Facilitating Productive Mathematical Discourse with Magma Math

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Facilitating meaningful discourse in mathematics classrooms is one of the eight Mathematics Teaching Practices that NCTM and NCSM identify as supporting equitable mathematics instruction. Meaningful or productive mathematical classroom discourse is vital for promoting learning and understanding of mathematical content (NCTM, 2014). Discourse is the principal means by which students develop conceptual understanding, meaningful learning, reasoning, and problem-solving (Carpenter, Franke, & Levi, 2003; NCTM, 2014; Michaels, O'Connor, & Resnick, 2008). Through explaining, questioning, comparing, sharing, and justifying solution strategies, students have opportunities to construct mathematical knowledge (Erath, Prediger, Quasthoff, & Heller, 2018; Franke et al., 2015; Rittle-Johnson & Schneider, 2015).

In addition to supporting student learning, productive mathematical discourse can promote student agency and more equitable classrooms. Meaningful discourse supports the development of student agency by including students as collaborators and knowledge generators (Vaughn & Faircloth, 2011, 2013, Vaughn, Hillman, McKarcher, & Latella, 2017). Including student strategies and ideas positions the students as sources of mathematical knowledge, which can disrupt negative self-images students hold of themselves (Seda & Kendall, 2021). Moreover, using student work to facilitate classroom discourse can move the class towards greater equity by broadening opportunities for students to participate in meaningful mathematics. When teachers intentionally choose the solution strategies of students who would not normally participate, more students are engaged in the discourse, and the self-confidence of the student whose work is shared is increased, leading to increased future engagement (Webb, Franke, Ing, Wong, Fernandez, Shin, & Turrou, 2014). Classroom discourse, when facilitated with equity in mind, has the potential to broaden the opportunities for students to participate in mathematical activities as well as reframe student ideas of themselves as mathematicians and develop students' mathematical agency.

This paper will outline how Magma Math can be used to facilitate productive mathematical discourse for the purpose of promoting student learning and more equitable student outcomes by broadening opportunities for students to participate in meaningful mathematical activities.

Using Student Work to Facilitate Productive Mathematical Discourse

Using student work can be a key part of facilitating mathematical discourse. In traditional classrooms, students are often asked to volunteer, or students with advanced solution strategies are asked to explain their work. This use of student work is not effective because students disengage when a peer is explaining their work (Liljedahl, 2021), students who volunteer may not align with the key ideas of the lesson (Smith & Stein, 2011), and demonstrating a desired solution strategy decreases the likelihood that a student who did not arrive at a correct solution will be successful on the next task (Liljedahl, 2021).

Instead of having students volunteer or choosing a student with the target solution to present, teachers can engage more of the class in mathematical thinking by facilitating students to engage with each other's thinking and by drawing connections between the work of the students and the key mathematical ideas of the lesson. Using student work to facilitate classroom discourse by having students engage with each other's thinking has been found effective in increasing student understanding of mathematics and reasoning ability in both young students and older students (Groth, 2014; Legesse et al., 2020; Smith, 2018). Furthermore, more students engage in conversations where they are asked to make sense of a peer's thinking than when they are asked to listen to a peer explain their thinking (Liljedahl, 2021).

Smith and Stein (2018) outline five practices for facilitating productive mathematical discourse:

1. Anticipating student responses prior to the lesson
2. Monitoring students' work on and engagement with the tasks
3. Selecting particular students to present their mathematical work
4. Sequencing students' responses in a specific order for discussion
5. Connecting different students' responses and connecting the responses to key mathematical ideas

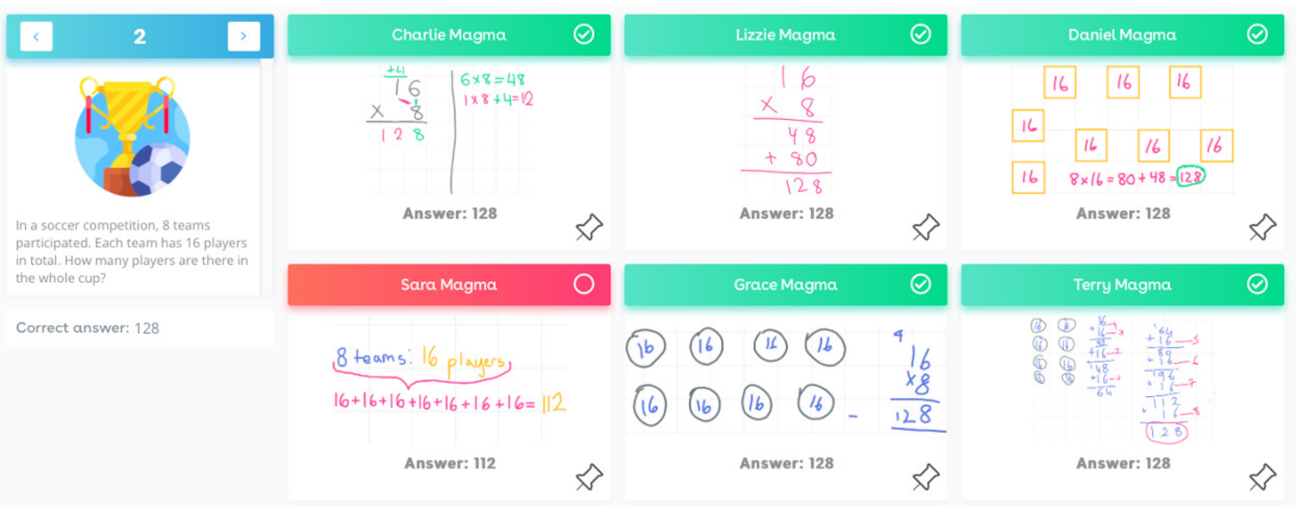

Figure 1: *Student solution view of problem 2*

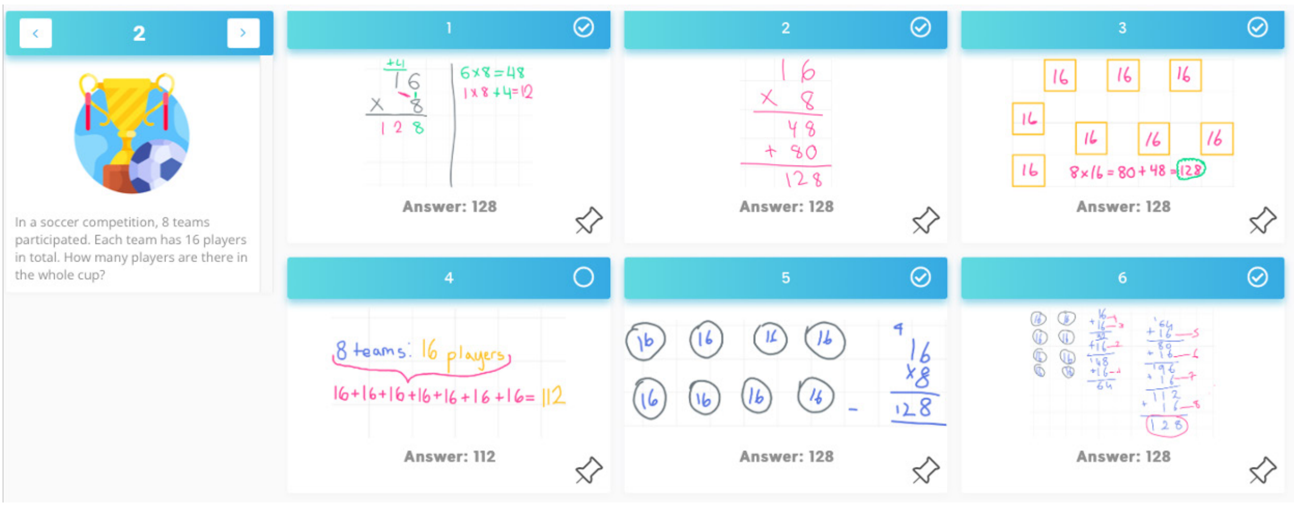

Figure 2: *Student solution view of problem 2 with anonymous student work with anonymous student work*

In Smith and Stein's Five Practices, student work is used to shape the class discourse. Teachers select and sequence student work to support the development of the key mathematical idea(s), address student understanding they see unfolding while monitoring the class, and promote understanding of mathematics by drawing connections between representations and ways of thinking.

Liljedahl (2021) found that using a sequence of student work to facilitate class discourse was an effective means to consolidate the content of the lesson. The discussion is started by asking the class to explain portions of the student's work. He states the teacher should carefully sequence the presentation of student work to "[follow] the same path as… [the] flow while the students worked through the task(s)" (Liljedahl, 2021, p. 172). Hence teachers start with a solution method that all students were able to complete in the given time and then extend the discussion by sequencing student work that becomes more nuanced. This strategy, coined "consolidating from the bottom," allocates the most time to ideas that all students can access and the least amount of time to the furthest extension, which only a few students may have gotten to.

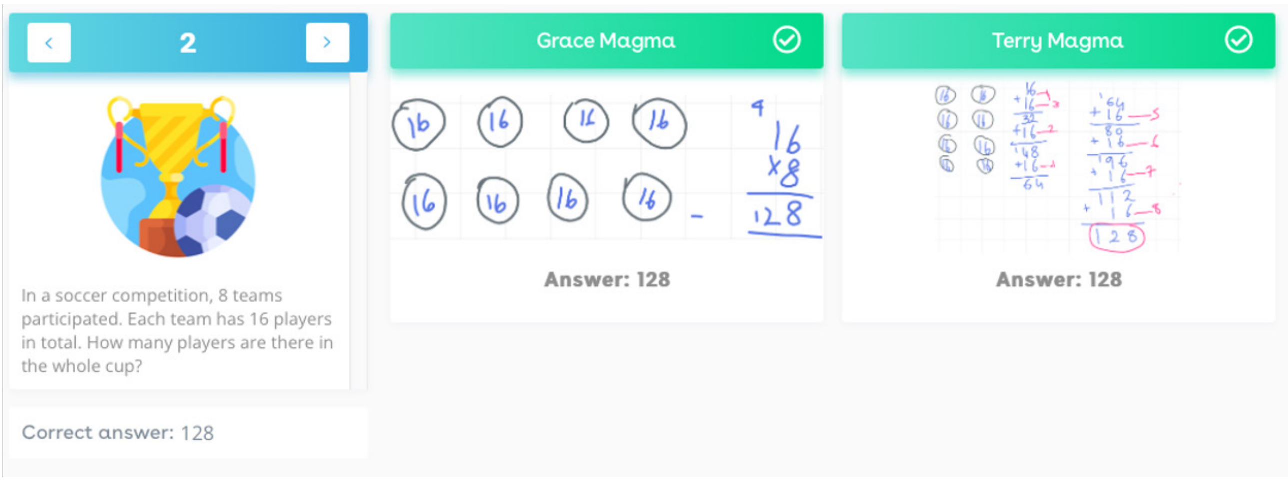

Figure 3: *Teacher can "pin" student work to show to class*

Magma Math as a tool to facilitate Productive Mathematics Discourse

Magma Math includes tools that allow for teachers to monitor, select, and sequence student work to facilitate classroom discourse. Since Magma Math includes student work, the teacher can easily note the various solution strategies their students are using by viewing the student solution view (see Figure 1). Teachers can then intentionally select student work to facilitate moving the class's thinking forward while leveraging opportunities to include work and ideas from students who would not usually volunteer their thinking in class. Students who would not regularly volunteer their ideas in class discussions can have their work leveraged by the teacher broadening the students' opportunities to participate in meaningful mathematical discussions and promoting more equitable teaching practices (Moschkovich, 2013).

The teacher might, for example, notice in the student solution view of problem 2 (see Figure 1) that some students used addition to solve the problem while others used multiplication. The teacher can choose to present student work with student names and correctness or choose to hide the names and correctness (see Figure 2). If a goal of the lesson is understanding multiplication as repeated addition, a teacher could select Terry's work and Grace's work for the students to compare. The teacher can "pin" Terry and Grace's work to display to the class and decide whether it will be displayed anonymously (see Figure 3 and Figure 4). Both students have similar representations of the problem and arrive at the same solution. By setting the class up to compare the two solutions, the teacher can facilitate a class conversation where students identify that the two solution methods arrived at the same solution because multiplication is repeated addition.

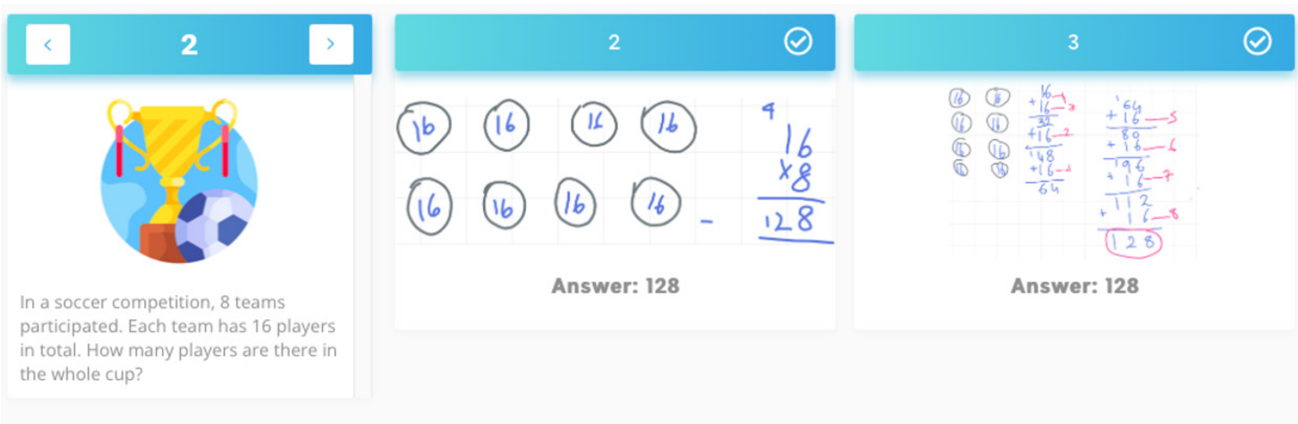

Figure 4: *Teachers can "pin" student work and present it with names and correctness hidden with anonymous student work*

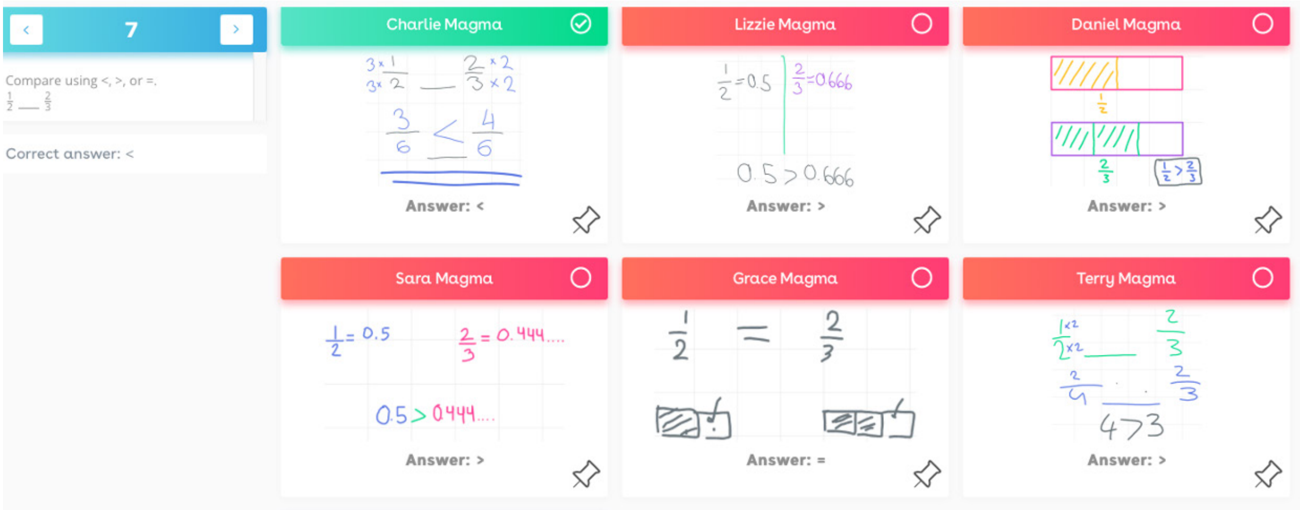

Figure 5: *Student solution view of problem 7*

As another example, consider the student responses to problem 7 (see Figure 5). A teacher monitoring their class's progress using Magma might notice that while only one student arrived at the correct solution, most of the students used viable strategies to manipulate or represent the two fractions. Sequencing Daniel, Lizzie, and Charlie's work gives the opportunity to draw connections between three solution strategies. For example, students can draw connections between Charlie's multiplying to get common denominators and Daniel's bar diagram to see how the multiplication changes the whole and the part of the fraction but not the amount.

Magma Math as a tool to broaden participation

In addition, Magma Math can serve as an important tool for teachers pursuing more equitable outcomes in their classes by broadening the ways students can participate in the classroom (Moschkovich, 2013). Magma Math helps students access math by allowing all content to be translated into 120 languages, by having a read-functionality in 40 languages, and by allowing to increase the text size of problems depending on the need. Furthermore, the canvas available to the student is multi-modal in the sense that it both supports handwriting and keyboard input, to also be workable for students with writing disabilities.

A teacher can also use the student solution view to look for opportunities to build the mathematical confidence of students who do not view themselves as capable. Magma Math allows for teachers to either display the student's final written solution or press "play" to show a video of the solution. The class can then engage with the video showing the process of the student solving or the final written solution creating opportunities for these student voices that would normally not be heard to be highlighted. The teacher can help the student recognize that they are capable of doing mathematics which promotes the student's success in the class by having the class engage with the solution strategy of a student with low confidence (Seda & Brown, 2021).

Conclusion

Traditional means of facilitating class conversation, asking students to volunteer, or selecting students with target solutions to present their solutions fall short in supporting student learning and understanding because students disengage, and classroom inequities are maintained. Instead, facilitating students to discuss mathematics by making sense of and comparing each other's work can disrupt inequities, support student engagement, and promote student development of conceptual understanding.

Magma Math gives teachers access to every student's work immediately during the lesson, not just a select few, broadening participation to support more equitable outcomes (Moschkovich, 2013). By reviewing student solutions, teachers can make decisions about how to facilitate class discussions with two coinciding goals: (1) supporting students in developing a deep content understanding of the math at hand by sequencing or comparing student solutions and (2) supporting more equitable outcomes by giving students access to the math and allowing for many ways to express their thoughts and build mathematical confidence.

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