# PROMOTING COLLABORATION AND MATHEMATICAL ENGAGEMENT IN A DIGITAL LEARNING ENVIRONMENT

Alden J. Edson
Michigan State University
edsona@msu.edu

Merve N. Kursav
Michigan State University
kursavme@msu.edu

Amit Sharma
Michigan State University
sharma79@msu.edu

*Promoting mathematics learning without developing students' engagement is a critical issue in the teaching and learning of mathematics. This study reports on the student and teacher perceptions on mathematics engagement in digital collaborative settings. Emerging themes arose through open coding of the student survey responses and the teacher interview. Findings revealed two themes: (a) the digital learning environment holds promise for promoting real-time collaboration and productive disciplinary engagement in mathematics and (b) in the digital learning environment, some students requested explicit opportunities for initial individual work before accessing a shared workspace on the digital platform.*

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## Introduction

The 40th Annual Meeting of the North American Chapter of Psychology in Mathematics Education invites the mathematics education community to consider emerging opportunities related to technology use that can support each and every student. To this end, we are exploring ways in which digital technologies can support student learning of and engagement in mathematics. Through the use of design research methodologies, we report on initial work that offers promising directions for collaboration when teaching and learning mathematics.

## Theory of Productive Disciplinary Engagement

While it often appears to educators and scholars that students are engaged in problems in the classroom, students may not be involved in the mathematical underpinnings of that engagement. Students are productive in their disciplinary engagement when they make intellectual progress or demonstrate change over time on the disciplinary learning goal (e.g., Hiebert, et al., 1996). This notion is referred to as productive disciplinary engagement. Four design principles of productive disciplinary engagement are needed to be embodied in learning environments: problematizing, authority, accountability, and resources.

Good problem solvers are not passive recipients of knowledge. If students are to engage in the content, issues, and practices of mathematics, then something must exist that is of genuine uncertainty for which there is sufficient space for students to make progress. Problematizing in mathematics (Hiebert, et al., 1996) involves addressing problematic situations that encourage learner "perplexity, confusion, or doubt" (Dewey, 1910, p.12).

If learners are involved in the content, issues, and practices of mathematics, then they must have some degree of intellectual authority when addressing problematic situations (e.g., Lampert, 1990). "As learners are authorized to share their thinking, they become recognized as authors of the ideas and contributors to the ideas of others, leading to students becoming local authorities on a subject" (Williams-Candek & Smith, 2015, p. 3).

Accountability refers to the notion that students are self-regulated in their learning. This means that they are responsible for how their ideas make sense amongst the ideas of others. The goal is that students will make ongoing revisions in their work, communicate their ideas, and

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consider how the ideas do or do not make sense in the discipline so that they are better positioned to improve them when more thoroughly challenged.

Learning environments need to provide access to sufficient resources so that students can engage in the other principles of productive disciplinary engagement. Resources might include sufficient time and location, technology tools, or classroom artifacts. Resources are going to vary dramatically as they depend on the topic, learning goal, classroom setting, and other factors.

## Methods

This study is part of a larger design research (e.g., The Design-Based Research Collective, 2003) project focused on iteratively developing and enacting digital environments. The study is guided by thinking about how productive disciplinary engagement can be fostered in digital learning environments. The research reported in this study addresses the following research question: *In the digital learning environment, what are student and teacher perceptions of mathematics engagement in collaborative settings?* To this end, we report on data collected from four classes (approximately 25 students per class) that tested the developed digital resources over two days. The mathematics problem that was tested was from the seventh-grade unit, *Stretching and Shrinking: Understanding Similarity*. Problem 2.2 Hats Off to the Wumps: Changing a Figure's Size and Location comes from the *Connected Mathematics3* (CMP) curriculum materials (Lappan, Phillips, Fey, & Friel, 2014). While the teacher and students are familiar with CMP, the use of the prototype digital platform was the first experience for the students and the teacher. The platform supports students to make their thinking visible to others, to see and make changes in real time, and to publish their work (at any point in time).

The student survey was administered electronically after the testing of the mathematics problem. A total of 37 responses were captured from the students in the four classes. The teacher interview was also conducted after the testing of the mathematics problem. Interview questions focused on the experience using the digital platform and its features, student engagement in mathematics (problematizing, authority, accountability, and resources), student learning about similarity, and similarities and differences about the instructional model (Launch, Explore, Summary) from past teaching experiences. Student survey responses and teacher interview transcriptions were coded using an open coding approach (Strauss & Corbin, 1998). We report on the emerging themes on mathematical engagement in collaborative settings.

## Findings

In this section, we report on findings of student and teacher perceptions on mathematics engagement in collaborative settings for an open mathematics problem.

**Theme 1. The digital learning environment holds promise for promoting real-time collaboration and productive disciplinary engagement in mathematics.**

From the analysis of the interview, the teacher spoke towards the positive aspects of the digital platform for student learning and engagement in mathematics. Below are excerpts of questions and responses between the interviewer (I) and the teacher (T).

As shown on Table 1, students found that the real-time collaborative digital resources were helpful for mathematics engagement and learning. However, some students raised issues on the technical lags (e.g., freezing and refreshing) and the cultural norms (i.e., hesitation of mistakes/errors now being public and sharing of the work as "copying" of others work). Although issues were raised, no students indicated they did not want to work collaboratively with the digital resources.

*I:* In your own words, tell me about the different features of the digital platform and the different ways you and your students used those features.
*T:* So, the main feature was the collaborative space screen, and the students slowly get used to using that to be able to share their thoughts and the answers on the same screen. When one student had an answer, they were able to input it and then share with their group and the whole class.
*I:* Did you notice changes in how students were accountable for their ideas, to the ideas of their group mates, or to the ideas of the class?
*T:* I think students were held a lot more accountable to each other and group. Because they think their work is much more visible, they cannot just write. They have to discuss, talk, and share. They were accountable to the whole class with the publish feature.
*I:* Have you noticed changes in how students share their thinking or contribute to the ideas of others?
*T:* They were just a lot more specific. They had things to reference. They felt a little more comfortable with each other. I am excited to see as we keep going how that changes. The next day, we did a lesson in class just out of the book paper pencil, I can still definitely feel the vibe of the cooperation thing as we were doing. So, I am interested in seeing this throughout the rest of this book if they continue to keep the same tightness they forced to do with the digital platform.

**Figure 1.** Teacher interview

**Table 1: Select survey items and student responses**

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|---|---|---|---|---|
| Did the technology help you be more confident, less confident, or as confident as usual in mathematics and in sharing your ideas with others? Explain why. (n=37) | More Confident 30% | Less Confident 22% | No Difference 40% | Other 8% |
| Was the technology helpful to explore similarity by producing similar and non-similar hats? Explain. (n=37) | Helpful 84% | Not Helpful 8% | Other 8% | |
| The technology allowed you to publish your work. Was this helpful or not? Explain. (n=37) | Helpful 62% | Not Helpful 30% | Other 8% | |
| The technology allowed you to look at your classmate's published work. Was this helpful or not? Explain. (n=37) | Helpful 65% | Not Helpful 24% | Other 11% | |

**Theme 2. In the digital learning environment, some students requested explicit opportunities for initial individual work before accessing a shared workspace on the digital platform.**

Responses from the student survey surfaced an important consideration for working in collaborative groups. This consideration may be connected to an affordance of paper/pencil contexts. For example, below are sample student responses from students.

What changes, if any, would you like to see in the technology?

- *It should be individual and then you share your answers with your table group.*
- *You do a private thing then share with your group then publish*
- *I would make changes so that you can individually write things then discuss it with your group.*
- *I would have it work better; for example, everyone could have their own separate work and then share it when they were all done to compare answers.*

What did you not like about the technology?

- *It was hard to get work done because someone was trying to work on the table, and someone was working on the graph. I think each person should have their own interactive thing and then share with just their group of table.*

**Figure 2.** Sample of survey questions and students' responses

## Discussion

In this study, we reported on student and teacher perceptions related to mathematics engagement in collaborative settings. Our analysis of the data was limited to student and teacher perceptions around one mathematical problem. The two themes highlight the pivotal role of accountability in the theory of productive disciplinary engagement. As Engle (2011) noted,

developing and increasing accountability builds by asking learners to account for how their ideas make sense from the "inside out" - oneself, safer peers, more challenging peers, internal authorities providing increasing challenges, and external disciplinary authorities providing increasing challenges. In this version of the prototype, the digital platform began with the assumption that students would share a collaborative space. While students had the opportunity to create a space for themselves individually, it was an optional feature. The findings from the study suggest some need by students to work individually before moving to collaborative space. This finding may be interpreted as the students needing the opportunity to make sense of the problem themselves before sharing it with safe peers (group members). This study provides some evidence that resources and opportunities are needed to support accountability for the learner itself prior to moving outwards with others.

Despite the early stage prototype having technical glitches where students and the teacher had limited familiarity with the digital resources, this study underscores the important design consideration of collaboration when designing and enacting digital learning environments for promoting student engagement and learning of mathematics. Interestingly, the digital platform provided an option of an individual workspace for students (where group mates could not access their work), but its usage did not surface in our analysis of the survey.

While the digital learning environments reported in this study are different than paper/pencil contexts, students were still expected to be accountable to their ideas by justifying their work in their small group, to the whole class, and the teacher. Almost all students appreciated the value of working in a collaborative workspace, highlighting the benefits of real-time communication and sharing of work with others.

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