network of meanings of words, references, past events, future possibilities and other elements of the context in which the idea is situated. In our chat logs, we can see cognition taking place as knowledge artifacts build up, as words follow upon each other in subtly choreographed sequences to construct new ideas. The meaning can be seen there regardless of whether the words appear silently in the inner voice of one person, heard in the authoritative tones of a speaker, distributed among several interacting voices, in the pages of a book or even in the inanimate form of a computer log. Plato's ideas are as meaningful in a twentieth century edition of his writings as they were in his discourses thousands of years ago among small groups in the Athens marketplace or in seminars at his Academy, although the meaning has certainly shifted in the meantime.

The ideology of individualism gives priority to the thoughts of the individual. However, I believe that the foundational form of knowledge building actually occurs in small groups. Innovative knowledge building requires the inter-animation of ideas that were not previously together. A fertile ground for this exists when a couple of people come together to discuss a common topic. Recent CSCL studies have shown that it is precisely the friction between disparate perspectives that sparks productive knowledge building in the collaborative effort to clarify and/or resolve difference. The kinds of rhetorical and logical argumentation that arise in small-group discourse dealing with misunderstandings, alternative proposals or disagreements are then internalized in the reflection skills of individuals and in the controversies of communities. Thereby, small-group cognition provides the origin for and middle ground between individual cognition and community knowledge building.

Within the CSCL field and related disciplines, the ideology of individualism has been countered by a proposed shift in focus to communities-of-practice and learning communities. In my book, *Group Cognition*, I try to overcome this opposition of unreconciled extremes by pointing to the small group as the social unit that often mediates between individuals and their communities. Consider how groups of friends in a classroom or teams of colleagues in a workplace mediate the knowledge building that takes place there.

In the VMT Project, we have found that small-group collaboration is powerful. It enhances the desired characteristics of intentional learning and knowledge building. Effective collaborative groups not only produce knowledge artifacts that can be shared with a broader community, they also check to make sure that each individual group member understands (and potentially internalizes) the meanings of the group product. In responding to classroom assignments, small groups answer questions