Building Powerful Climates for Mathematics Teaching and Learning

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Using Tools in Support of Mathematical Thinking
Patty Ferrant, 8th Grade

Desiree H. Pointer Mace, David Foster, and Audrey Poppers with Patty Ferrant

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Appreciations

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With deep gratitude,

Desiree Pointer Mace, David Foster, and Audrey Poppers

Overview

How teachers start their year off, and how you can do the same, no matter what day it is.

Introduction: Happy new year!

(If you have already read other Patty guides, please skip to page 9.)

When is Day One for you?

Video reflection: Why do you love teaching?

Teachers have unique rhythms and timelines in their profession. There are multiple times when it makes sense to reconsider the way you approach your teaching. For you, it might be the beginning of the school year. You might have a new group of students, a new grade level or content area, or a new context. After the winter holidays might also be a time of renewal and reconsideration of your teaching practice. Or it might be at the beginning of a new semester or trimester. Or after required standardized testing is completed.

It doesn't matter when that Day One is for you-- what's important is that we all arrive at times when we resolve to try something new, to recalibrate the way we've been approaching the teaching and learning in our setting. This set of guides is for you.

In this guide, Inside Mathematics invites you to explore the teaching practice of an engaging middle school practitioner, Patty Ferrant (8th grade). Like most teachers, Patty would never describe her teaching as "best practice," but she is someone who continues to learn from and with her students each year. Through the documentation of her classroom, we open up new conversations-- around the daily work to help children begin to see themselves as mathematical thinkers who can draw on their own strategies and those of others to understand and find solution pathways in various problem settings.

Patty: I guess that I would say that if you want to do this job, you have to truly, truly believe that every single student can learn. And you want to see that happen... you want to inspire that to happen, and you want to rejoice when it happens, and you want to be there when it's not happening. You want to make sure that you're going to do everything in your power to help, and support, and see these students grow. For me, if that intrinsic belief is not there, then I honestly don't know if ... especially with math, you're in middle school, you're teaching math, that's your content area. If we don't believe that every single student, no matter who they are, no matter what their skin color, their ethnicity, their background, their struggles, their learning disabilities, whatever it may be, if you don't expect every single one of those students to succeed, then I don't know if it's the job for that person!

I think we have to do a lot of reflecting inside, to really challenge ourselves: do we really believe it? Do we have a fixed mindset or growth mindset? Because I feel like people still out there say, "Well, that kid's smart in math, and this kid's not smart in math." In my classroom, I address it the moment we start: we're all smart in math, but that doesn't matter. It's how much of the effort and perseverance we put forward."

But it's the teacher that has to lead that, and those kids know if you believe in them! Those kids that if you let them sit there, in the back of your class, and you don't expect them to learn, then they know you don't believe in them! They're not stupid! They know! It's sad, and depressing, and a disservice to not expect every single one of them to grow and succeed. I feel like that is so important.

So being always reflective about your own teaching, and who you are as a teacher, and challenge yourself: What do you really believe? Because people say, yeah, I believe it, but if the actions show that you're letting that kid off, if you're just giving up... I get it, if at the end of the day you're like, "I'm done with that kid!" But the next day is a fresh day. If we don't truly start every day a fresh day those kids know, and they see the mistreatment, the status. They see it, and they've seen it forever,

It also goes to, if we have those kids who misbehave, who constantly... you have to cut that off and let them know right away, "No. You can't do that in here." I know in some classes kids, they run the class. and it comes down to management. You just have to take control of "This is the class. This is how the culture is. We will build that culture together, and we need to truly believe in each other." If we don't do that, we're not serving all of our students.

No matter what day it is when you read this, for you, it is Day One. Like Patty says, it's a fresh start. Today, you're deciding to explore some other teachers' practices so you can rethink your own. Welcome!

> ☞ ***Throughout these guides, you will find occasional questions formatted like this for individual or small group reflection. We encourage you to use these questions to deepen your engagement with the video excerpts.***

Connections to Research and Standards

Building Mathematically Powerful Students

Our focus in creating these guides is to invite you into two classrooms so that you can consider different ways to approach your teaching. In Patty's classroom, though her school context and students may differ from yours, she and her students are engaged in practices that are strongly supported by research on teaching. Patty is working to challenge students to become mathematically powerful. Ruth Parker's landmark 1993 volume *Mathematical Power* reinforces the need for students to "do mathematics: to conjecture, invent, play, discover, represent, apply, prove, experiment, and communicate" (p.212). Our representations here show eighth grade students doing math in just this way.

We also draw on the Teaching for Robust Understandings in Mathematics framework (aka TRU Math Dimensions, Schoenfeld & Floden 2014). In it, the authors set forth characteristics of "mathematically powerful" classrooms.

The Five Dimensions of Mathematically Powerful Classrooms:

The Mathematics	Cognitive Demand	Access to Mathematical Content	Agency, Authority, and Identity	Uses of Assessment
The extent to which the mathematics discussed is focused and coherent, and to which connections between procedures, concepts and contexts (where appropriate) are addressed and explained. Students should have opportunities to learn important mathematical content and practices, and to develop productive mathematical habits of mind.	*The extent to which classroom interactions create and maintain an environment of productive intellectual challenge conducive to students' mathematical development. There is a happy medium between spoon-feeding mathematics in bite-sized pieces and having the challenges so large that students are lost at sea.*	*The extent to which classroom activity structures invite and support the active engagement of all of the students in the classroom with the core mathematics being addressed by the class. No matter how rich the mathematics being discussed, a classroom in which a small number of students get most of the "air time" is not equitable.*	*The extent to which students have opportunities to conjecture, explain, make mathematical arguments, and build on one another's ideas, in ways that contribute to their development of agency (the capacity and willingness to engage mathematically) and authority (recognition for being mathematically solid), resulting in positive identities as doers of mathematics.*	*The extent to which the teacher solicits student thinking and subsequent instruction responds to those ideas, by building on productive beginnings or addressing emerging misunderstandings. Powerful instruction "meets students where they are" and gives them opportunities to move forward.*

image from Schoenfeld & Floden 2014, p. 2

To be sure, daily life in classrooms is complex. No one teacher ever feels like all aspects of teaching are exactly in place. But if we think about these characteristics, we can then begin to align them with the moments when things are clicking, when students are making connections, when teachers are challenging learners to follow a line of reasoning or defend their thinking.

This framework asks us to keep in mind the math itself, how cognitively challenging the climate and task are, how learners are all equitably engaged in the task, how students balance and negotiate mathematical understandings among themselves, and how the teacher (and the students) evaluate and assess the learners' developing understandings.

Connections to Standards and Practices

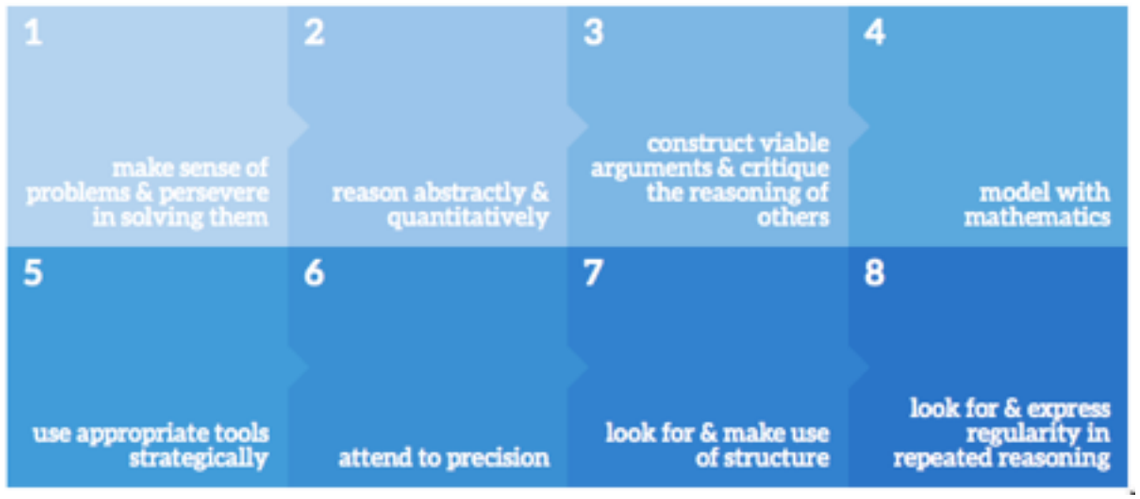
Depending on your school setting, you are also challenged to show how your instructional decision-making aligns with local or national frameworks for mathematics teaching. The National Council of Teachers of Mathematics (NCTM) has recommended eight Mathematics Teaching Practices as part of their "Principles to Actions: Ensuring Mathematical Success for All" series of documents.

Mathematics Teaching Practices
Establish mathematics goals to focus learning. Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Implement tasks that promote reasoning and problem solving. Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
Use and connect mathematical representations. Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.
Facilitate meaningful mathematical discourse. Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
Pose purposeful questions. Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.
Build procedural fluency from conceptual understanding. Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.
Support productive struggle in learning mathematics. Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.
Elicit and use evidence of student thinking. Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

NCTM, 2014 http://www.nctm.org/uploadedFiles/Standards_and_Positions/PtAExecutiveSummary.pdf

Like the TRU framework, the Principles to Actions practices focus on active engagement in mathematics by teachers and students alike. There is no passive or receptive stance if students are being supported in productive struggle. There's no lecturing for sustained periods if practitioners are facilitating meaningful mathematical discourse. Active exchange of ideas undergirds all of these practices.

The Common Core State Standards also highlight eight standards of mathematical practice, which Patty uses in her home state of California.



Standards of practice are distinct from content standards in that they not only address what students should *know*, but what mathematically powerful students *do* when they are engaged in thinking and reasoning. Creating the conditions for mathematical practices in students takes time and careful creation of a learning environment and interactive norms to support students in increasingly assuming responsibility for their own mathematical learning.

Building Cultures of Thinking

While we have highlighted teachers' practices during math instructional time, you don't have to be a math teacher to draw from their insights and their work to engage learners. The teachers' classrooms we've documented open up conversations about what it takes to create cultures of thinking to make thinking visible. Elements of the work of Harvard University's Project Zero on Visible Thinking are evident in Patty's classroom. Ron Ritchhart's 2015 book *Creating Cultures of Thinking* describes ways in which teacher expectations, language, use of time, modeling and apprenticeship, routines, structured opportunities, interactions, and environment all contribute powerfully to student learning. From day one, Patty establishes and reinforces the expectation that learning is an active process and that engagement with the math and with other learners is continuous. Ritchhart distinguishes "learning-oriented" from "work-oriented" classrooms; in the latter, teachers are concerned with compliance and completion of tasks, in the former they are "listening for the learning" (p.45) and using questioning to scaffold and extend students' understandings.

Powerful Assessment Outcomes

This is not just a story about great teaching (though the people with whom we've collaborated certainly are strong practitioners!) We want to reinforce the powerful outcomes of approaching teaching in an authentic way that develops students' agency, authority and identity as mathematicians. Each year since 1999 students in districts in the San Francisco Bay Area have taken a performance assessment test called the Mathematics Assessment Collaborative (MAC) exam. The design and architecture of these performance tasks were developed by the Shell Centre at the University of Nottingham. The exam assesses not only math content, but also the Standards of Mathematical Practice. All the tasks must be hand-scored. The test

is given in grades 2 through Algebra 2 or Integrated Course 3 in high school. Prior to adopting the Common Core State Standards in Mathematics, students in middle school underperformed on the performance assessments. In 2013, only 21% of eighth graders met standards on the MAC exams. In 2015, eighth grade students showed significant gains in student achievement. The percentage of students meeting standard almost doubled with 40% of the students meeting standard. This dramatic gain is due to more effective instruction and de-tracking students. By engaging all learners in interesting tasks, students' assessment data rose dramatically.

Thinking about Content, Structure, and Strategies

In all of the guides in this series, we want to underscore that teachers are considering multiple dimensions of mathematics learning as they teach. They think about the content outcomes (like understanding place value and "ten-ness"), they make explicit to students the structure of a problem (Is this a put-together or a take-apart problem? is this a constant rate of change problem?), and they present and refer back to strategies for problem solving (Do you count all? Count back? Think about a part/part/whole relationship?). Your students will benefit most if you consider how they will respond to these dimensions in any given problem or learning opportunity.

Patty: That [Common Core] Math Practice Seven, I feel I'm understanding that math practice a lot more, particularly this year, and definitely with system of equations. In 8th grade, they're supposed to be able to take a real-world context and represent it, mathematize it, model it with an equation. There's three main different structures that students, depending on what type of problem it is, that they could make. It could be a constant rate of change and starting point problem, it could be a part-part-total problem, or I have a part, and I have a part-part-total so I can use that part to help me figure it out.

Video reflection: Teachers and 8th graders are continuously learning about structures and methods

We spent a lot of time on being able to understand all these different structures, and then being able to make a decision on what structure to use, and it all came down to context. Having to understand: What do I know? Do I know a part? Do I know a total? Do I know a constant rate of change? Those structures, and we <u>say</u> structure, it's on the anchor poster that we came up with, what structure do I use? Some students are in it, they can get it, but a lot of others would go back to the anchor poster.

Once they've figured out a structure, then they can decide, use what they know to solve it with that type of structure. There's different methods. There's substitution. Different methods, once they

have the structure. So for them, it's really being familiar and connecting to what they've already learned.

The biggest thing that really connected for me this year, because I'm always trying to understand the math more, is: Part-Part-Total? You've been doing Part-Part-Total since before [your elementary teachers] had you! 2+1 is 3! It's the same thing! So I really try to support them with making that connection that this is the same thing. Yes, there's variables, but this is the same exact thing. Or even when they had an unknown when they were in sixth grade. "Something equals 5!" That's substitution, and using that type of structure to help them solve problems. That was the experience of it, but naming it and saying "This is the structure that's going to help you make sense of this problem." (Play video for more)

Getting to know your learners deeply, getting to know the mathematics deeply, takes time. It's important to be patient with ourselves as learners, just as it's important to be patient with our students.

The Power of Re-engagement

The teachers represented on Inside Mathematics frequently make use of re-engagement to surface misconceptions or identify stronger approaches. Inside Mathematics has several resources related to this approach at (http://www.insidemathematics.org/classroom-videos/formative-re-engaging-lessons) . This approach frequently presents two or more different approaches to solving a problem (e.g. "Learner A" and "Learner B") and then invites students to evaluate the learners' approaches and make recommendations to them. Often these exemplar learners' work is selected directly from a teacher's own group of students. Though students may recognize work as their own, what's critical in formative re-engagement is that the emphasis is on advising and recommending changes to the learner rather than simply engaging in peer correction of the answers.

Using Tools in Support of Mathematical Thinking

Access to mathematical tools informs their use in middle school classrooms.

2

Using Tools in Support of Mathematical Thinking

Concepts

1. **Presenting Tools**
2. **Using Classroom Supports**

Introduction

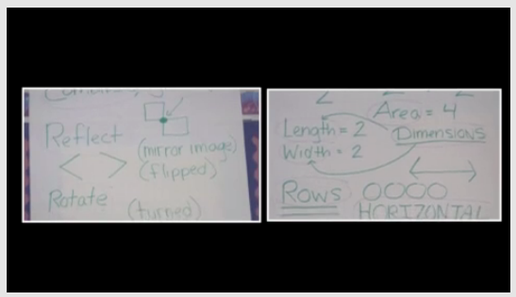
In Patty's classroom, students and teacher have equitable access to tools, resources, and supports for learning.

Presenting Tools

In the middle school setting, on the second day of school, Patty presents her anchor posters to "anchor our understanding from what came up yesterday."

Patty: Ready? Put your pencils down. Okay. Actually, look over there. Do you see those two posters? Take one minute to – by yourself, in your head, silently – look at those two posters. Think about the vocab. These are called "anchor posters," and it is anchoring our understanding from what happened yesterday. These are some things that came up yesterday, some vocabulary that helped us speak as mathematicians. This is a resource for us in this class. During the year, we will have anchor posters throughout this whole class. Those will be a resource for you to always refer to. All right.

Video (Day 2): Introducing anchor posters



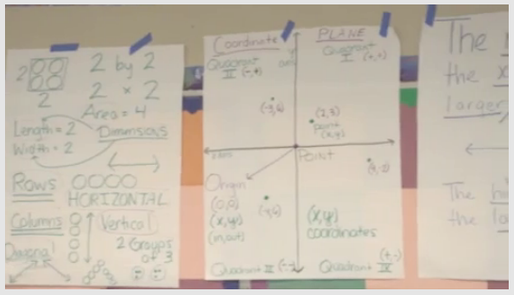
It's critical to help students understand the content and the function of anchor charts; otherwise, they are just wall decorations and don't activate and deepen students' learning.

> ☞ ***How do you describe the purpose of the tools and supports for learning in your classroom?***

Just a few weeks later, Patty's students have gained enough experience with their anchor posters that she can refer to them as a strategy to "catch her students' understanding." She models how she might engage a learner in using the posters, having a dialogue between herself and a hypothetical student:

Patty: Look at the anchor posters. That's their understanding. And I'll say, like, "What do you see?" And they'll say, "I see a straight diagonal line." "Okay, what does that mean?" and they'll just be, like, "He's going straight." "Really? Where does it say that in our understanding?" "What?"
Patty: What did we learn about in distance/ time graphs about the steepest line. What did that mean? What's that mean?
Student A: More distance in less time.
Patty (reflecting): Those are the anchor posters, so it's just like catching their understanding. That's very procedural, but they look up there for vocab. When they're trying to explain, I had kids looking up there. It's not necessarily so much like that's some "answer" for them, but that's a resource for them when they're trying to communicate.
Patty: So if it's steeper, more distance, less time. Meaning the person is going...
Students: Faster.
Patty: Fast? Or Faster, compared to if it's.... what? Flatter. So how does that connect here? This isn't distance-time. Tell me more. You want to add more to what you were going to say?
Student A: They're also the same relationship.

Video (Day 19): Routinizing the use of anchor posters as a resource for learning.



By this time, the third week of school, she describes these posters as a "resource for them to communicate." By this point, students are able to make use of the posters during whole group, partner and small group tasks.

> ☞ ***How has students' use of the anchor posters developed even after only a few weeks?***

Using Classroom Supports

Once students have access to tools, they can then incorporate them into their reasoning.

After establishing the use of anchor posters in support of her students' learning in the first weeks of school, Patty is then able to use them to sequence problems and prompts for discussion. In this example from week three of the school year, Patty represents examples from the students' homework responses on chart paper and uses them to support students' group work on comparing costs between different rate plans.

Patty: ... best buy. And every person in here said B. They said B was the best buy. I'll put this [chart] back. Every person in here said B was the best buy. And these are some things people wrote:
"Plan B provides the most minutes for a good price." "Second cheapest and second best minutes." "Low price, more minutes." "Reasonable amount of minutes and suitable cost." So these are things that people said; they were trying to justify or prove why they knew it was Plan B. Everybody in here said Plan B.
Patty: You know that we're always trying to prove things on the graph: I saw someone do this (places a chart paper graph on the board).
Patty: I want to know: does this strategy help us prove Plan B is the best buy? So just think in your head, try to make sense of this, connect what we have been doing with distance and time graphs. Just think in your head, I don't want anyone talking yet. Don't say anything yet! Just think in your head.
Patty: If you can't see it, feel free to get out of your seat and go look closer. If you can't see.
Patty: I want to know: how does that strategy prove Plan B is the best buy? Connect to what we've been doing with distance-time graphs.

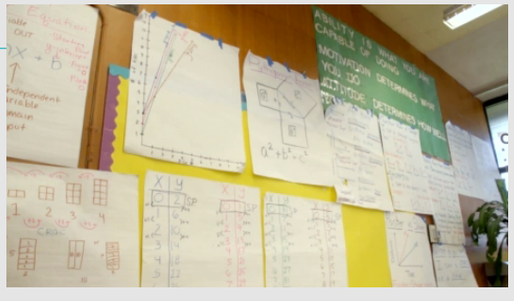
Video (Day 19): Making use of anchor charts as supports for learning

She says, "I saw someone do this--I want to know, how does this strategy help us prove plan B is the best buy?" The anchor charts serve as large representations of students' strategies to support group engagement.

By mid-year, Patty's students have oriented themselves to the anchor charts as supports for learning and she can make regular reference to them in discussions.

Patty: Okay, so, Chloe stated to us how to find the length of the hypotenuse. Let's look at the anchor poster. What's the area that

Video (Day 118): Activating students' use of the anchor poster

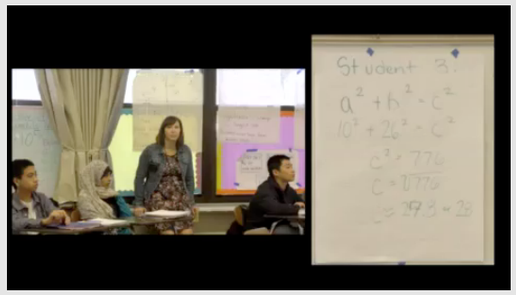


is related to the hypotenuse? Area up there. And whose land is that? Is that Nico's land? Or Damien's? That's Nico's land. So what's the area of Nico's land? It's up there.
Student: C^2.
Patty: C^2. So if we want to find the <u>length</u> of his land, which is also the what of the right triangle?
Student: The hypotenuse.
Patty: The hypotenuse of the right triangle. What math did Chloe say we need to do to the area? Find the what?
Student: Square root.
Patty: Find the square root of it. Do the <u>inverse</u> operation.
Patty: So I felt like, I felt before pretty comfortable with that, and I felt that you guys were getting that.
Patty: Damien's land. Damien's land, A^2. That area. Francine, I hope you're looking up there! A^2. How would we find the length of his land, which is the leg? How do you find that length?

Together, the class orients not toward individual people, but to their ideas, with the anchor charts as supports for their arguments.

Patty: Let's do what Roman said and go <u>back</u> to the diagram.
Patty: Something, right away, there's a red flag. Right away, you should be like, "What?"
Patty: How long is this length?
Students: 10.
Patty: And how long is this length?
Students: 26.
Patty: Now, I'm looking at the diagram, that's what Roman said to do. How long is this length, according to this person?
Students: 28.
Student: It can't be longer than 26.
Patty: So what's the issue?
Student: It can't be longer.
Patty: It can't be longer than what?
Students: The hypotenuse.
Patty: So maybe that advice that Roman had, connect back to that picture. Because even though they said it was C, if you look back at your diagram, you're like, "Oh, I'm finding this length, and I think that's 28, but there's a big issue, right?" So it's <u>making sense</u> of your answer. Not just finding an answer, but making sense of it, seeing if it matches up.

Day 118: Connecting strategic use of tools and resources to making sense of a problem



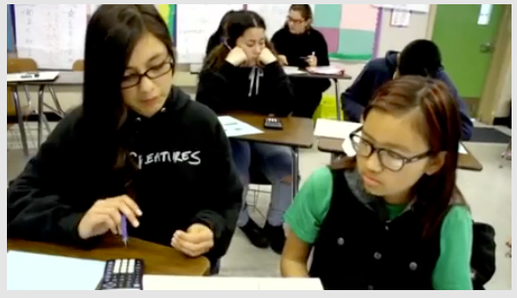
☞ ***How can students begin to make use of supports for learning without needing to be reminded to do so?***

In their class discussions of the Pythagorean Theorem, students like Roman connect their thinking to the representation on the anchor poster, recognizing that the visual representation helps them identify that the quantities <u>cannot</u> be correct.

Moving into the last weeks of the school year, Patty's students individually and collectively make use of tools and resources in their classroom to support their learning.

Student A: We can find the strength of...
Student B: So you would...find the remainder for the two smurfs, and divide by 2.
Student A: So, 3.25 - 1.25 is
Student B: 2? 2.
Student A: Yep. So 2 smurfs...
Student B: Equal 2, so the strength of one smurf is 1.
Student A: Yes.
Student B (writing): 1.
Student B: Okay, so since we know the strength of the cat and the smurfs, you just combine it.
Student B: So 3.25 plus 3. Is 6.25.
Student A: Yep. Wait.
Student B: Because there's 3, there's 3. So.
Student A: 3 add.
Student B: You add 3.25 and 3.
Student A: Oh, ok. 6.25.
Student B: So the cat and 3 smurfs are stronger.
Student A: The winner.

Video (Day 158): Peers make use of tools in support of learning



Students have full and flexible use of tools (anchor charts, posters of student work samples, calculators). They make use of these tools when appropriate to support and check their accuracy.

☞ ***What are the tools and resources that support and deepen your students' learning? How can you grant access to them and create routines for their use?***

Future Directions

3

What else might we mine from these classroom documentations?

Future Directions

Concepts

1. **Connections to Teacher Learning**
2. **Teachers as Sense-Makers**

Connections to Teacher Learning

Another powerful component of these guides is the coaching conversations throughout our documentation of Mia's and Patty's classrooms. Both teachers are experienced with both sides of a coaching dynamic, and recognize that engaging with a colleague in reflection on practice is enormously generative for our development as teachers. Others can see strengths and growth areas that we miss when we're in the middle of teaching.

Reflection: "I'm a very collaborative person by nature."

Reflection: "I get that opportunity to work with my colleagues and do the math together."

The University of Texas Dana Center has created helpful tools for evaluating effective coaching (Dana Center 2011). Within the dimension of **facilitating adult learning**, coaches engage in building relational trust, developing capacity to improve student achievement, providing collaborative opportunities for faculty reflection, authentic listening, and supporting teacher ef-

forts and needs. Within the domain of **planning and collaboration**, coaches use research-based resources, support standards, encourage and advocate for collaboration, maintain collegial partnerships, and link administrators to teachers with a focus on student achievement. Within the domain of **data support and analysis**, coaches use cyclical processes embedded in collaborative planning that provide ongoing evaluation of student learning, support teachers' focus on student learning, and maintain sustainable assessment systems. Lastly, in the dimension of **strategic competence**, coaches maintain a vision of excellence in teaching, balance content and pedagogical knowledge in context, work continuously to establish routines and trust, engage teacher groups in collaboration around key outcome questions, and consistently refine her or his knowledge of and practices for facilitating adult learning (Dana Center 2011).

The coaching conversations supporting both teachers' classrooms address many of those dimensions.

Teachers as Sense-makers

It's obvious that teachers are sense-makers too, but it was powerful to accompany Mia and Patty as they sought to understand their own teaching through a documentary lens. Too often, the complexity of teaching goes un-noticed because the practitioners are in the middle of the action. Engaging with thinking partners, looking at footage, examining student work samples to try to help external audiences understand children's thinking-- all of these are powerful and deep practices. We are fortunate for the generosity, investment, and time given to this project by both teachers, and hope that these guides will help even more

practitioners deepen their own approaches to math teaching and learning!

Resources

4

Resources

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