Diversity in Virtual Math Teams

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Abstract: We are investigating how digital libraries can be used collaboratively by teams of students to engage in problem solving of school mathematics. We are experimenting with procedures for matching students who come to the mathforum.org digital library site to form effective collaborative learning online teams. Our hypothesis is that group learning will be greatest in groups that carefully combine diverse perspectives and backgrounds. We are investigating how to design curriculum, community practices and groupware support to foster deep learning of math. In the first half year of this five-year research project, we have generated the following pilot studies: 14 videotaped sessions in middle school and university classrooms and 33 online chat sessions among researchers, college students or K-12 students. In analyzing these studies, we will embrace a diversity of learning science methodologies within a design research paradigm.

Keywords: Digital library, group formation, math problem solving, collaboration

Collaboration and Learning in Digital Libraries

Considerable effort has recently been put into the creation of web-accessible digital libraries with a wealth of information that could be used for educational purposes. However, the overwhelming proportion of this effort has been dedicated to developing information storage and retrieval technologies or to compiling collections of documents. Our focus is on developing contexts in which these informational resources can be used for learning by students. In particular, we want to address the question of how to open up digital libraries for collaborative learning. To date, the only major funded project in this direction was the Ariadne project, that explored collaborative browsing in the UK in the late 1990's (Twidale & Nichols, 1998).

The Virtual Math Teams Project is a new research project based at The Math Forum and Drexel University, that also includes a number of international researchers in the learning sciences. (For a periodically updated description of the VMT Project, go to www.cis.drexel.edu/faculty/gerry/vmt.) The Math Forum (mathforum.org) is a well established digital library with about a million unique visitors during a year. Among its popular services is the Problem of the Week (PoW), which offers challenging word problems in pre-calculus school math (e.g., algebra, geometry, number theory, statistics). The VMT Project is the first project funded by the NSF digital library program to apply digital library resources to collaborative learning by K-12 students. VMT aims to increase the level of collaboration and interaction at the Math Forum site, thereby (a) fostering reflective and metacognitive interactions, (b) driving the elaboration of deep understanding of math, (c) leveraging peer interaction to increase support without burdening adult mentors and (d) further building the structure and coherence of the online community. In the process, we hope to demonstrate a general model for using the resources of a digital library for collaborative learning.

Online Formation of Diverse Groups

The primary service to be developed by the VMT Project is a collaborative learning version of PoWs. Students surfing to The Math Forum site will be invited to join a team of their peers from around the world to discuss a PoW. VMT software will match students up based on a survey that the students complete when registering for this service and on prior performance. Perhaps four students who are starting to learn algebra will be put together in one team: One could live in a remote area of the world, one might be confined to a hospital bed, one may be home-schooled and perhaps one just does not have any friends who are interested in doing math in their spare time. The software matches them because they collectively have the prerequisite math knowledge to do the problem and because they can all be online during the same time period – but also because they bring different personalities, skills, backgrounds and interests to the group. Although the project will conduct experiments to measure the effects of various combinations of similarities and differences among group members on the quality of the group interactions and the effectiveness of the group knowledge building, we hypothesize that the inclusion of specific forms of diversity (e.g., gender, culture, technological bent) combined with the matching of practical considerations

(native language, time zone, prerequisite knowledge) will make for the best groups with the deepest discussions of math. While educational and industrial psychology have studied face-to-face groups extensively, studies of online group formation (Ayala & Saito, 2003; Haake, Schuemmer, & Haake, 2003; Inaba *et al.*, 2000; Wessner & Pfister, 2001) are limited in their extent and their applicability to this situation.

Diverse Design Research Methodologies

In addition to specifying an algorithm for matching students for virtual math teams, the VMT Project must develop curriculum for the collaborative PoWs, including procedures for motivating students, presenting problems, assessing solutions and rewarding exceptional accomplishments. Like many efforts to innovate in the learning sciences, the VMT Project must intervene in a complex and 'messy' situation of students, technology, curriculum and community (Brown, 1992). In fact, the project must extend the community, write the curriculum, implement the technology and form the student groups. All of these dimensions will be evolving throughout the project. In general, a given student team will only exist for the duration of one PoW, making control and reproducibility of conditions impossible. Although we will attempt to conduct rigorous and intersubjectively verified micro-analysis of individual sessions and to conduct mini-experiments where variables are controlled as much as possible to test specific variations, our work cannot be confined to a narrow paradigm of experimental methodology. This is design-based research (Design-Based Research Collective, 2003): In designing technical artifacts, activity structures, institutional practices, instructional scaffolds and curricula as mutually determinant, we will be looking for emergent features and empirical discoveries that could not have been predicted in advance. We will have to mix a diversity of formal and informal, quantitative and qualitative, interpretive and descriptive methods, and gradually evolve practical approaches to group formation, curriculum definition, technology implementation and community practices that work together to produce effective collaborative learning of math in real world conditions. We will be collaborating with learning sciences researchers experienced with a variety of methodologies.

Expected Results

Although the VMT Project just started in September with the awarding of two NSF grants and the hiring of research assistants, we will have results of initial pilot studies to share at the ICLS conference. We have already recorded and begun to analyze 4 video sessions of students collaborating on a math exercise in a Philadelphia public middle school. During the Winter quarter, we will videotape 10 collaborative sessions with university students working together face-to-face on math problems and another 16 sessions of online collaboration by the same university students. We wanted to get a sense of collaborative math work in traditional face-to-face settings before studying the online situation. All together, the analysis of these pilot studies will guide us in designing the group formation, curriculum writing, software support and community practices for our work on the Math Forum site.

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