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Table of Contents

Observing Mathematics Lessons: What Does It Mean For Principals To Be Up-to-Speed?

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The 2008 release of the PRIME Leadership Framework has refocused our attention on what leaders in mathematics education can do to support and improve teacher and student learning. A central idea in this framework is that mathematics education leaders need to make certain that teachers have the knowledge of mathematics and pedagogy to ensure a high quality mathematics education for all students.

Such knowledge on the part of teachers enables them to make sense of the content of their students' mathematical thinking in order to assess what they know. Research by Carpenter, Fennema, Peterson, Chiang and Loef (1989) and Cohen and Hill (2000) reports that students' achievement in mathematics is affected positively when teachers pay attention to students' mathematical ideas. The information teachers can gain when they listen carefully to their students is critically important because it enables teachers to adapt their instruction to the levels of understanding across the class; when teachers probe their students' thinking to determine where the soft areas are and where their thinking is robust, they position themselves to make informed decisions about which instructional steps would most effectively strengthen their students' grasp of the concepts. As mathematics education leaders, principals of elementary schools need to be able to recognize when teachers are paying close attention and responding appropriately to their students' mathematical thinking and to recommend what kinds of additional support teachers may need when they aren't.

One of the most important opportunities principals have to influence classroom instruction in mathematics is through the process of classroom observation and teacher supervision. When principals observe mathematics lessons, they make judgments about the effectiveness of the instruction and use this information to decide what to feature in their evaluations of teachers and in their post-observation conferences with them. They also may use what they learn to formulate improvement plans and priorities for teachers' professional development.

At Education Development Center[1] we have been researching the supervisory practices in mathematics of a national sample of principals with various degrees of *leadership content knowledge*. Stein and Nelson (2003) define *leadership content knowledge* (LCK) as a combination of mathematics knowledge, views of how mathematics should be learned, and views of what high-quality mathematics instruction should look like. A primary goal of our research has been to understand how principals' LCK affects their supervisory practice. We measured the LCK of approximately 500 elementary and middle school principals using a survey to collect information about their professional histories, their views about mathematics learning and teaching and their mathematics knowledge for teaching.[2]

[1] The Education Development Center in Newton MA has a 6-year grant from the National Science Foundation for a national study of elementary school principals' leadership in the area of mathematics instruction. The work reported in this paper was supported by a grant from the RETA program of the National Science Foundation, grant # EHR 0335384. Any opinions, findings, conclusions, or recommendations expressed here are those of the authors and do not necessarily reflect the views of the Foundation.

[2] Refer to http://www2.edc.org/tmi/tmi_survey.html for more information about this survey.

We then selected a sub-sample of 13 principals with a range of LCK profiles to be case study subjects. We studied the supervisory practices in mathematics of these 13 principals, making three site visits to each of them.[3]

We found that principals' LCK greatly influences what they focus on when they observe mathematics classes and what they discuss with teachers in post-observation conferences. The principals in our study fall into nine groups according to their LCK; each group has its own distinct LCK profile that combines different amounts of mathematics knowledge with different views about the learning and teaching of mathematics. For example, one group of principals *(Profile A)* has strong mathematics knowledge for teaching, compared to other principals in our sample, and views of effective instruction that are aligned with reform teaching practices. These views consist of the teacher paying attention to the content of students' mathematical thinking and using this information to plan next instructional steps. When these principals observe in mathematics classrooms, they look for evidence that the teacher's actions are directed toward obtaining a detailed understanding of students' mathematical thinking. In post-observation conferences, these principals are in a position to judge the extent of the teacher's understanding of her students' thinking and the quality of her plans to further her students' mathematical development.

LCK	Mathematics knowledge for teaching	Views of effective instruction
Profile A	High	A focus on students' thinking

At the other end of the spectrum is another group of principals *(Profile C)* whose LCK reflects a modest amount of mathematics knowledge for teaching, compared to other principals in our sample, and traditional views of effective instruction where the teacher presents information and closely guides students' thinking. When these principals observe, they look for whether the teacher clearly demonstrates how students should solve the assigned problems and whether she quickly corrects any mistakes students may make. In post-observation conferences, these principals are in a position to comment on the teacher's clarity and the extent to which students successfully executed the mathematical procedures. However, these principals are not well positioned to work with the teacher on what might be impeding the progress of students who are having difficulty and what teaching steps would further the understandings of these struggling students as well as the students whose understanding of the lesson's mathematical concepts is already strong.

LCK	Mathematics knowledge for teaching	Views of effective instruction
Profile A	High	A focus on students' thinking
Profile C	Low	A focus on executing correct procedures

A third group of principals *(Profile B)* are those whose LCK can be characterized by mathematics knowledge for teaching that is in the middle range of principals in our sample and views of teaching that are associated with commonly accepted forms of instruction such as having students develop and share their own problem-solving strategies, dialogue with each other, and explain the thinking underlying their problem-solving approaches. Because these principals pay attention to these forms of instruction when they observe in classrooms and in post-observation conferences, they are often considered "up-to-speed" in

LCK	Mathematics knowledge for teaching	Views of effective instruction
Profile A	High	A focus on students' thinking
Profile B	Medium	A focus on students' doing
Profile C	Low	A focus on executing correct procedures

[3] During these site visits, we observed and audio-taped their pre- and post-observation conferences with teachers. We also observed and took ethnographic field notes of the mathematics lessons themselves. We transcribed all audio-tapes and analyzed them as well as the ethnographic field notes for what they revealed about how these principals used their LCK in their supervisory practices.

their understanding of mathematics instruction. However, principals with this kind of LCK do not closely examine the mathematical thinking these practices support students to do; they are more focused on what students are doing than on the content of their thinking. This limited focus places significant constraints on these principals' ability to judge whether this important area of a teacher's practice—the capacity to understand and work with the content of students' thinking—requires further development.

In this paper, through the use of dialogue excerpted from post-observation conferences, we show how much more a *Profile A* principal can achieve in a post-observation conference with a teacher than is possible for a *Profile B* principal.

Focusing on What Students Do Rather than the Content of their Thinking

We begin with Ms. Fordham[4] whose LCK puts her into the *Profile B* group. At the time of our study, she was a third year principal of a K – 5 school located in a middle class suburb of a mid-western city. The lesson we observed in her school took place in the kindergarten classroom of Ms. Mantle. It was about learning to add and subtract small numbers through solving story problems.[5] Students worked in groups, drawing pictures to help them solve the problems. As they worked, the teacher moved around the room and talked to students about the different approaches she observed.

During their post-observation conference, most of Ms. Fordham's comments focused on Ms. Mantle's classroom management and general pedagogical practices. She praised Ms. Mantle for how well her students knew the routines of the classroom, how engaged they were in the activities, how little time was wasted during class, and for the rigorous pace she had set.

In addition, at several points during their post-observation conference, Ms. Fordham and Ms. Mantle turned their attention to particular students' problem-solving approaches. The exchange below about the solution strategy of one of Ms. Mantle's students, Orrin, is illustrative of how Ms. Fordham used her LCK in her practice. It demonstrates Ms. Fordham's capacity to move beyond the limited focus on classroom management and teachers' actions to a consideration of how the student interacted with the mathematics. However, this exchange also suggests that Ms. Fordham did not appreciate the importance of Ms. Mantle developing an understanding of this student's mathematical thinking in order to use what she learned to plan her next teaching steps.

The story problem Orrin was working on was: *A toad ate 22 dragonflies. A snake ate 12 more dragonflies than the toad. How many dragonflies did the snake eat?*[6] For his visual representation, Orrin made 22 marks on his paper, followed by 12 marks and then struggled with how to use the representation he had drawn to solve the problem. Ms. Fordham and Ms. Mantle discussed the pros and cons of giving smaller numbers to Orrin, but they did not consider what Orrin was thinking and what might be getting into his way of solving the problem.

> ***Ms. Mantle:*** *…And then even my little Orrin who is very brilliant, is drawing out 22 and drawing out 12. He didn't know even how to solve that. But when I gave him the problem, the same exact problem but with three and one, he knew right away, four…*
>
> ***Ms. Fordham:*** *Watching how quickly Orrin did the three plus one or four plus one or whatever that was, I thought, I kind of had a little wondering thinking what would have happened if he had done the easy one first and then the 22 and 12… He's such a smart thinker when it comes to that stuff. But I don't know how that happens.*
>
> ***Ms. Mantle:*** *It might have. But part of the reason I did it the way I did it is, in that group, if I give them those simple problems, two of them will immediately write the answer down. Won't show me how they solve it… And I will say, "How did you get that answer?" And we've really fought this all year, "I just knew it," or "I did it in my head."*

This small piece of Ms. Fordham's practice demonstrates the preliminary nature of the mathematical issues she raised for discussion with Ms. Mantle. Ms. Fordham made a good start by talking to Ms. Mantle about her choice of numbers. When Ms. Fordham asked about this, she

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4 The principals, teachers, and students have been given pseudonyms.

5 Ms. Mantle formed small groups for her students and developed a list of Cognitively Guided Instruction-based story problems for each of the groups.

6 These numbers, unusually large for kindergarten age children, were chosen deliberately by Ms. Mantle to encourage students in this particular group to demonstrate their solution strategies visually.

demonstrated she understood that the choice of numbers makes a difference in how accessible a problem is to students and that teachers must give careful consideration to the numbers they select. Ms. Mantle explained that she used the larger numbers to push Orrin, someone who can manipulate smaller numbers in his head, to create a visual representation to demonstrate his problem-solving approach.

In addition to discussing the choice of numbers, there is an important set of mathematical and pedagogical questions related to how Orrin interacted with the mathematics that Ms. Fordham and Ms. Mantle did not address such as: What did the representation he created indicate about where the boundaries of his mathematical understanding were? What might be interfering with his ability to use his visual representation to solve the problem? Would he have benefitted from using cubes before he drew a representation on paper? Did he understand that 12 and 22 could be broken apart and put back together? What would next best steps be for him?

Ms. Fordham might also have explored with Ms. Mantle what next best steps for the class as a whole might be. For example, Ms. Mantel and Ms. Fordham might have looked across the range of ways students approached the story problems with the goal of analyzing the mathematical thinking each approach reflected. They then might have ordered students' approaches in terms of their level of sophistication and considered which ones would be best to feature in a whole class discussion and in what sequence. Through the deliberate selection and sequencing of several students' approaches for the whole class to make sense of and through the shaping of the ensuing discussion, Ms. Mantle would have given everyone access to the significant ideas that emerged from students across the class. Ms. Fordham's LCK did not position her to address these important practices with Ms. Mantle. The capacity to do this is at the heart of what it means for principals to be up-to-speed.

What does the supervisory practice of a principal who takes these additional steps with their teachers look like? One of the principals whose practice we examined provides such as image. Harriet Umsel was principal of a K-5 school located in a suburb of a large East Coast metropolitan area. Her LCK placed her in the *Profile A* group, and as such, when observing in classrooms, she focused her attention largely on students' mathematical ideas and how the teacher worked with their ideas. This capacity allowed her to provide valuable input as she worked with teachers on several important fronts during post observation conferences:

- Making sense of students' problem-solving strategies and of what their strategies revealed about their understanding of the mathematical concepts.
- Categorizing and ordering students' strategies from less to more sophisticated.
- Using what has been learned about students' thinking to inform next teaching steps.

Making Sense of Individual Students' Problem-Solving Strategies

The lesson we observed was in the first grade classroom of Ms. Harvey. For this lesson, Ms. Harvey presented several subtraction word problems orally to her students. The children worked on each problem using cubes, counting on fingers, drawing pictures, or drawing on known math facts. They then wrote out their solutions and explained their answers and the strategies they had used to solve the problem.

Like many principals, when Ms. Umsel observed in a mathematics class she attended to a range of classroom management and general pedagogical practices, such as students being on task, the pacing of the lesson and transitions between activities. In addition, she attended very closely to the particulars of students' mathematical thinking. As such, she was in a position to contribute to the knowledge her teachers were acquiring about their students' mathematical thinking as the following comments reflect:

> ***Ms. Umsel:*** *So the first thing [Micha] started with is really knowing his doubles stack. And then he started to decompose…It's interesting the way Micha represented this because he represented it as an addition problem instead of seven minus two.... Intuitively he knew that he took away from one seven and he needed to add it to the other seven.*

> ***Ms. Umsel:*** *…and Sohn…he's using what he considers friendlier numbers. Instead of doing a double digit number minus a single digit number, he's changed it to single digit numbers because somehow it's easier for him to compute. And he knows it in his head.*

Insights such as these that connect what students did with what they seem to understand about the mathematics are

very important pieces of information for teachers to have as they work to get a sense of the skills and understandings of individual students and of the class as a whole.

Categorizing and Ordering Students' Strategies

Once Ms Umsel and Ms. Harvey had analyzed students' individual approaches, they started a process of grouping, categorizing and ordering their approaches from least to most sophisticated. As they engaged in this analysis, Ms. Umsel and Ms. Harvey built on each other's thinking about what was going on mathematically for students. Through the course of the discussion, Ms. Umsel and Ms. Harvey developed the insight that some students saw the numbers as whole solid entities while others saw them as having smaller numbers nested within them and, therefore, it was possible to decompose and manipulate them in order to find a solution. As is clear from the excerpt below, Ms. Umsel was very much involved in helping to develop a picture of the problem-solving approaches of the class as a whole.

> ***Ms. Umsel:*** *So that's somewhere in here. So you have quite a range here. And it looks like we have kids who represented with pictures or counters. Counters seem to be the first pass. And then being able to represent what they did with counters with pictures.*
>
> ***Ms. Harvey:*** *Right.*
>
> ***Ms. Umsel:*** *That sort of next part of the spectrum is those kids who use pictures but didn't need the counters could create a more abstract way of representing it. That they could pretend that this picture is a kid. They didn't need the actual thing to do it.*
>
> ***Ms. Harvey:*** *…It feels to me that there is a space here. There's something in the middle and I'm not sure what it is. Maybe it's that they start to use the cubes... That they start to say, "Okay, I've got 14, I'm going to take 10 away. Or take 4 away to get to my 10, and then take one more away." …Began to decompose the numbers.*
>
> ***Ms. Umsel:*** *It seems to me these kids are looking at the whole as one thing and these kids seem to be able to see the numbers inside of it…*

Ms. Umsel's LCK positioned her to engage in such an analysis of students' mathematical thinking with Ms. Harvey. What they learned about students' thinking in turn laid the groundwork for planning the next steps Ms. Harvey would take with her students.

Using What has been Learned about Students' Thinking to Inform Next Teaching Steps

In the latter part of their post-observation conference, Ms. Umsel and Ms. Harvey turned their attention to how to help students move to more efficient strategies. Ms. Umsel played an important role in this discussion when she suggested to Ms. Harvey that she organize a whole class discussion around what she learned about her students' thinking when they were working individually and in small groups.

> ***Ms. Harvey:*** …. I think that's the part I struggle with is helping kids finding the strategy that's more efficient for them in that whole group setting. I find that a tricky thing to do.
>
> …Maybe pull over the kids who did counters and pictures…and say, "Okay, let's share." And then I can push the counter kids to think about what do the picture kids do. And then maybe pull the picture kids and the kids who started to think a little more abstractly about number over so they can hear the sort of next big jump. But I do think it's so individual that it's hard, in that whole group, to say this is a really efficient strategy. Well for some kids it is, but for some kids it's not. And that's tricky I think.
>
> ***Ms. Umsel:*** You know what I'm wondering? ...When you were going around working with kids if you had some children at different levels in mind to share and spend more time sharing three or four examples, what that would have done for the math congress?
>
> ***Ms. Harvey:*** Sharing three or four examples—like sharing one, sort of each type of thinker?
>
> ***Ms. Umsel:*** Yeah, to be able to say, "Alright, well I'm seeing several models from problem-solving." And what if you had chosen one from essentially each pile? Three or maybe four. And then explored them in depth…

Here again, Ms. Umsel demonstrated how well-served she was by her LCK, not only in terms of her capacity to understand the mathematical content of students' thinking, but also because of her ability to devise a teaching plan to help students become more efficient problem solvers. In contrast, Ms. Fordham's LCK did not position her to help Ms. Mantle work with her students' problem-solving

approaches; Ms. Fordham's understanding of mathematics was not strong enough for her to understand the mathematics in students' thinking; nor did she demonstrate the capacity to help Ms. Mantle to design a lesson that would have further developed students' understanding of the mathematics by providing opportunities for them to explore and make sense of each other's problem-solving approaches.

Getting Up to Speed

Most principals are not mathematics specialists trained to take on the challenging role of mentoring their teachers. Given this, what do principals need to know in order to help their teachers, and how can they learn it? Importantly, they need to understand the value of furthering their own professional development, both mathematically and pedagogically, and to look for opportunities to do so.

One way for principals to begin building the requisite knowledge is through professional development programs for principals that help them learn to both focus on students' mathematical thinking and assess the effectiveness with which teachers are able to work with students' mathematical ideas. *Lenses on Learning* by Grant et al is one such program. Attending professional development programs in mathematics content and pedagogy along with their teachers is another. In addition, principals can learn from the expertise of others, such as math coaches or teachers whose mathematical and pedagogical content knowledge are already very strong. These coaches or teachers can support principals' own efforts to improve their understanding of what is happening in mathematics classrooms throughout their schools with the goal of ascertaining what teachers need to learn and what types of professional development would best facilitate that learning.

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