Collaboration within Mathland: What Do We become Together

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Abstract: Research has pushed Papert's (1980) seminal ideas of mathland and microworlds but remain focused on computational environments designed for individual work. Current group-centered activities using networked computational environments distribute mathematical objects among students and their relations and then assemble these objects in a shared public space. Within these new technological contexts, we ask how students identify with the mathematical objects distributed and maintained in socio-mathematical relations.

Introduction and literature review

Over the last 40 years, research has pushed Papert's (1980) seminal ideas further in understanding students as epistemic agents and their material environments as fostering microworlds. Yet much of this work has remained focused on computational environments designed for individual work. A growing strand of literature has introduced group-centered activities using networked computational environments to distribute mathematical objects among students and their relations and then assemble these objects in a shared public space (Brady et al, 2013; White & Pea, 2011). Researchers have yet to broaden Papert's constructs of mathland and microworlds to these new technologies and students' collaborative interaction with them, but doing so reveals how these socio-technological *infrastructures* (cf Hegedus & Moreno-Armella, 2009) can provide rich collaborative spaces where students *identify with* mathematical objects at both the individual and collective level.

Early work in constructionism (Papert & Harel, 1991) using microworlds focused primarily on design and implementation of digital environments to support students' mathematics learning. But the microworld idea offers a framework to understand *any* designed space embodying powerful ideas (Papert, 1980) in a self-contained logical structure that students can explore and "bump up against" in order to (a) appropriate particular powerful ideas, and (b) build experiences of *what a logical structure is*, i.e. have epistemological experiences of mathland. Eisenberg (2003) broadened the notion of microworlds to extend it 'outside the computer,' exploring the material possibilities of physical or hybrid/instrumented objects to create a mathland in a child's familiar surroundings. Broadening the construct even further, we propose to analyze socially distributed activities and learning environments as microworlds on the basis of the patterns of interaction that they support. With such a frame, the social peer group can act both as infrastructure instantiating a microworld and as a social medium linking individuals with their mathematical roles. These interactional mechanisms among students, their participation structures, and the mathematical structures become essential when the nature of the computational environment leverages the peer group by aggregating distributed mathematical objects in a shared space.

Group-centered activity design with technology support has a growing base of literature establishing its unique capabilities and impact on classrooms (e.g. Kaput, Hegedus, & Lesh, 2007; Stroup, Ares & Hurford 2005). Such designs leverage technological infrastructures in classroom activities to model participation structures to mathematical structures (Brady et al. 2013; Hegedus & Penuel, 2008). For example, individual students act as points while student-pairs form a line and the collective forms a family of lines (White & Pea, 2011). Within such collaborative digital environments, the relationship between the classroom's social and mathematical structures can readily be seen as dialectic (Stroup et al. 2005), where the social influences the mathematical and the mathematical influences the social. We argue these types of environments can generate the conditions in classrooms that define microworlds as learning environments. This view highlights microworlds' interactional nature, where the social space is a medium and a representational infrastructure. In the context of a particular group-centered network activity, the preceding framing leads to the following research question: How do students identify with mathematical objects when those objects are distributed to individuals but maintained in socio-mathematical relations in a shared public space?

Methods

To investigate the above research questions, we implemented a design-based research study of a series of activities in the 8th grade mathematics classrooms of a partner teacher at a public middle school serving a racially and economically diverse population within a large metropolitan district in a midsize southern city in the USA. Students ranged in backgrounds and relationships with mathematics from positive to negative, but the established classroom culture was overall positive and focused explicitly on a growth mindset. The two authors entered into the classroom space to assist the teacher in implementing rich mathematics tasks with technological support. All three adults participated in supporting students' thinking during a series of weekly activities. Data for the larger project was collected broadly and is ongoing, but the current study draws on data collected from two stationary cameras and screen capture of the 'teacher' computer (which was displayed publicly via a projector), along with field notes generated during discussions of what to improve in continued activities.

To understand how students were identifying with mathematical objects in the activities, we analyzed a class discussion between two of the mathematics tasks. The previous week, the second author led the class in a group-centered activity where each student controlled a point in a shared display. By following simple verbal rules, students generated lines together; for example, "make your y-coordinate equal 4" generated the horizontal line seen in Figure 1. Together, students generated horizontal, vertical, and slanted lines by following different rules coordinating x and y coordinates. To better assess what the students recalled from this activity, the teacher prompted them to write in their journals, asking, "What do you remember from last week when [the authors] were in the room?" Students' responses to this prompt revealed how they were identifying with (or not) the mathematical objects from the previous week's task.

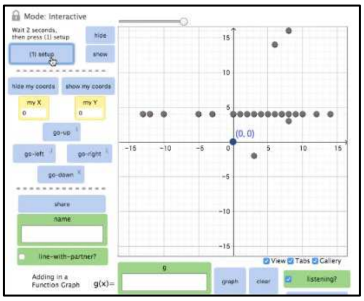

Figure 1. Collaborative group-centered activities where students control points.

Findings

In the class discussion, students readily identified themselves with the point they controlled, using statements that blurred themselves and their point, such as "I remember chasing each other with the dots." Further, they related the technological space with the classroom space saying, "I like how we can see the whole class when we go in there." The students' use of "we" was significant, signaling a collective solidarity in the community (c.f. Hegedus & Panuel 2008). On the other hand, students did not (yet) seem to identify as strongly with the *emergent* mathematical objects (the lines), describing these as "how [second author] would give us points and stuff to go to." These descriptions hearkened back to traditional roles of teacher-as-rule-maker and student-as-rule-follower. This finding indicates further support is needed for groups of students to relate themselves with emergent mathematical objects (e.g., functions and loci of points), and our ongoing work is pushing technology designs and class discussions to explore these possibilities.

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