Active Facilitation: What Do Mathematics Specialists Need to Know and How Might They Learn It?[1][2]

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Abstract

For the last decade, sustained, innovative professional development has been widely acknowledged as essential to the improvement of mathematics instruction in the nation's schools. In recent years, this recognition has prompted the establishment in many elementary schools of a position called "mathematics specialist"—individuals responsible for supporting teachers working to strengthen their mathematics instruction. Mathematics specialists use a variety of mechanisms to meet their goals: for example, coaching teachers in their classrooms, facilitating peer observations, leading seminars…. But even as systems create specialist positions, serious concerns arise as to the kinds of knowledge required to do such work and the means by which this knowledge is to be acquired. The authors of this paper address such questions, specifically with regard to the specialists' role of facilitating professional development seminars and in the context of the professional development seminar series, *Developing Mathematical Ideas*. Our paper builds on the research of Remillard and Geist (2002) who identify the potential for learning in those moments of discontinuity—"openings in the curriculum"—in which the beliefs, knowledge, and commitments of seminar participants diverge from those of facilitators or materials developers. By looking closely at several such moments, we establish how successful facilitation entails deep content knowledge, awareness of seminar goals, and appreciation of the beliefs and understandings of seminar participants. We conclude the main body of the paper with a description of the kinds of supports available to DMI facilitators to help them cultivate the skills and knowledge needed to

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exploit these openings productively. In an addendum, we suggest that our conclusions apply to mathematics specialists' tasks more generally and support that contention with the further example of a coach facilitating a peer-observation exercise.

Introduction

One considerable obstacle to improved mathematics instruction in the United States is that many teachers simply lack the necessary understanding of mathematics, of how mathematics is learned, or of children's mathematical thinking (Conference Board of the Mathematical Sciences, 2001; Kilpatrick, et al., 2001). Themselves the products of traditional mathematics education, these teachers doubt their own abilities to think mathematically and view mathematics as no more than a given sequence of facts, definitions, and rule-governed procedures (Cohen et al, 1993; National Research Council, 2001). Having had few or no opportunities to construct new visions of mathematics, mathematics learning, and mathematics classroom process, teachers who adopt ambitious curricula may use them in ways that subvert the intentions of their developers. And some may never even *try* to introduce such materials in their classrooms, because they cannot picture how to work with them.

If students are to leave U.S. schools as developed mathematical thinkers, continuing teacher education is critical. However, the staff development crucial to improved mathematics instruction is often blocked for lack of necessary resources. Mathematics educators at all levels are thus challenged to build the capacity for promoting teacher change in resource-efficient ways.

One option for support of widespread school staff development is the cultivation of cadres of "mathematics specialists," groups of teacher-leaders positioned to offer demonstration lessons and classroom consultations, facilitate grade-level meetings, and lead professional development workshops and seminars.

But if school systems are to assign specialist roles to teachers who, in turn, provide professional development to their colleagues, the next question involves the kinds of knowledge required of those specialists. What must such specialists know and understand in order to provide effective professional development and how might they acquire it? These are the questions addressed in this paper.

Our discussion is set in the context of a professional development curriculum

called *Developing Mathematical Ideas* (DMI). DMI, like other, similar programs, provides structure and content for in-service programs and can be used by a wide range of teacher educators, including teachers who become mathematics specialists. Further, these tools can underwrite system-wide, long-term, and ongoing staff development.

The DMI materials were designed in response to the widely recognized need of elementary- and middle-school teachers to understand more deeply the subject-matter content they teach. However, rather than offer that content "cleansed" of "distracting" reference to classroom context, these materials present the mathematics as embedded within those tasks of teaching which daily require teachers to call upon their own mathematical understandings (Ball, 2000; Schifter, 2001). Thus, seminars are designed around a set of print and video cases that particularly focus on children's articulation of their mathematical thinking and ways of solving problems. Along with these cases, the materials offer mathematical explorations, analyses of mathematics activities from K-5 curricula, assignments for teachers to conduct with their own students and classes, and readings about related research.[3]

Currently, DMI consists of five modules, two on themes of number and operations, two on geometry, and one on data.[4] Each module, containing a casebook, a facilitator's guide, and a videocassette, is designed for eight three-hour sessions.

The Questions

To frame our approach to issues of facilitation in professional development settings, let us start with this scene: Having read a set of cases involving kindergarten and first-grade children who solve various problems by counting, a group of teachers now comes together to discuss what they see in these cases. Their facilitator describes what happens next.

I began, "What did you find interesting in [the case called] 'Insects and Spiders'?"

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[3] The DMI materials were produced in the context of the teacher enhancement project, Teaching to the Big Ideas (ESI-9254393and ESI-9731064), co-directed by Deborah Schifter, Virginia Bastable, and Susan Jo Russell.

[4] The five modules published thus far are: *Building a System of Tens*; *Making Meaning for Operations*; *Examining Features of Shape*; *Measuring Space in One, Two, and Three Dimensions*; and *Working with Data*. In production are two modules on early algebraic thinking: 1) *Functions, Patterns, and the Mathematics of Change* and 2) *From Actions to Number Systems*.

Tomi offered the first response: "I have kindergartners and this is first grade. I was looking at how, if they were given 5 spiders and they had 9 more to count, they were able to start counting on from 6. My children aren't at that level yet. I've tried to get them to do it on their own, but they don't. I even try to do it with them, but they still don't do it."

As Tomi was talking, I had the sense this wasn't a complaint; she didn't seem to be reporting a problem. Rather, this was something she had noticed about the way people learn.

Carla commented, in support of Tomi, "I think the issue is developmental. I have third graders who still start from 1."

Even though, on the face of it, Carla's comment is valid and a worthwhile contribution to the discussion, I get a little nervous when I start hearing teachers say, "That's developmental." Too often, I've seen people use that label to get themselves off the hook. If "it" is developmental, there isn't anything the teacher can do. The child just has to grow into "it." The word *developmental* can mark the end of discussion and the end of thought. But at the same time, I think there *is* something developmental about the issue Tomi and Carla were talking about.

I chose to steer the conversation toward the mathematics of counting on. "Whether this is developmental or not, what is 'it'? Can you put into words what the math is we're talking about? What ideas are in here, what mathematics has Tomi been working on with her kindergartners?" (Schifter, et al., 1999a, p. 91)

In this short scene, the facilitator begins with a general question—"What did you find interesting?"—but from there, she works to shape the discussion. Choosing to steer it away from talk about whether a particular skill is "developmental," she asks instead that the group think about the mathematical ideas children must put together in order to move from "counting all" to "counting on."

In this paper, we will examine this and other episodes drawn from our professional development work to consider the questions, Does facilitation necessarily entail active leadership? If so (and our answer is "yes"), what are the facilitators' interventions aimed to do? What must a facilitator know or understand in order to select appropriate interventions? And what, in our project, do we offer facilitators to help them

develop such knowledge and understanding?

Facilitation Is an Active Role

A first question to consider is whether a group of adults coming together to study the mathematics in tasks of teaching requires active facilitation at all. Might they not simply gather as a study group, each member offering ideas to stimulate the thinking of others? Of course, there may be the rare group of teachers prepared to learn together in this way. However, where the nature of the activity being aimed for sharply departs from current practice, most groups will not find their way without determined and knowledgeable leadership. For example, in scenes like the one illustrated above, if teachers were to be satisfied with the comment, "That's developmental," and in the absence of skilled facilitation, would they be likely to press on to examine the mathematical ideas raised in Tomi's observation? Or more generally, will a group of teachers seriously interrogate children's mathematical ideas if they are used to thinking of mathematics in terms of computational routines?

Evidence for our initial proposition, that teacher professional development requires active facilitation, is provided by a research study conducted in 1996-97, the first year of DMI field tests. In this study, Susan Jo Russell (1997) traced the issues faced by a group of teachers who were stepping into their first teacher-leadership roles, facilitating DMI seminars for their colleagues.

Granted, Russell's subjects were not typical teachers. They had spent three years studying mathematics and student thinking in a program led by the DMI developers. Indeed, these same teachers had written some the cases that form the basis of DMI. Yet, though their knowledge of DMI content was considerable, they were very apprehensive about becoming their colleagues' teachers. And to cope with this anxiety, many of these neophytes started out telling themselves that they were there "merely" to facilitate. This entailed, they explained, convening the sessions, setting up the activities, then letting the discussions go where they would.

The thrust of Russell's findings was that once the seminars got underway, this stance of "mere" facilitation could not long be sustained. Having studied mathematics and student thinking for three years, these teacher-leaders had a vision of the potential for learning the DMI materials offered, but their colleagues were not taking up the important

questions on their own. These fledgling facilitators realized that seminar discussions would not move in what they knew to be fruitful directions without active intervention. After the first session, which included playing a mathematics game, one facilitator wrote,

> Most … teachers thought that this was a fun game. . . . I was disappointed with that. I wanted them to think more about their strategies and relate their strategies to the work of the students in the cases. I still look back and wonder how (or if) I could have pushed the teachers' thinking along. (p. 6)

Later in the seminar, a team of facilitators who had been afraid to take strong leadership in discussions realized that participants had also become frustrated. The team had opted for a passive role in order not to anger their colleagues, but now that those colleagues were angry anyway, they decided they might as well take a different tack.

> I made a resolution that if they were going to be mad at me I wanted them to be mad for a good reason. By this I mean that all fall we never really got the questions about 'Where's the math?' . . . [Now my partner and I were] absolutely resolved to continually bring the discussion back to that question, "So what are the mathematical ideas here that this child is pushing on or bumping into?" (p. 16)

At that point, the entire tenor of the seminar began to shift. A few weeks later, one of these facilitators wrote:

> I could see layers and layers of complexity and that is what I was trying to add to the discussion....complexify it up! and that . . . felt right and legitimate and interconnected and important. (p. 17)

While Russell's study illustrates the need for active facilitation, a second study, conducted that same year, characterizes the situations that require determined intervention. Janine Remillard and Pamela Geist (2002) observed three DMI seminars facilitated by a teacher-leader, a university faculty member, and a staff developer working for a school district, respectively. In each of these settings, the researchers were particularly drawn to examine those instances in which seminar participants' questions, observations, challenges, or resistant stands required facilitators to make judgments about how to guide the discourse. These moments, they argued, arose when the goals and commitments of the facilitators, the expectations of the participants, and the agenda of the curriculum conflicted. Initially struck by the awkwardness occasioned by such

moments, the researchers ultimately came to refer to them as "openings in the curriculum," "openings" because, if capitalized upon, they hold significant potential to advance inquiry and learning.

> Often initiated by the concerns and observations of participants, including the facilitator, these openings invite opportunities for facilitators to structure conversations and explorations that can extend or challenge participants' knowledge and beliefs. (p. 24)

The "counting all/counting on" case illustrates just such an opening: The facilitator judges that discussion of Carla's observation that her students' difficulties are developmentally determined could interfere with a goal for the session—examining the mathematics of children's counting strategies. Aware that many teachers use the phrase "it's developmental" to put an end to deeper inquiry, the facilitator circumvents the phrase—"Whether this is developmental or not, what is 'it'?"—to bring the group's attention to the mathematics. Similarly, the teachers in Russell's study learned to ask their participants, "So what are the mathematical ideas here that this child is pushing on or bumping into?"—a question these participants were not conscious needed investigation.

Remillard and Geist identify a set of skills required of facilitators in order to take advantage of the potential for learning offered by such openings in the curriculum: to recognize them as they occur, to interpret the tensions that underlie them, to consider responses and possible consequences, and to take action. They further comment that

> well-navigated openings allow facilitators to take deliberate action to foster the kind of learning intended by DMI developers even when doing so involves "veering" from the plans suggested in the curriculum. In a sense, openings may be signals that the curriculum is working. (p. 28)

What Kinds of Knowledge are Required to Navigate "Openings"?

Russell's research has provided support for the principle that facilitation is necessarily active. Remillard and Geist have characterized those moments that require a facilitator to respond with determined action as "openings." This then prompts the question, What is it that a facilitator must know and understand in order to identify an opening, unpack the tensions that underlie it, and choose a response?

Our own analyses point to three areas in which facilitator understanding is called upon in order to take advantage of openings: seminar content, learning goals for teachers, and participants' perspectives. In this section of the paper, we present examples to illustrate how facilitators mobilize their understandings in each of these areas. Of course, in any seminar event, a facilitator is likely calling upon all three strengths. However, we have chosen occasions that particularly highlight each in turn.

- Facilitators must understand seminar content.

Just as classroom teachers must understand the mathematics they are responsible for teaching, so, too, must teachers of teachers. And as in the classroom, so too in the professional development setting, the form that such mathematical knowledge must take in order to be useful differs from the manner in which it is conveyed in the typical mathematics class. Certainly, to understand an idea as presented in a conventional textbook may be helpful. However, in addition, and more to the point, a facilitator must be able to recognize that mathematical idea as it is situated in a classroom case, or how it plays out in a variety of mathematical activities. As shown in the example below, a facilitator must also recognize when an important idea is being broached by a participant—and be able to respond with questions or suggestions that help move the seminar into that idea.

One issue explored in the seminar *Measuring Space in One, Two, and Three Dimensions* (MS123) is the effect of scaling the sides or edges of two- and three-dimensional objects: double the sides of a rectangle, say, and the perimeter also doubles, but the area quadruples; double the edges of a rectangular solid, and the surface area quadruples, but the volume multiplies by eight.

These ideas are new to most of the teachers who participate in MS123. Indeed, we suspect that few elementary teachers anywhere in the United States have had any experience envisioning spatial relationships. Thus, a seminar facilitator is frequently called upon to help sort out such matters.

In one homework assignment, teachers solve the following problem: *How much sand is needed to fill a sandbox 2 yards long and 4 feet wide to a depth of 6 inches?* Although the problem is first about how cubic units are structured from linear units, exploration of the relationships among cubic inches, cubic feet, and cubic yards brings

participants back into issues of scaling. In one seminar, participants initially offered the following solutions, which the facilitator duly listed on the board:

4/9 cu. yd.

144 cu. ft.

12 cu. ft.

1728 cu. in.

Seminar participants were challenged to reconcile these solutions: Are they equivalent and, if not, which, if any, are correct?[5] The facilitator later wrote an account of what had transpired in response to those questions.

> Corinne explained how she got 12 cu. ft. "I changed all the dimensions to feet: 6 feet times 4 feet times 1/2 foot; that comes out to 12 cubic feet."…
>
> "Oh, right!" Laura exclaimed. "I forgot to change the 6 inches to feet. I multiplied 6x4x6, but that's wrong, 144 cu. ft. is wrong. But if 12 cubic feet is the right answer, then it's 144 cubic inches."
>
> When asked how she came to that conclusion, Laura thought it was obvious. There are 12 inches in a foot, so you multiply the 12 cubic feet times 12. But Andrew disagreed. "You have to go to inches in all dimensions. It's 48 inches times 72 inches times 6 inches."
>
> I wrote out "(4x12)x(6x12)x6" so people could see where Andrew's numbers were coming from. Now everyone set to work, some with calculators, others with pencil and paper. In the middle of all this calculation, Jean blurted out, "Oh, I did 12x12x12 and got 1728. That's the number of cubic inches in one foot, so that can't be the answer. Multiply that by 12 and you get 20,736."
>
> On our list I had crossed off 144 cu. ft. and 1728 cu. in. and now added 20,736 cu. in. "How can we think about whether this is the right answer?" I asked.
>
> Andrew was busily figuring numbers on his paper and declared, "It can't be right. Look, 4/9 cu. yd. is close to 1/2 cu. yd. So you take 18x18x18 and that doesn't get you close to 20,736."

[5] The correct solutions are 4/9 cu. yd., 12 cu. ft., and 20,736 cu. in.

It took me a few seconds to see what Andrew was doing, but I quickly realized he was making a fruitful error, one that would give us an opportunity to work on the ideas behind the exercise. I asked him to slow down and explain again what he was thinking.

"Well, I said the volume is 4/9 cu. yd., and I'm sure that's right. If you change all the dimensions to yards, you get 2 yards x 4/3 yards x 1/6 yard, and that gives you 4/9 cu. yd." I stopped him there for a moment to allow everyone to do that calculation; then I asked him to continue. "But 4/9 is close to 1/2, so I was thinking I needed to find what 1/2 cubic yard is. Well, 18 inches is half a yard, so it would be 18x18x18, and if you round 18 up to 20 you get 8000. So 18x18x18 doesn't get you anywhere near 20,736."

The issue here was exactly what we had worked on last session—what happens when you double the edges of a solid—except that Andrew was talking about halving the edges. But since the images are not so accessible—spatial visualization in three dimensions is so new for them—it wasn't clear to everyone (anyone?) that Andrew had made an error. To help the group picture what was going on, I drew a picture of a cube on the board. (Schifter, et al., 2002, pp. 189-190)

The discussion continued, with additional wrinkles, and the facilitator remained active in slowing the pace, emphasizing particular questions, and introducing spatial representations, first as diagrams drawn on the board and then with cubes. The main idea here was for them to see that when each of the three dimensions of a cube is 1/2 yard (18 inches), you end up with 1/8 cubic yard, not 1/2. Halving just one dimension, 18x36x36 inches, will give you 1/2 cubic yard (close to 4/9).

It is important to note that the mathematical strengths called upon by the facilitator are not limited merely to knowing the effect of scaling the edges of a three-dimensional object. They also include understanding seminar participants' ideas, recognizing how scaling is at issue, posing questions that bring the results of scaling into focus, and offering representations that help participants visualize the relationships for themselves.

Once the teachers could picture the relationship between 18 inches cubed and one

cubic yard and then were able to show that 20,736 cu. in. was a correct solution to the original problem, they could work with images of one cubic foot in relation to one cubic yard in order to see how 4/9 cubic yard is the same quantity as 12 cubic feet.

The example given here highlights how a facilitator calls upon a deep understanding of subject-matter content. However, it should be clear from the examples included in this paper that issues of learning and pedagogy are equally central to the seminars' ambitions. Certainly, facilitators must know this content, as well.

- In planning and in interactions with participants, facilitators must learn to think in terms of the goals of the seminar, and not merely in terms of getting through prescribed activities.

It may *seem* obvious that, in order to identify openings in which participants' expectations conflict with the agenda of the curriculum, the facilitator must understand that agenda. However, the importance of entering each session with a set of learning goals is more often honored in the breach than in the observance. At the level of day-to-day classroom routine, many teachers view their charge as taking students through a series of prescribed activities, unaware that—or how—these activities serve the development of underlying mathematical concepts. Similarly, some teachers of teachers tend to treat the session agenda as an activities' timetable, rather than a conceptual roadmap.

However, without facilitator intervention, the purpose of an activity is often likely to be missed even after clear instructions have been articulated. In the scene presented below, a facilitator acts on her knowledge of the specific learning agenda for the session, as well as for the course as a whole, in order to bring to participants' attention issues otherwise outside their field of vision.

The point of the seminar *Building a System of Tens* (BST) is exploration of the many-faceted idea of place value: how our number system represents quantity and how this idea is employed when calculating with whole and decimal numbers. Conceptual issues challenging to children of different ages are identified and ways teachers and particular curricular activities can support children facing such challenges are investigated.

Thus, in the second session of BST, teachers read a set of cases depicting children

working hard to put together the ideas they need in order to use numbers flexibly. The introduction to the cases points out that many of the children are confused, and "that's what makes these good cases to study. That is, when children are doing everything correctly, the hard thinking they have done is often invisible. On the other hand, if we examine their thinking when they are confused, the ideas they are working on are often easier to identify" (Schifter, et al., 1999b, p.20). As teachers read the cases, they are asked to consider, "In what ways does the children's thinking make sense? What are the ideas they are putting together?"

In order to follow what happens in the second session, the following details of one of the cases up for discussion are relevant: Sarah, a third grader who already knows the "carry" algorithm for addition, chooses to represent 45 + 39 with yellow cubes for tens and black cubes for ones. Thus, after adding, she has 7 yellow cubes and 14 black cubes. "There are way too many to keep on the ones side, so I try to carry them," she says as she moves 10 black cubes to join the 7 yellow cubes. But now having lost track of the fact that 10 black cubes are to be counted as 1 ten (thus, the 7 yellows and 1 group of 10 blacks yield 8 tens), Sarah reckons she has 17 tens and 4 ones: 174. Yet she knows from the other procedures that the correct answer is 84. In the case, the teacher poses questions to Sarah that eventually enable her to find her mistake. Thus, toward the end of the exchange, she points to the 10 black cubes and explains, "It equals 10 ones. It's 10. Not 100…. It is *a* ten." In this way, she reconciles her cube representation with the other procedures she knows, all now yielding the same answer, 84. (Schifter, et al., 1999b, p. 26.)

With the story of this case in mind, let us turn to a teachers' seminar, one whose facilitator reported on how her group seemed unable to examine Sarah's thinking.

> I was … struck by the group's need to find a simple fix; several people talked about what they would have done with Sarah to prevent her from making mistakes. Mainly, they said that Sarah needed to have a larger block for the quantity 10; she shouldn't have represented tens with a different color block the same size as a one. Despite my questions to the small groups, few teachers noticed that, in the course of the episode, Sarah had corrected herself. They skipped over this evidence and did not ask if she was developing a deeper understanding of multidigit addition.

So at this point [now in whole group], I stopped the discussion and had someone in the group act out how Sarah had come up with 174 when combining 45 and 39. Once everyone agreed with the demonstration, we turned back to the text to read together what happened next; I actually asked someone to read it aloud. Then my next question was, "How did Sarah change her model to come up with 84, the answer she already knew was correct? What did she understand to begin with, and what did she figure out in her interaction with [her teacher]?"

Marta was looking back at the first page of the case and shared what the teacher had written about Sarah: "She understood all the various methods that had been presented." [Now, following Marta's lead, the teachers began to discuss the evidence in the case, taking a closer look at what Sarah does and says to consider what she might have been thinking and what she might have figured out.] (Schifter, et al., 1999c, p. 125)

In this example, participants who initially dismiss the case with the comment that the teacher shouldn't have allowed Sarah to represent the numbers as she did are operating from the premise that confusion is best prevented. However, one of the facilitator's goals is to convey the insight that avoidance of confusion is not necessarily a useful goal. She wonders, "Can they come to see that confusion is a necessary part of the learning process? that a person who has come up against a point of confusion now has an opportunity to learn?" (Schifter, et al., 1999c, p. 124)

In order to move the group toward this insight, the facilitator takes a strong lead in whole-group discussion. First she asks the teachers to repeat Sarah's demonstration with the cubes. Then she asks the teachers to read a section of the case aloud. In this way, she draws their attention to the elements of Sarah's representation that do make sense, to the knowledge that Sarah already brings to the task, and to the specific idea that Sarah needs to put into place to make her representation work. By bringing teachers back to the particulars of the case, the facilitator *opens* up for them opportunities to address the larger issues of the mathematics of the problem, the learning that took place, and the interactions that supported that learning.

- Facilitators must work to understand participants' perspectives—their deeply held ideas and commitments. Interactions with seminar participants must be based at once

on genuine appreciation of those ideas and commitments, but also on the determination to provoke deeper reflection and expanded insight.

Remillard and Geist remark that skillful navigation of openings in the curriculum requires an understanding of the tensions that underlie them. In order to know where the discontinuities lie between participants' goals and those of the curriculum, facilitators must constantly work to identify the ideas and commitments held by participants, which, if they are learning, are in flux. In the previous examples, the facilitator was acting not only on the learning goals she held for teachers, but also on what she understood about the ideas and dispositions held by those whom she was addressing.

This work of identifying participants' commitments and dispositions is explicitly illustrated in the following excerpt from a facilitator's journal, written after the fourth meeting of BST. To prepare for the session, the teachers had been assigned to conduct a mathematics interview of one of their students. The meeting began with the teachers sitting in small groups, sharing what they had discovered.

> I went around, listening in on groups to get a sense of where people were, and I learned that they were all over the place. Despite the discussion we had at our last meeting, some teachers couldn't separate this interview task from teaching, and their vision of teaching *didn't* involve eliciting students' ideas. There were teachers who couldn't separate being successful teachers from having their students get the problem right. Tomi felt the need to report to me that she stayed with her student until she straightened him out. And Sheila seemed to be at the same place as last time—she would never ask a question of a student unless she were quite sure the student could answer it correctly; it's unfair to ask something you haven't already taught; and so forth. Her interpretation of the interview assignment was, first explain the task to the child, and then ask questions to make sure he does it right.
>
> So, what does it mean that it's the fourth session and some people still don't have an inkling of what it means to examine student thinking? Am I doing something wrong? Is there something I can do so that they'll get it? As I write this, I realize that there's a parallel here between how I'm feeling and the position I put them in when I assigned these interviews. Here I am, panicked (and that's

only a slight exaggeration) that there are teachers in the group who just aren't getting it—they had this big assignment, and they didn't do it right. And that makes me think that maybe I'm a lousy teacher, maybe this seminar is a flop. At the same time, I am telling them to interview students and discover the ways they think about the mathematics. So they interview students and discover that they just don't get all those things they had been taught. And how does that make the teachers feel? Lousy. This isn't just an intellectual exercise. A teacher is compelled to act on what she learns about her students, and so it makes sense that some of these teachers avoid learning things they don't know how to act on.

Hence, that issue comes back to me. What can *I* do? What can I do to make it safe enough for these teachers to begin to discover something about student thinking? And to make them begin to see that teaching involves listening to their students' mathematical ideas?

To answer my questions, I can apply exactly what I want the teachers to learn. What I can do is listen hard to what the teachers are saying—listen to their mathematical ideas as well as their ideas about teaching and learning. But where, in all that, can I find elements of strength in their ideas that can be highlighted and leveraged to help them reconsider some of their own notions? (Schifter, et al., 1999c, pp. 136-137)

In this session, the facilitator is disturbed by the response of a handful of teachers to the assignment to conduct a mathematics interview of a student. She is trying to figure out what to do when teachers' ideas diverge sharply from her expectations. But in order to decide what to do, she must first work to consider why they act as they do. Assuming that the teachers behave rationally and responsibly—that they care about being good teachers—what might they believe that causes them to behave this way?

As this facilitator reflects on the teachers' behavior, she actually finds a point of contact and can empathize. Understanding something of their beliefs and commitments, she is now better able to choose a course of action that can both connect with where they are and challenge them to move on.

Supports for Facilitator Learning

Thus far, we have argued that the role of the DMI facilitator is/should be regarded

as an active one. If what, following Remillard and Geist, we are calling "openings in the curriculum"—instances of discontinuity between participants' ideas or beliefs and the goals of the curriculum—are to issue in fruitful learning, then the facilitator must take determined action to exploit them. And in order to choose effectively among possible responses, facilitators must understand seminar content, be guided in their work by their learning goals for teachers, and respond sensitively to the beliefs, ideas, and dispositions of the participants. This is a tall order. How is a facilitator, particularly a novice, to acquire such knowledge?

The DMI materials were written with an eye toward the facilitator as learner. The casebooks, themselves, provide multiple supports for the facilitator, each chapter beginning with an introduction that describes the major idea the set of cases is threaded on. And each casebook concludes with an essay, Highlights of Related Research, offering another articulation of some of the major ideas to be mined in case discussion. Finally, of course, each session will offer the facilitator new insights into content and goals, new appreciation of participants' perspectives—insights and appreciations that will be carried forward and amplified in succeeding seminars.

In addition, the DMI developers have created structures expressly designed to support facilitator learning. In this section, we describe three: facilitator's guides, the DMI Leadership Institutes, and facilitators' inquiry groups.

- Facilitator's guides

As the DMI developers prepared facilitator's guides, we looked back on our own rich experience leading the seminars and tried to find ways of sharing some of what we learned. But we also looked forward: What could we offer the groups of teachers with whom we were just then working closely and who were about to lead their own DMI seminars for the first time?

Included in the guides are such familiar features as: lists of materials to prepare, agendas for each session describing the activities, pages of mathematics exercises, and focus questions to copy and distribute. The guide opens with a set of "tips," suggestions for how to become familiar with the module, how to prepare for a session, how to facilitate small- and large-group discussions. Mainly, these are directions "how to."

The major component designed to address those areas of knowledge described

above is a document called "Maxine's Journal," ostensibly the reflections of a facilitator written after each session of the seminar. "Maxine's Journal" was created to convey a sense of what a DMI seminar might look like—the types of discussions that can take place, the types of lessons seminar participants can draw from the sessions—and how it might feel to facilitate one. Maxine is a composite character and so, too, are the teachers in her seminar. Though Maxine is fiction, her journal entries describe events and individuals observed and recorded by the developers of the materials and by those who field tested the first DMI seminars. The seminar scenes depicted in the previous sections of this paper are all excerpted from "Maxine's Journal."

A primary purpose of "Maxine's Journal" is to portray a seminar in which participants' ideas take center stage, but where the facilitator actively steers discussion, persistently drawing teachers' attention to a set of ideas or issues. The seminar is neither a lecture, nor merely a free-form discussion. Entries, as in the excerpts quoted above, depict a facilitator who pays careful attention to what participants say and do, who tries to choose responses that convey an appreciation of their ideas but who is committed to pushing them to think harder.

Through the specificity of Maxine's references, the reader can gain insights of a more general nature. By reporting on the events that take place in each session, she shows how, guided by the facilitator, seminar curriculum translates into participant discussion. And by elaborating on resulting confusions and insights, both, that arise, she provides an opportunity for facilitators to work through that same content.

Maxine is constantly trying to understand the perspectives her participants bring to the seminar. As she learns more about her group and the teachers who comprise it, some of her goals become individualized. For example, after the second session, Maxine writes, "What do I want the teachers to learn? I guess one thing I want them to appreciate is that avoiding confusion is not a useful goal. Can they come to see that confusion is a necessary part of the learning process? that a person who has come up against a point of confusion now has an opportunity to learn? But that is not my immediate goal for Amira, Tony, and Shannon. Instead, for Amira, it is simply that she become comfortable enough in this class to be able to think! And for Tony and Shannon, my goal is that they begin to expand their ways of thinking about mathematics." (p. 124)

Participants come with many different perspectives and beliefs, contributing to the richness of seminar discussions. As individuals exchange their ways of interpreting an event described in a case, their methods for solving a particular mathematics problem, or their connection to a finding presented in the research literature, opportunities to explore mathematics, learning, and teaching "complexify."

Accompanying "Maxine's Journal" in the Number and Operations modules is a document called "Two Portraits of Change," tracing the learning of a pair of teachers. Drawing on reflections they recorded in regular writing assignments (prepared for each session), their facilitator tells how these two, who began the seminar with very different perspectives and despite having taken away from it very different ideas, were each changed in significant ways through participation in the same set of activities.

However, the fact that participants come with different perspectives, beliefs, and personalities can complexify the group's dynamic considerably. And so Maxine writes about her efforts to temper dominant personalities who present their ideas with authority, to draw out others who are thinking hard but are too timid to volunteer their views, and to manage those whose exasperation threatens disruption.

Maxine is by no means the "perfect" facilitator— occasionally frustrated or angry, at times confused, unsure about how to interpret what has happened. This, too, is part of the facilitator's experience, and we want new facilitators to understand that. Nonetheless, in spite of self-doubt and confusion, Maxine carries on with a sense of commitment to seminar participants and to the ideas they are to work on.

Users of the DMI materials report that, prior to each session, they read the relevant section, saying that it gives them an image of what is possible. Even though, inevitably, their own seminars will take a different turn, "Maxine's Journal" provides a referent that helps them guide their group (Lee & Buonopane, 1998). Over time, facilitators' own stores of experiences join Maxine's.

- Leadership Institutes

Two-week summer institutes were created to help facilitators deepen their understanding of the mathematics, articulate seminar goals more clearly, become aware of participants' perspectives, and expand and refine their repertoire of facilitation strategies. These institutes include opportunities for future facilitators to go through the

DMI modules, experiencing mathematics explorations, engaging case discussions, analyzing tasks drawn from elementary and middle-grade curriculum, and gaining familiarity with relevant educational research. For some, this is an opportunity to encounter new ideas about mathematics, learning, and teaching. Those more familiar with seminar content take on the role of participant observer—as they move through the material with the group, they are positioned to take note of facilitators' moves and register how their fellow participants are reacting.

Once curriculum content has been foregrounded, goal setting becomes possible. In particular, by identifying session-to-session mathematical objectives, participants become aware of the ways ideas are connected all across the curriculum.

In order to focus on participants' perspectives, we examine one teacher's trajectory over the course of a seminar: careful reading of "Two Portraits of Change" and "Maxine's Journal" allows us to spot specific instances of movement toward seminar goals, highlighting moments of confusion that open up opportunities for learning.

As participants gain confidence in their understanding of seminar content and goals and in appreciating participants' perspectives, the actual work of facilitation itself comes into focus. What is the facilitator's role in group discussion? When should the facilitator intervene? When should the facilitator listen quietly and move on? How might the ideas of the participants be used to raise the level of discussion?

Our attention then turns to developing a repertoire of strategies to support more effective facilitation. We begin with hypothetical seminar scenarios, considering multiple strategies for dealing with common, but complicated, situations. And we work on formulating questions that, while building on the ideas shared in small groups, raise the level of the whole-group discussion. We also analyze samples of participants' writing, focusing on the ideas being conveyed, identifying "openings" registered in their work, and creating responses both respectful and challenging.

An opportunity to co-facilitate a DMI session for other institute participants is the final synthesizing experience of the two weeks. Now responsible for actually setting goals, formulating questions that bridge the mathematics and the cases, and running whole group discussions that build on and challenge the ideas of the group, institute

participants are able to test their strengths in anticipation of their work as facilitators and leaders once back in their workaday settings.

- Facilitators' inquiry groups

In addition to the annual summer institutes, a variety of networks and inquiry groups have been established over the years. During the first year of field tests, project staff met monthly with 35 teacher leaders who were, for the first time, taking on leadership roles in their systems. During the second year, a continuing electronic discussion was established linking facilitators at various sites around the country who were working through sixteen DMI sessions at approximately the same pace. During these meetings or over the electronic network, facilitators described their successes, as well as dilemmas they faced; they shared strategies that worked for them, as well as those that didn't; and they talked about the emotional challenge of the work. While these groups offered support to participating facilitators, they also provided a feedback mechanism for those DMI developers responsible for final revisions.

Now that the materials have been published, we are aware of other projects that structure opportunities for facilitators to work together on their practice. In one project, in particular, located in Boston, Amy Morse works with a group of coaches who, among their other responsibilities, facilitate DMI seminars. To ground discussions about their practice, coaches write their own cases—much like the cases in the DMI materials—about facilitation moments they choose to reflect on with their colleagues.

Addendum: Beyond the Professional Development Seminar

Our paper considers facilitation in the context of the DMI seminar—discussing the facilitator's role, the knowledge required to facilitate well, and the supports offered to develop strong facilitation. But by so confining our considerations, we have left ourselves open to the challenge to defend the generalizability of our conclusions. Is active facilitation of the kind we posit for the DMI seminars solely a function of the nature of the DMI materials?

Although the empirical work presented is all DMI-related, the logic of our argument for active facilitation has persuaded us that its generalizability, too, depends on the gap between the beliefs and understandings of practicing teachers and the goals of the particular professional development program in question. It is precisely when such

gaps—in Remillard and Geist's terms, "openings in the curriculum"—present themselves that determined action on the part of facilitators is needed and promises to be most fruitful.

The overarching goals of the DMI seminar—that teachers come to recognize that mathematics is about ideas rather than simply computational routines and that they and their students should actively entertain such ideas; that teaching involves close attention to what children say and do to express their mathematical thinking; that teachers' moves be based on their grasp of the mathematics to be learned and their analyses of what their students understand—tend not to be widely shared among K-12 teachers. To induce teachers to adopt these goals for themselves, professional development activities must not be easily assimilable into established frames of reference. But even where assignments are explicitly stated (e.g., to figure out the sense in a child's mathematical mistake), teachers will tend to interpret them in familiar terms (to explain what the teacher should have done to prevent a child from making that mistake). Without a facilitator who acts with determination—drawing teachers' attention to what they otherwise would not see—teachers are unlikely to commit to fundamentally change their practice.

Indeed, although our paper focuses on the facilitation of professional development seminars, the same considerations apply to other kinds of tasks a mathematics specialist might take on—for example, coaching teachers in their classrooms or leading discussion following demonstration lessons. Here, too, if teachers are to be helped to move forward, specialists will need to identify and exploit openings—helping teachers attend to students' mathematical ideas, or encouraging them to dig more deeply into the mathematics at hand. And this work, as well, will call upon the same three areas of knowledge treated above.

To illustrate, consider the following story told by a mathematics specialist. One of the schools for which she was responsible was engaged in a process of peer observation—groups of teachers visiting one another's classrooms to observe mathematics lessons—followed by discussions which she led.

> Five teachers, the assistant principal, and I visited a class of 5th graders, whose teacher had opened up her classroom for an observation. The teacher was wonderful. The activity was a review of the unit on which the students were going

to be assessed in a few days. The mainly African-American and Latino students were very comfortable with their teacher and eager to demonstrate to their visitors all they knew about the factors of 100, 300, and 1,000. The students enthusiastically raised their hands to share their thinking and questioned each other's strategies in a respectful and thoughtful manner. The sticky part came when the students were asked to figure out the answer to 53 x 24. This part of the lesson was so unlike the rest of the work I saw that it took me by surprise. All of the students went about finding the answer by using the same method, which they called "FOIL[6]," using the letters F-O-I-L to remember particular steps. My concern was that, if the students were engaged in any real thinking about the problem, it was hidden. It seemed that the FOIL method was another standard algorithm students might learn without having to understand the mathematics.

I wondered how I was to handle this in the post-observation discussion. Here I was, trying to build trustful relationships with these adults whom I had met only twice before, and now I had to raise an issue in an otherwise wonderful lesson. On the way to the assistant principal's office, where we were to debrief, I wrestled with what to say. Of course this was an "opening," an opportunity to "open up" a space for everyone's learning, but at the time it didn't feel that way.

When we got to the principal's office, we sat down and began talking about all we had seen and heard, both from the teacher and her students. Some time into the discussion, a special needs teacher said, "You know, when we saw how the students solved the answer for 53 x 24, here's how I did it." Apparently she and another special needs teacher had already shared their own methods with one another, and they now showed these methods to the group.

When the two teachers talked about how they figured out the answer, it provided me an opportunity to say to the demonstration teacher, "Now that your students have one way to figure out that kind of problem, is there a way for them to learn other strategies? That is what we want for our students. We want them to

[6] "FOIL"—standing for "first, outer, inner, last"—is a mnemonic device sometimes used by algebra teachers to help students remember how to multiply binomials. Presumably, in this fifth-grade class, students broke two-digit numbers into tens and ones (e.g., 53x24=(50+3)x(20+4)) and used the device to insure all four subproducts were computed.

have several strategies, to be flexible in their mathematical thinking." The two special educators' different strategies provided me with a way to honor and not disrespect the teacher who had taken the risk of exposing her practice, as well as a way to support her and the other members of the team with understanding that children need to have several strategies which are student generated.

In this episode from a session of peer observation and reflection, the mathematics specialist identified an opening, considered possible consequences of the responses she might offer, waited to learn more about the ideas held by the group, and only then acted. Guided by the goals at the heart of the mathematics education reform effort in her school system (which goals included that students have opportunities to demonstrate their thinking and solve problems in a variety of ways) as well as her knowledge of the curriculum unit the class had completed (which didn't include the FOIL method), the specialist had identified an issue she thought needed attention in the debriefing discussion. Inferring that the teacher had presented her class with but a single method for solving two-digit multiplication problems, she felt that student learning had been short-circuited: The children had not been led to explore a variety of methods for multiplying (neither their own nor their classmates'), where such exploration would have provided deeper insight into the distributive property.

Sensitive to the vulnerability of the teacher who had just been observed and to the tentative nature of her own, recently established relationship to the group, the specialist was unsure about how to raise this issue in a productive way. She began the discussion as a listener and, even as she provided the members of the group the space to present their ideas to one another, she was giving herself time to learn about their thinking. In this way, when an opportune turn in the conversation offered itself, she was ready to introduce her concerns. But now her intervention could be so framed as to demonstrate appreciation for the teachers' ideas and commitments, while also provoking the group to deeper reflection.

This episode shows that the intellectual demands on the math specialist can be even greater in non-seminar settings. For the seminar materials are designed to bring participants' attention to specific issues. And before each seminar session, facilitators are afforded the luxury of familiarizing themselves with the activities prescribed for the

session and so can think through the questions they pose. But when a group that has just observed a live lesson sits down to discuss what has been seen, facilitation issues become much less predictable. The specialist is now responsible for interpreting what cannot have been anticipated, and with little time for analysis, must decide how to guide further discussion. Withal, the vulnerabilities of participants, likely heightened, will need to be negotiated tactfully.

Such complexities highlight even more so the importance to math specialists of strength in the three areas of knowledge discussed in this paper: first, they need a deep understanding of content—of mathematics, of student learning, of pedagogy, and of the particular tools (e.g., curriculum) used by the system—if they are to interpret accurately what they see and hear; second, in order to choose wisely the directions discussion should take, they need a clear idea of the goals they are working toward; and finally, developing and solidifying the relationships central to their work requires they be particularly attuned to teachers' beliefs, understandings, and sensibilities.

Given the weight of these desiderata, the necessity for on-going professional development for mathematics specialists is evident. They, too, in their turn, must be given opportunities to come together to deepen their understanding of mathematics as it arises in classroom settings, become clear about their projects' goals as they are enacted throughout the systems to which they answer, and explore the challenge—and promise—of navigating openings in their curricula.

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