VMT Year I Report

Overview of Year I

- In Spring 2003 we submitted proposals to NSF to fund a research project on collaborative math problem solving at the Math Forum website. The project proposal listed a number of collaborators — primarily CSCL researchers in Europe and the US — who would help to guide the research. This list has grown slightly since then.
- Over the Summer, the project was funded for five years, under NSF's NSDL and IERI programs. We secured IRB approval from Drexel University and from the Philadelphia School District for working with human subjects in local schools and online.
- In the Fall, we started up the Virtual Math Teams (VMT) Project, hiring three research assistants and starting weekly meetings with several Math Forum staff.
- We videotaped a session of face-to-face collaborative math problem solving in a Philadelphia public middle school math class to provide a quick baseline experience.
- In the Winter, we collected a considerable amount of data on face-to-face and online math problem solving in small groups by involving about 40 undergraduate and graduate students as both subjects and researchers.
- We also started up our proposed service at the Math Forum website on a small, experimental scale. Since it is a collaborative version of the popular PoW (Problem of the Week) service, we call it Pow-Wow!
- In Spring 2004, we developed a multi-dimensional coding scheme for quantitative analysis of the data we are collecting.
- We continued to experiment in various ways with the Pow-Wow service.
- In the Summer, we are expanding our VMT project team to include people collaborating at a distance. With their advice and assistance, we will undertake quantitative and qualitative analysis of our data, investigate the theory of collaborative math problem solving and plan software development to support the service.

The VMT Project is off to a good start and seems to hold forth an exciting potential. Of course, we are already confronting problems and hard questions:

- How to attract, motivate and group students into effective online math problem solving teams; how to encourage students to return and to bring friends, so the collaborative community grows and matures.

- How to design math problems that will work well in the given situation, will foster productive interaction, fruitful discourse, group understanding and deep individual math insight.
- How to design software and pedagogical infrastructures to support fluid collaboration and math exploration.

Local Team Start-Up

The first priority for Year I of the Virtual Math Teams Project was to form a local team and get it working. During the first year, the local team included:

- The project principle investigators: Gerry Stahl, Steve Weimar and Wes Shumar;
- Math Forum staff: Suzanne Alejandre, Kristina Lasher, Annie Fetter, Ian Underwood, David Tristano, Lisa Lavelle, Tracey Perzan, Steve Risberg;
- Graduate research assistants from the College of Information Science: Ramon Toledo, Murat Cakir, Wanda Kunkle, Nan Zhou;
- Other students: Ilene Litz-Goldmann, Pete Miller, Johann Sarmiento, Rajini Rajendran, Kevin Meaker, Deb LaBelle;
- Visiting researcher: Jan-Willem Strijbos (Open University of the Netherlands).

The local team met on Wednesdays at noon in the Math Forum office.

The Philadelphia School District offered us access to its schools for investigation of collaborative math problem solving. We observed two sessions at the Sharswood Public School in South Philadelphia and conducted an experiment in this classroom.

We conducted an international workshop in June with 36 participants, many of them internationally renowned CSCL researchers: Bob Aiken, Wolfgang Appelt, Gerardo Ayala, Chip Bruce, Santi Caballé, Hugo Fuks, Geri Gay, Ricki Goldman, Jörg Haake, Thomas Herrmann, Jim Hewitt, Cindy Hmelo-Silver, Chris Hoadley, Victor Kaptelinin, Tim Koschmann, Sten Ludvigsen, Ana Marjanovic-Shane, Eugene Matusov, Stefan Trausan-Matu, Martin Wessner, Fatos Xhafa, Alan Zemel. During the workshop they collaborated in discussing the issues of the project. They will form the core group of external collaborators on the VMT Project in the following years.

Several of these project collaborators had visited the project earlier and gave talks on relevant topics at the Drexel University College of Information Science speaker series: Chris Hoadley, Tim Koschmann, Cindy Hmello-Silver, Chip Bruce.

Activities

The project has been exploring the mechanisms of collaborative math problem solving, particularly online. Collaborative learning of mathematics is an open field of research. Online math problem solving is an educational approach that has not yet been explored

much. This project is attempting to create a collaborative learning service that takes advantage of an established digital library.

The project began with a collaboration with the Philadelphia School District. PIs Stahl, Weimar and Shumar and several staff members from The Math Forum observed two 8th grade math classes engaged in collaborative learning at Sharswood School, a K-8 school in Philadelphia. The Math Forum team then led their own collaborative learning activity with the classes at the Sharswood School. Data from the observations and experiments at Sharswood helped the research team to sharpen questions about the nature of collaborative math problem solving face-to-face and raised questions about the similarity and differences between the face-to-face practices and online practices.

The project has focused in its first year on generating a rich corpus of data illustrating the online collaborative problem solving of challenging math problems by small groups of students. A number of hour-long video recordings of face-to-face collaborative math sessions have been created: a session in a local urban middle-school classroom and nine sessions in university courses. A larger number of online sessions have been captured in chat logs with associated drawings: about 20 Pow-Wow sessions with K-12 students, about 30 online sessions with university students and about 8 sessions with adults.

Part of the effort to generate experimental and base-line data involved conducting experiments in online collaborative math problem-solving in the PI's courses. In particular, two courses on Human-Computer Interaction (one undergraduate and one graduate) centered on this topic. The students participated in experiments solving math problems in small groups. They then analyzed and explored their own and each others' data using various analytic methods: threading analysis, coding utterances, statistical analysis, interviews, focus groups, surveys, discourse analysis. They also designed software interfaces for supporting collaborative math. This activity involved many students at Drexel in the research project, as well as providing the project team with considerable insight into the issues it faces.

The project has established a new educational activity at the Math Forum: Pow-Wows. A Pow-Wow is a collaborative problem-solving session around a challenging Problem-of-the-Week (PoW). PoWs are an established and successful service of the Math Forum, engaging about 2,000 students a week. Pow-Wows are a promising extension of this service into collaborative learning.

Toward the end of its first year, the project organized and hosted an international gathering of experts in CSCL and related fields to reflect on the work of the project. The workshop involved researchers from Albania, Brazil, Canada, China, Columbia, Germany, Mexico, the Netherlands, Norway, Philippines, Romania, Spain, Sweden, Turkey and the US. During four intensive days of the workshop, the 36 participants each gave presentations of their research. They engaged in hands-on experience with collaborative math problem-solving and analysis of project data. In collaborative small groups, they discussed many of the central issues of the project. In the end, they discussed specific ways they wanted to work with the project in the coming year.

Findings

The project will be intently analyzing the data corpus that was generated in the first year of the project, using both quantitative and qualitative methods. In Year I, a detailed coding scheme was developed for analyzing chats and video transcripts along the dimensions of: mathematical moves, problem solving steps, social interaction and conversational acts. The project has begun to work with a conversation analyst and an ethnographer, who will be leading the qualitative analysis next year, as well as with an educational psychologist who will be helping guide the quantitative analysis.

Already, the project is gaining insight into major issues of collaborative math problem solving in the form envisioned for the project, such as adoption, motivation, sociability, graphic representation and parallel learning.

The workshops for international collaborators resulted in identification of key issues in three areas:

- Pedagogy: design of math problems for collaborative problem-solving, end user recruitment and participation in design-centered approach;
- Research: research methods for analysis of text-based chat and video recordings of team meetings; and
- Software: software to support sharing of graphical approaches and to scaffold user organization of knowledge development and solution approaches.

Research teams for the second year were formed in five sub-areas: a design team, software scaffolding team, auto data analysis tools team, data analysis team, ethnography and video team. The design team plans to take on issues of overall design of the online collaborative learning space and the tools that might be useful to online problem solving. The team will also think about ways to link the design to the capture of data. The software scaffolding team will work specifically on the development of software tools for online collaborative problem solving. The auto data analysis team will work with the design team and the software scaffolding team to develop tools that will allow the project to capture data about the collaborative problem solving process automatically and then organize and store the data in useful ways. The ethnography and video team will collect and analyze ethnographic data from the online and face-to-face collaborations in order to give a rich and detailed account of the subtlety of the problem solving interactions. Finally the data analysis team will coordinate data analysis from the other two data analysis teams as well as design quantitative and other qualitative data collection and analysis techniques.

With the PoW-wow experiments using Instant Messenger software, the project accelerated the investigation of student behavior and interest in online collaborative problem-solving. Initial indications are strong that students both enjoy and benefit from collaboration with peers, developing solution strategies that they would not have pursued so effectively on their own. It also seems clear that support is needed for students to improve the quality of the attention they are able to give to each other's thinking and to organize better the knowledge developed in their conversations. One key area for investigation is the nature of the learning that takes place as students work "in parallel".

Another area for study are the means of forming effective groups depending on relative homogeneity in terms of group member's mathematical competence, particularly in terms of being aligned with the level of a problem's difficulty.

Publications

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