Demo of Collaborative Dynamic Mathematics in Virtual Math Teams

Gerry Stahl, The Math Forum at Drexel University, Gerry@MathForum.org
Anthony Mantoan, The Math Forum at Drexel University, Tony@MathForum.org
Stephen Weimar, The Math Forum at Drexel University, Steve@MathForum.org

Abstract: Dynamic mathematics software like GeoGebra provides new opportunities for mathematics education. With proper technological and pedagogical support for collaborative dynamic mathematics, it is possible to create a CSCL approach to foster significant math discourse. The demo of the Virtual Math Teams (VMT) online environment will focus on the recent development of a multi-user version of GeoGebra within VMT. To support effective use of VMT, a coherent set of dynamic-geometry activities has been developed; this will be discussed as well as a professional-development course for in-service math teachers, preparing and supporting them for introducing collaborative dynamic mathematics in their schools. Tools built into the VMT software for detailed interaction analysis will be demoed and sample case studies referenced.

Virtual Math Teams: Contribution to CSCL

The Virtual Math Teams (VMT) Project is an on-going design-based CSCL research effort, funded by NSF from 2003-2016 (see Acknowledgements). It has already produced a significant impact within the field of CSCL, with an edited volume in the Springer CSCL series (Stahl, 2009) and many papers published at CSCL conferences and elsewhere. It is in many ways a prototypical CSCL project, including the development of software to support collaboration, a school content focus (mathematics), a design-based approach with cycles of trials/analysis/redesign, an analytic method (a form of interaction analysis, with special tools) and an emergent theory (group cognition (Stahl, 2006)). Previously, VMT has not been demoed at a CSCL conference, only at practitioner conferences like NCTM and ICME or regional and international GeoGebra conferences.

While the importance of collaborative learning for online education is obvious to CSCL researchers and its possible advantages have been well documented in cooperative-learning and CSCL research for decades, support for collaboration is still not always designed into new educational platforms. For instance, the latest hot approach to university instruction—massive open online courses or MOOCs—are generally based on the lecture paradigm, where students passively watch talking-head videos of famous professors and are not given any sanctioned opportunities for interaction. Similarly, the acclaimed Khan Academy offers YouTube videos explaining thousands of detailed topics in school mathematics, but students have no support for exploring the topics themselves or discussing them with peers. These technological opportunities are generally not designed to incorporate constructivist learning principles.

With the development of dynamic-geometry and dynamic-mathematics software environments like Geometer's Sketchpad, Cabri, Cinderella and GeoGebra, there has been a resurgence of interest in basic geometry around the world. The free availability of open-source GeoGebra (http://geogebra.org) has resulted in a burgeoning user community, primarily of math teachers. Although dynamic mathematics encourages active learning and student construction of meaning, these technologies have not been designed to support collaboration. In working with the GeoGebra software development community, the VMT Project team has

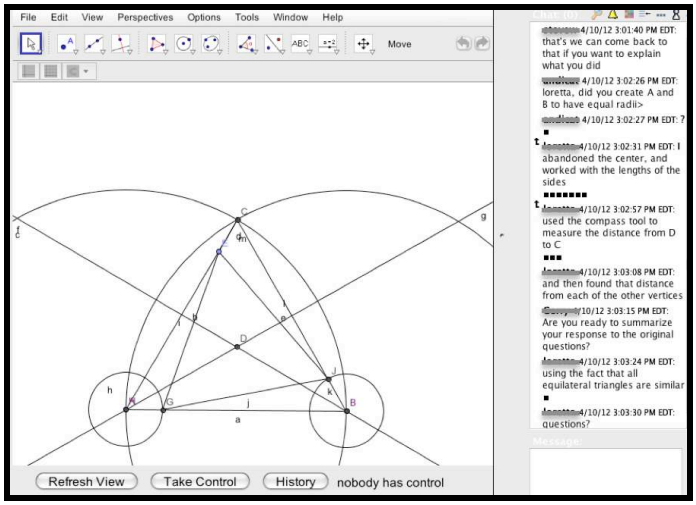

Figure 1. A view of a VMT chat room while three students are exploring a challenging geometry task.

created the first effective multi-user version of a dynamic-math environment. This allows small groups of students to collaborate on a shared construction and to engage in text chat about it at the same time (see Figure 1). This opens up the exciting new mathematical tool of dynamic math for the first time to true, convenient, supported collaborative learning. All the collaborative activity in this environment is persistent and readily available for review and reflection both during the collaboration session and at any time thereafter.

The VMT CSCL technology is unusual in that it is neither a general-purpose platform nor a single-application specialized tool. It provides a suite of components to support individual, small-group and classroom-wide collaborative learning, but it is oriented to school mathematics, especially basic geometry. We are exploring many aspects of how to use this technology to shift geometry education from the classical approach dating back to Euclid to a contemporary approach based on the principles of CSCL (Stahl, 2013b).

Another uncommon aspect is the level of pedagogical support developed within the VMT research project. This is an outgrowth of the fact that VMT has been developed at the Math Forum (http://mathforum.org), one of the first and most prominent online sites/organizations for supporting the learning of mathematics. The Math Forum has considerable expertise and experience in professional development and mentoring of math teachers. Consequently, the VMT Project provides masters-level courses and mentoring for teachers interested in introducing computer-supported collaborative learning of dynamic mathematics in their schools (http://vmt.mathforum.org/vmt/courses.html). We have also developed a hundred-page curriculum with tutorials for the use of VMT with GeoGebra in online small groups of students (Stahl, 2012).

Finally, the VMT software system includes tools for analysis of the interaction that took place within a VMT mathematics chat session. This supports reflection by students on their own group's interaction and collaborative learning, as well as reflection on that of other groups. It enables teachers to review the work of student groups at whatever level of detail they require. Also, it gives researchers access to all group interaction that took place, in a variety of convenient electronic formats. A researcher can review in complete detail everything that the students themselves experienced of the group interaction—either in a view identical to that of the students (see Figure 2) or in logs formatted for inclusion in papers. The analytic issues for research introduced by video capture and speech transcription are thereby avoided.

Case studies of interactions in the VMT environment have shed considerable light on the nature of collaborative learning in this kind of CSCL environment. They have guided the design, on-going re-design, debugging and tweaking of the VMT software, pedagogy, curricular materials, analytic tools and theory. Case studies of VMT interactions appeared in the latest issues of *ijCSCL* (Zemel & Koschmann, 2013) and *JLS* (Medina & Suthers, 2013). Other studies will be reported in a workshop, two papers and a poster at the CSCL 2013 conference (Magee, Mascaro & Stahl, 2013; Stahl, 2013a; Stahl et al., 2013; Stahl & Öner, 2013).

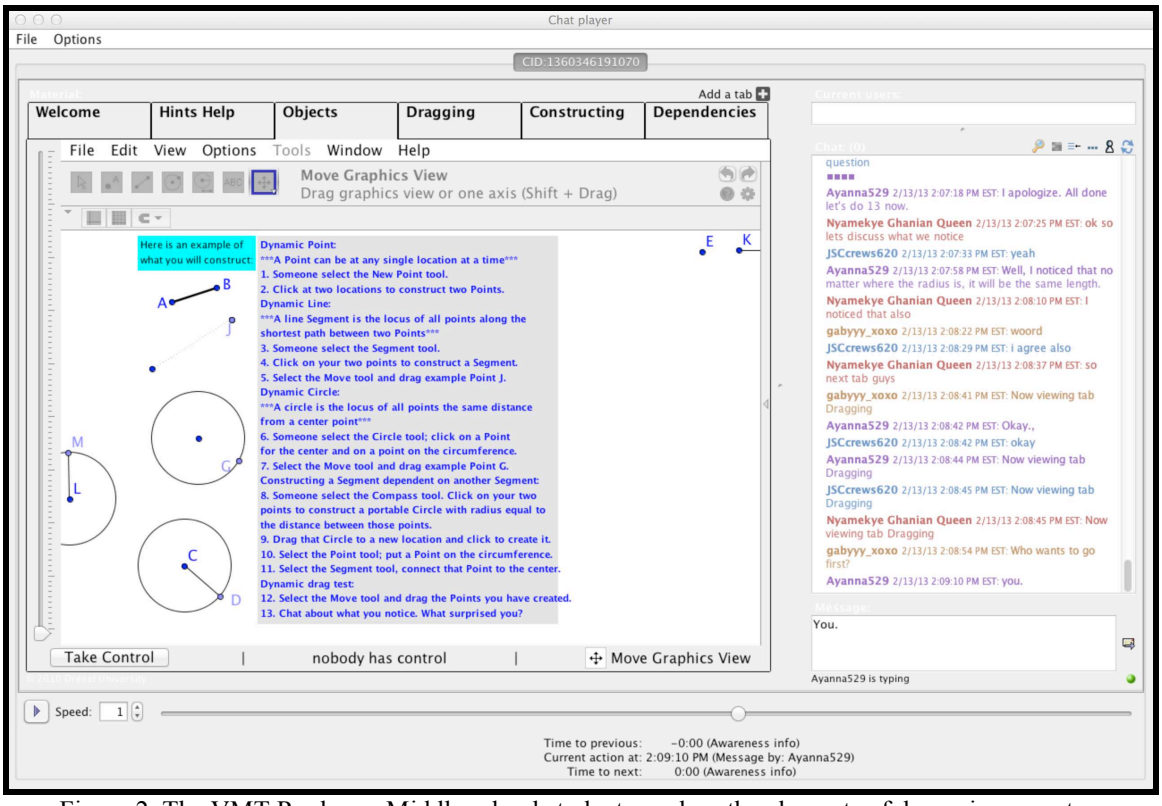

Figure 2. The VMT Replayer. Middle school students explore the elements of dynamic geometry.

Virtual Math Teams: Software, Curriculum, Pedagogy, Analysis

These are the aspects of the VMT Project support for collaborative dynamic mathematics to be presented in this demo: software, curriculum, pedagogy and analysis. The amount of time spent on each aspect will be determined based on audience prior knowledge and interests.

VMT software environment. The VMT environment is multi-faceted. There is a lobby that users enter upon login (http://vmt.mathforum.org). There they can browse a list of existing chat rooms under different math topics. Teachers can also create new rooms, review student work in existing rooms or register a class of students for VMT access. A chat room can have multiple tabs with different media; the demo will focus on the affordances of GeoGebra tabs. In particular, it will discuss the features that had to be adapted or supplemented in GeoGebra to make it truly and effectively multi-user.

VMT curriculum for dynamic geometry. A hundred-page booklet featuring 18 hour-long activities was developed for small groups of students using VMT with GeoGebra to learn basic geometry and to develop facility with GeoGebra. This includes paced tours of the software and activities for individual exploration followed by collaborative construction. Each activity includes prompts for significant mathematical discourse. The curriculum is developmental, designed to gradually increase the ability of the students to engage in open-ended exploration, reflection and un-scaffolded use of GeoGebra. The emphasis is on understanding the role of dependency in dynamic geometry through construction—to counteract a tendency in GeoGebra pedagogy toward pre-constructed apps that students or teachers simply drag around.

VMT pedagogy for teacher professional development and student collaboration. A course for in-service math teachers will be described briefly (http://vmt.mathforum.org/vmt/courses.html). This is an online CSCL-style course given at the Schools of Education at Drexel University and Rutgers University, with support from the Math Forum. It emphasizes collaborative learning through a focus on mathematical discourse, accountable talk, making thinking visible, and articulating noticing/wondering.

VMT analysis tools. Any user—whether student, teacher or researcher—can download chat logs (optionally including GeoGebra actions, etc.) in a variety of spreadsheet formats. They can also download data files for the VMT Replayer. These facilitate rigorous interaction analysis (e.g., by researchers), as well as less formal review for reflection (e.g., by students) or assessment (e.g., by teachers).

Virtual Math Teams: Demonstration

There will be a live demo (see Figure 3) of the VMT environment, with several members of the audience collaborating on simple tasks in a shared GeoGebra workspace on their own laptops.

The presenters will first give a tour of the VMT software, including the Lobby, chat room, teacher interface, social networking components, log generation, associated wiki pages and Replayer tool. Copies of curricular materials and publications will be available. Many publications on VMT and CSCL are available at: http://GerryStahl.net/pub. The analytic tools and case-study approach of VMT research will be discussed.

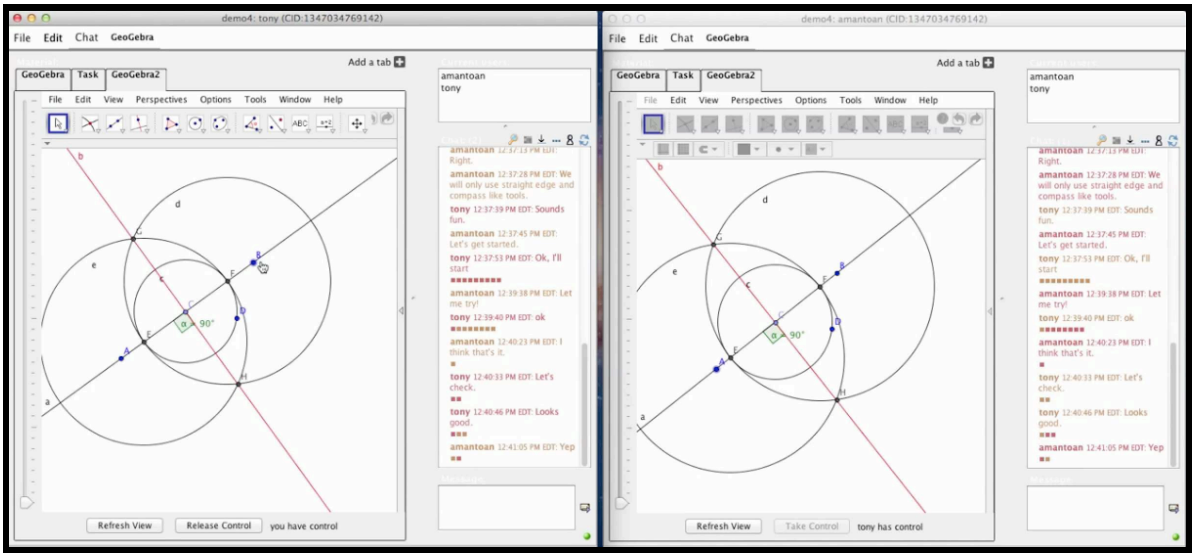

Figure 3. A demo of two students constructing, dragging and chatting about a shared geometric figure. The student on the right currently has control for using the GeoGebra tools. The other student also sees any changes made by the first student.

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