Supporting Sense Making with MATHEMATICAL BET LINES

This discourse strategy helps students understand story problems by revealing the task in stages and having learners adjust their predictions.

Lara Dick, Tracy Foote White, Aaron Trocki,
Paola Sztajn, Daniel Heck, and Kate Herrema

In the mathematics classroom, making sense of story problems can be a challenge for all students. Strategies that promote student discourse offer teachers one way to support their students' sense-making processes (Cengiz 2013; Greer 1997). Further, when embedded into teachers' daily mathematics instruction, strategies that promote mathematics discourse allow teachers to monitor the ways in which students are making sense of information (Moschkovich 1999; Sammons 2011; Soto-Hinman and Hetzel 2009).

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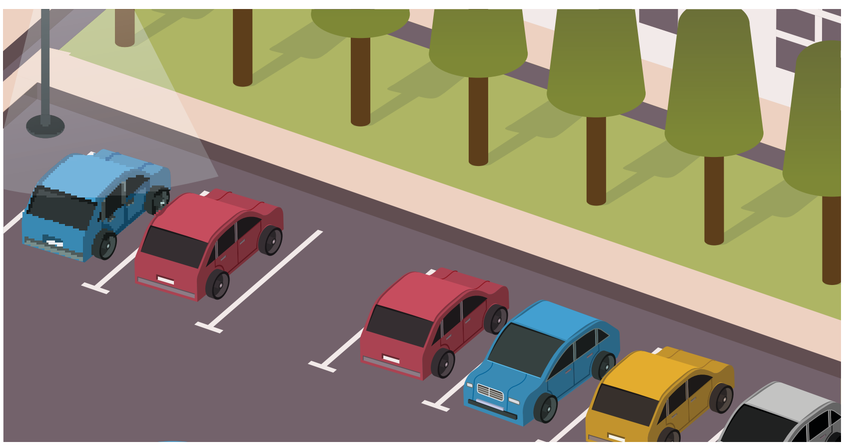
In this article, we present a mathematical discourse strategy that was introduced to elementary school teachers during Project All Included in Mathematics (AIM), a forty-hour, yearlong professional development (PD) program focused on promoting discourse as a viable approach to support all students in developing meaning for mathematics content. The strategy is called *Mathematical Bet Lines* and was adapted from the Bet Lines with English language learners (ELLs) as a literacy strategy to develop students' ability to make predictions on the basis of their comprehension of the context (Soto-Hinman and Hetzel 2009). The Mathematical Bet Lines strategy was designed to promote classroom discourse and support sense making when teachers are launching a lesson about mathematics story problems. In this article, we discuss how teachers implemented the strategy in their own classrooms to help students make sense of story problems. We show how such strategies, designed to promote sense making and mathematical discourse, are beneficial to not only ELLs but also all students in the classroom (Goldenberg 2008; NCTM 2013).

Teachers learn Mathematical Bet Lines

In ELL literacy, the Bet Lines strategy focuses on making predictions:

> Bet Lines are key stopping points (text lines) where teachers ask students to dialogue about what they have just read and make predictions about the future. (Soto-Hinman and Hetzel 2009, p. 95)



Students draw on both their personal experiences and evidence presented in the story to predict what will happen next. In ELL literacy, the Bet Lines strategy is used as an interactive and ongoing approach to involve students with the meaning of the text. In particular, Bet Lines offer opportunities for students to "see how proficient readers think and begin to monitor their own comprehension" of the text (Soto-Hinman and Hetzel 2009, p. 96). In Project AIM, we introduced the Mathematical Bet Lines strategy with the goal of helping students make sense of story problems by articulating to themselves and others their predictions regarding what is happening in the problem.

Mathematical Bet Lines are structured as a conversation between the teacher—who begins by reading the opening phrases of a problem and stopping at a point where students are to anticipate what comes next—and students—who predict what comes next in the story problem. For example, a teacher might start a story problem as follows:

> Fifteen cars are in the parking lot, and two cars are blue; what do you think will come next in the problem?

At this point, students offer their predictions before the teacher continues to read the problem, stopping at other parts of the story for further predictions or revisions of previous ones. The teacher supports students as they learn to make predictions that serve as continuations of the story and make mathematical sense. The teacher can also attend to students who might continue to make bets, or predictions, that have no mathematical bearing on the context of the problem. For example, in the problem above, a bet of "Cars are nice because you can drive them" does not indicate that the student is attending to the story as part of a mathematical problem. With Mathematical Bet Lines, as students make bets, the teacher facilitates students' reflections on their own sense making of the story problem by asking follow-up questions.

In Project AIM, Bet Lines were first modeled as a literacy strategy with a familiar children's story. Teachers participated in a Readers' Theater, using a classroom transcript of a teacher implementing the Mathematical Bet

Lines strategy. Then, teachers role played and rehearsed the strategy in small groups. Following the professional development session, teachers were asked to design, implement, and reflect on a lesson that incorporated the Mathematical Bet Lines strategy to engage all students in their classrooms with mathematics discourse, especially their ELLs. Here we discuss a lesson of one participating teacher, Kate Herrema, who, after this initial reflection exercise, made the strategy an integral part of her mathematics teaching. We then share the reflections of other teachers who implemented the strategy.

A teacher implements Mathematical Bet Lines

Herrema explained that in her classroom, the Mathematical Bet Lines strategy made word problems interactive and engaged all students in discussing the story context of a problem. She noted that a student was no longer a "bystander of a problem." Herrema found that use of the strategy allowed her students to initially be less interested in the numbers in the story problem, focusing instead on understanding the scenario. She explained that before she implemented the Mathematical Bet Lines strategy, her students would quickly pick out numbers and try to add or subtract them on the basis of a clue word they would identify in the problem. After adding the new instructional strategy to her teaching repertoire, story problems became less to her students about getting a quick answer and more about making sense of the problem.

Herrema had nineteen children in her second-grade classroom, including two ELLs. According to Herrema, one of her ELLs enjoyed participating in whole-class discussions but could be hindered by the demands of academic language in mathematics. She characterized her other ELL as shy and lacking confidence in his mathematical abilities. Herrema found that Mathematical Bet Lines allowed both ELLs to feel comfortable participating because—

> they were interacting with an "unfinished problem." There were rarely incorrect bets. . . . There was less stress and worry for them because it didn't come with a right or wrong answer.

Instruction involving Mathematical Bet Lines

Mathematical Bet Lines emphasize that students should make sense of a problem text; they de-emphasize getting straight to an answer. The classroom transcript below is from a story problem that focused on the CCSSM second-grade Measurement and Data content standard (2.MD.D.5) for relating addition and subtraction to lengthy story problems.

Herrema: So far we have this: "Rachael and Alberto each flew a paper airplane. Rachael's airplane flew 283 centimeters." What do you bet comes next?

Carol: I bet that Alberto flew 282 less than Rachael.

Herrema: OK, so you're saying that Rachael's airplane flew 283 centimeters and that Alberto's flew 282 centimeters less than Rachael's? OK, so what would that be? Carol just bet that Rachael's airplane few 283 centimeters and that Alberto's airplane flew 282 centimeters less than Rachael's. What do you bet is going to come next?

Kevin: "How far did Alberto's paper airplane fly?"

Herrema: That would be a good question to follow up with: "How far did Alberto's paper airplane fly?" If that is our question, how would we solve that? What would be the equation we might use? What operation would we use?

Kevin: Subtraction.

Herrema: Subtraction; why?

Kevin: Because Alberto threw it 282 less than Rachael.

Herrema: So, it could say, "Rachael's airplane flew 283 centimeters, and Alberto's airplane flew 282 centimeters less than Rachael's. How far did Alberto's paper airplane fly?" Let's check what comes next: Alberto's airplane flew 59 centimeters farther than Rachael's. It now says, "Rachael and Alberto each flew a paper airplane. Rachael's airplane flew 283 centimeters. Alberto's airplane flew 59 centimeters farther than Rachael's." What do you bet is coming next? Amy?

Amy: "How many centimeters did Alberto throw his airplane?"

Herrema: OK, so you think it is going to ask, "How many centimeters did Alberto fly his airplane?" OK, does anyone have a different bet than that? Isaac?

Isaac: "How many did they fly together?"

Herrema: Oh, it could be. That would be a really tricky problem. Let's see why that would be tricky. Isaac bets that the question is, "How far did Rachael and Alberto throw their paper airplanes. . . ?"

Students: Altogether

Herrema: Altogether; so, that would be like Rachael threw hers, and then Alberto flew his airplane after that. What would we need to still solve for, if that was our bet? What do you think, Lin?

Lin: How far Alberto flew his airplane.

Herrema: Oh, we would still have to find out how far Alberto flew his airplane in order to find out how many they flew altogether. Let's see what the last part is: "How many centimeters did Alberto's airplane fly?" How would you go about solving this?

The transcript (see the **sidebar** above) illustrates instruction involving Mathematical Bet Lines as Herrema implemented the strategy with her students for the following story problem, which focuses on the Common Core State Standards for Mathematics (CCSSM) grade 2 Measurement and Data content standard for relating addition and subtraction to length story problems (2.MD.D.5):

> Rachael and Alberto each flew a paper airplane. Rachael's airplane flew 283 centimeters. Alberto's airplane flew 59 centimeters farther than Rachael's. How many centimeters did Alberto's airplane fly?

The transcript picks up after Herrema had revealed the second sentence of the story problem (see the **sidebar** on **p. 541**). At this point, the whole story problem had been shared and students had solved the problem on their individual whiteboards. The transcript shows how Herrema was able to elicit thoughts from a number of different students in a brief conversation that illustrates one aspect of the first of the Common Core's eight Standards for Mathematical Practice (SMP 1): *Make sense of problems* (CCSSI 2010). Herrema constantly asked questions of the students to ensure that their bets made mathematical sense in relation to the story problem context. Her questioning verified that her students' ideas focused on making sense of the story problem through talking about the numbers and the operations that fit the different student predictions. Students engaged in not only making and analyzing their own bets but also listening to and making sense of other students' bets. Isaac's (an ELL) bet shows him working to make sense of the problem (see the **sidebar** on **p. 541**). His bet, followed by Herrema's questioning, engages his classmates in thinking deeply about the problem situation.

Tips for implementing Mathematical Bet Lines

The use of the Mathematical Bet Lines strategy in Project AIM has helped us understand what it takes to successfully implement it in the classroom. On the basis of feedback from participating elementary school teachers, we developed the following tips.

1. Have the problem, with given stopping points, written out. Then you can use an interactive whiteboard, document camera, or overhead projector to display the appropriate pieces of the problem as you reveal them and pause for students to make and discuss their bets.
2. Good places to pause are immediately before information that suggests either the operations that will be used or a number that will be used in solving the problem.
3. Mathematical Bet Lines have no right or wrong predictions, although some predictions certainly are not helpful for making mathematical sense. Students should be encouraged to present bets that make sense and could be mathematically productive, given what has been revealed in the problem up to the point at which you pause.

   Possible follow-up questions to ask after a bet include the following:

- What new math information do we know about the problem? Do we know what we might do with that information?
- Why do you think we might (add or subtract)? What about that new information makes you think we might do that?
- If that "bet" is right, what do you think the question in the story problem is going to be?

Monitor the time spent on Mathematical Bet Lines and limit the number of "bets" made to two or three students. Other students can then be included in the conversation around the "bets" during the follow-up questions.

Teachers' experiences with implementation

In reflecting on their implementation of Mathematical Bet Lines, other teachers who participated in the professional development reported that the strategy successfully engaged their students in thinking about and discussing story problems in depth. One teacher explained,

> Students began thinking more mathematically about possibilities for what could happen in the "story.". . . Students offered mostly bets about possible addition or subtraction scenarios and unknowns related to those operations. I was impressed by a few students who evolved their bets into multiple-step possibilities; they really demonstrated the sense they were making.

Highlighting how Mathematical Bet Lines emphasize making sense of the problem text and de-emphasize getting straight to an answer, another teacher indicated that ELLs—

> as well as students struggling with comprehending math word problems, benefited immensely. The class environment was less stressful, and wrong answers [predictions] were encouraged because it gave

the students opportunities to explain and understand. It enhanced their confidence level and empowered them to think prior to solving a problem.

Despite the noted success of Mathematical Bet Lines, teachers also identified some challenges with implementing the strategy. Unlike many teachers who identified the strategy as being engaging, some teachers encountered difficulties with getting all students involved. Teachers offered such reflections as these:

- "At times the bets got off track and did not relate to the problem,"
- "Some students just wanted to focus on their 'bet' and weren't willing to listen or respond to other students' bets."

In hindsight, another teacher realized that she "totally took too many bets." These challenges contributed to concerns about limited instructional time that some teachers faced when implementing Mathematical Bet Lines.

To address these challenges, teachers shared successful modifications they made to the strategy. To assist students who tended to hastily provide guesses instead of mathematically sensible bets, some teachers found it beneficial to have their students turn and talk with a partner to come up with an agreed-on bet before sharing in the whole-group setting. To increase student engagement, some teachers had their students individually write down a bet; other teachers incorporated an agree or disagree part to the discussion of the bets to keep students involved with one another's predictions. To better scaffold their students' understanding of what makes a useful mathematical bet, other teachers created multiple-choice bets using, for example, the free iPad® app Student Clicker-Socrative (Socrative 2014).

Let's chat about this

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On **Wednesday, May 11, at 9:00 p.m. EDT**, we will expand on the article "Supporting Sense Making with Mathematical Bet Lines" (pp. 538–45), by Lara Dick, Tracy Foote White, Aaron Trocki, Paola Sztajn, Daniel Heck, and Kate Herrema. Join us at #tcmchat.

We will also Storify the conversation for those who cannot join us live.

Facilitate, monitor, and question

Recall that the purpose of the Mathematical Bet Lines strategy is to help students make sense of story problems by focusing on the given problem's story context and then making predictions. Similar to its use in ELL literacy, the mathematical application of the strategy requires teachers to facilitate a classroom discussion and monitor students' sense making through questions surrounding the implications of students' predictions. ELLs and other students struggling with comprehending story context can benefit from learning how to predict and think inferentially about mathematics story problems. Mathematical Bet Lines create a safe, fun environment that is also engaging and substantive in an atmosphere that supports students as they develop their mathematical sense making of story problems.

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Common Core Connections

SMP 1

Authors' note: We believe that the Mathematical Bet Lines strategy can be used throughout grades 3–12 whenever the need is present for making sense of a story problem.

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Lara Dick, **lara.dick@bucknell.edu**, is an assistant professor in the mathematics department at Bucknell University in Lewisburg, Pennsylvania. She is interested in the development of preservice and in-service teachers' specialized content knowledge. **Tracy Foote White**, **tswhite@ncsu.edu**, is a research assistant in mathematics education at North Carolina State University at Raleigh. She is interested in the equitable use of discourse for teaching and learning mathematics. **Aaron Trocki**, **atrocki@elon.edu**, instructs mathematics at Elon University in Elon, North Carolina. He is interested in the role of discourse to promote conceptual understanding in mathematics. **Paola Sztajn**, **psztajn@ncsu.edu**, is the department head of teacher education and learning sciences as well as a professor of mathematics education at North Carolina State University in Raleigh. Her research focuses on elementary school teachers' mathematics professional development. **Daniel Heck**, **dheck@horizon-research.com**, is a senior researcher and partner at Horizon Research in Chapel Hill, North Carolina. His research focuses on teacher learning in professional development. **Kate Herrema**, **kherrema@wcpss.net**, is a fifth-grade teacher at Farmington Woods Elementary School in Cary, North Carolina. She is interested in helping all students make connections in mathematics.