WHAT LITERACY MEANS IN MATH CLASS

TEACHER TEAM EXPLORES WAYS TO REMAKE INSTRUCTION TO DEVELOP STUDENTS' SKILLS

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While much has been written in the last decade about the need for disciplinary literacy instruction and its potential to support higher levels of student learning and communication (Fang & Coatoam, 2013; Hynd-Shanahan, 2013; Lee & Spratley, 2010; Moje, 2007, 2008, 2015; Shanahan, 2012; Shanahan & Shanahan, 2008, 2014), relatively little is known about how current teachers are adopting and enacting disciplinary literacy practices.

Secondary teachers and leaders, many of whom are implementing the Common Core State

Standards, are seeking guidance about how to implement disciplinary literacy practices. In our own work with secondary teachers over the past eight years, we have heard countless versions of this question: What will it take for us to introduce disciplinary literacy instruction into our middle and high school classrooms?

This is perhaps most true for mathematics educators. Of the four core subjects taught in secondary schools — English, history, math, and science — we have found that math teachers are least likely to be offered support in learning about, designing, and refining disciplinary literacy practices, despite the highly specialized and prevalent literacy practices that math demands. Literacy work in math classrooms remains underspecified and underexplored.

The reduced focus on literacy practices in math classrooms is perhaps an artifact of a widely held perception that literacy and math instruction are distinct enterprises. This perception may be fueled by the persistent need to improve scores on discrete tests of reading/writing and math.

With the two disciplines often set up in opposition, it is understandable that math teachers might be hesitant initially to consider the ways in which literacy is threaded throughout math learning and how they might support students in using the literacy skills necessary to the discipline of math. When invited to take a disciplinary literacy stance toward instruction, secondary math teachers rightly ask:

- Will a shift toward disciplinary literacy instruction bolster mathematical teaching and learning?
- What might a disciplinary literacy stance mean for an entire math department?
- What kinds of professional learning might best support learning about disciplinary literacy?
- Ultimately, for math teachers, is it worthwhile to invest time and energy in disciplinary literacy professional learning and teaching initiatives?

If literacy is to be central in every classroom, and if secondary math teachers are expected to engage in disciplinary literacy work, then we must address these questions. To begin finding answers, let's examine a larger professional learning and research initiative in which math educators are collaboratively and productively engaging in disciplinary literacy instructional design work.

Math literacy "is literally everything. It's communication, it's discussion, it's looking at graphs. It's so many things."

— Team leader

We have learned a great deal about math disciplinary literacy from a dedicated team of six high school math teachers at Brookline High School in Brookline, Massachusetts. In 2014, the team volunteered to participate in a two-year exploration of disciplinary literacy in content classrooms as part of a larger four-year disciplinary literacy professional learning and research initiative known as the Content-area Reading Initiative.

The math team chose a well-respected colleague in the department as team leader to facilitate weekly professional learning community (PLC) meetings for two years and help guide the team's inquiry into and exploration of various aspects of literacy instruction in math settings. As a result of the team's two-year exploration, the teachers designed instructional routines in math classes that are sensitive to and supportive of students' development of the literacy skills necessary for mathematics.

Supporting literacy in math classrooms means giving teachers the

support they need to design literacy-rich instruction, and clear professional learning routines are key to achieving this goal. In our experience, three supports proved essential: a summer institute introducing disciplinary literacy domains, scheduled time for collaborative inquiry into disciplinary literacy, and a designated team leader. Together, these supports helped the team engage deeply with the theory and practices of math disciplinary literacy and create agreed-upon mathematical habits of mind that have become keys to their current approach.

SUMMER INSTITUTE

The team first assembled and began its work by attending a week-long summer institute led by us, as university consultants, and designed to introduce key domains of literacy instruction (e.g. discipline-specific reading comprehension, academic vocabulary, discussion).

Our theory of action was straightforward: The team would learn about these domains, then spend two years using this knowledge in weekly meetings where they would work collaboratively to adopt, adapt, invent, and evaluate disciplinary literacy practices for their math classrooms. The initial institute was essential, providing the team with starting places to spark later inquiry and collaborative tools to guide investigations (e.g. discussion-based protocols, examples of successful inquiry cycles from previous teams).

One of the primary goals of the summer institute was to challenge the widely held perception that math and literacy are separate enterprises. Our goal was to help teachers frame their work as moving students from simply performing mathematical operations to taking first steps into the larger disciplinary culture (Moje, 2015) of communicating like mathematicians.

For example, we spent a half-day of the institute focusing on how academic discussions and teacher talk moves (e.g. extending, clarifying, revoicing, probing) in math classrooms could promote deeper mathematical reasoning, which can be translated into more sophisticated problem solving. However, we understood that shifting the instructional culture would only be accomplished over time, not in the single institute week.

When team members entered the institute, they were uncertain whether the content would even apply to them. Yet they were eager to learn ways to shift their practice. This willingness paid off. By the end of the five-day review of literacy domains, the team reported brainstorming more than 40 ideas that they wanted to explore across the next two years.

For the math team, the biggest takeaway from that institute may have been a reframing of what *literacy* could mean in a math context.

The team leader described it this way: "I think the summer institute last year [is where we first] talked about 'what is literacy.' How it is literally *everything*. It's communication, it's discussion, it's looking at graphs. It's so many things, and how pervasive it is, and how it really is in our curriculum, and how we can focus on it and work on it. … It's not *English* we're talking about. It's *literacy*. I think that, in math and science, [we've] confused those two. It's not English. We're not reading a novel about math. It's these common, basic communication skills. I think that was a major eye-opening thing."

As a direct result of its summer learning together, the team chose to begin its inquiry and classroom experimentation work by focusing on academically productive classroom discussions, with a dual emphasis on encouraging students' use of general academic language and discipline-specific mathematical language.

FACILITATED TEAM TIME

Teachers reported that the weekly, facilitated, one-hour meeting time made perhaps the most difference in their ability to generate new instructional practices together. Before the project, teachers did not have a designated time to come together as a team to investigate a topic like disciplinary literacy over time.

The collaborative inquiry time, facilitated by a team leader after school hours, provided the group with the inventive space needed to explore mathematical disciplinary literacy practices together. The only stipulation within the overall project was that the team eventually share successful practices with the rest of the department. So, week after week, over two years, the team focused on big inquiry questions such as: "What difference could it make if we were more explicit with our academic language instruction in math classrooms?" and "How might we better support students in identifying, understanding, and synthesizing key mathematical concepts when reading independently?"

With this approach, the team moved through six cycles of inquiry over the two years, focusing iteratively on: classroom discussion, academic language and vocabulary, multiple representations in mathematics, mathematical reading, engaging in productive failure, and mathematical writing.

Each of the cycles produced dozens of new instructional routines as well as related resources (e.g. a library of short math-focused readings arranged by topic and degree of reading difficulty), all of which the team shared with the larger math department. Instructional practices the team adopted include:

- **Academic discussion:** The team introduced and practiced academic discussions to coax students to describe reasoning and explain thinking processes

to others. By fostering a healthy discussion atmosphere and encouraging attempts, we saw students become more willing to problem solve collaboratively and resolve misunderstandings together. The team leader reported: "Allowing time for discussion around student questions saved instructional time in the long run because it targeted student misconceptions."

- **The language of math and multiple representations:** As we listened to student discussion, it became clear that students needed support in using the precise language of math and understanding how words mapped onto symbolic and pictorial representations of mathematical concepts. In response to this need, teachers piloted vocabulary concept journals and modified word walls to focus student attention on key concepts. As a result, team members saw students using words more accurately and moving between representations of concepts more fluidly.
- **Mathematical reading:** Teachers quickly realized that they had sometimes avoided doing much reading in math for fear that it would be difficult for students or that it would take too much time. The team assembled a library of readings to encourage wide reading in mathematics. These readings supported not only familiarity with concepts when represented in multiple ways, but also promoted students' acquisition of general mathematical literacy through grappling with and ultimately working to understand math in the real world. Over time, teachers' inquiries resulted in instruction that included more purposeful reading in the mathematics classroom, leading to students developing deeper and clearer conceptual knowledge.

RELATED RESOURCES FROM LEARNING FORWARD

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MATHEMATICAL HABITS OF MIND

As a result of its ongoing collaborative inquiry work, the math team devised a set of mathematical habits of mind (ways of thinking and working) that now guide instruction. Agreeing on these habits of mind, and making them visible for students, is at the heart of math disciplinary literacy work for the team.

These habits, such as discussing problem solving aloud, reading about mathematical concepts and famous mathematicians, being conscious of math vocabulary, understanding multiple representations of information, and embracing productive failure when working with challenging problems, have been transformed into important routines throughout the year and across the broader math department.

The mathematical habits of mind and routines have also mapped quite neatly onto the Massachusetts Curriculum Framework for Mathematics, particularly the Standards of Mathematical Practice (**see www.doe.mass.edu/frameworks/math/0311.pdf**, pp. 15-17). By using these habits of mind to frame instruction, in conjunction with the math practice standards, these math teachers are bringing the authentic thinking, reading, writing, and communicating work of mathematicians into their classrooms on a daily basis.

Notably, it was teachers' inquiries, occurring in PLCs led by a team leader and guided by new learning from the summer institute, that led to the development of new instructional approaches. As more math educators nationwide consider whether and how to engage in disciplinary literacy work, we encourage teams to focus not just on the emerging *products* of disciplinary literacy practices, but also to focus on the *processes*. Teams of teachers need support as they collaboratively explore what it means to enact disciplinary literacy in math settings so that stronger disciplinary literacy teaching and learning routines might emerge.

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An argument for learning

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promising results in changes in teachers' practices and student learning.

The study found that 9th-grade biology students in the experimental condition outperformed students in control group classrooms on two measures of science comprehension across multiple texts that required reading, synthesizing, explanatory model building, and argumentation (Goldman et al., 2016).

Results such as these show the promise of preparing teachers to teach inquiry-driven literacy and science practices as a process of actively making meaning. This type of inquiry-based professional learning may be especially important in the context of science — a field driven by inquiry practices — and when teachers are being asked to teach in ways that are substantially different from how they were taught or how they learned to teach (Borko, 2004).

To do so, teachers will need support for their own learning over time with opportunities to learn that mirror these forms of inquiry (Pearson, Moje, & Greenleaf, 2010).

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