Project: **Delaware Exemplary Mathematics Curriculum Implementation**
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Polishing the Mirror: Reflection on Practice in Middle Grades Mathematics

This was the third and penultimate summer of our professional development institutes and we all felt that it was time to crank it up a notch. It's not that we thought our previous PD had been somehow inadequate, only that we and at least some of our teachers were ready for a more integrative experience.

Auspicious Beginnings

A little background might be helpful. Our LSC, the Delaware (6-12) Exemplary Mathematics Curriculum Implementation, aka DEMCI, was not a from-scratch operation. It represented the fruition of a number of previous efforts including a Teacher Enhancement Leadership Development Project and an SSI, and came at the confluence of the standards and high stakes assessment movements in Delaware. Curriculum supervisors from a group of school districts in northern Delaware, the progeny of a desegregation case from two decades ago, had banded together to improve mathematics teaching at both the elementary and secondary levels. Local businesses had helped fund grass roots efforts to introduce NSF-supported curricula into high school math classes across the county. By the time the ink was dry on our LSC grant submission in August, 1999, superintendents from 16 of the 19 school districts in Delaware were ready to initial a Memo of Understanding "to become a full partner in the Delaware Exemplary Mathematics Curriculum Initiative" and to "support and endorse" a series of activities toward "providing the best professional development opportunities for all of our teachers." The stage was set. Now all we had to do was hire the best cast we could find - primarily mathematics teachers on loan from participating districts - and work on the professional development script.

For our first summer's professional development, we drew a convenient line of demarcation between content and pedagogy, convinced mathematicians who were also curriculum developers to teach the first, and teacher educators to model the second, and discovered right out of the gate that our participants were not pleased with this approach given their urgently-felt need to master a new curriculum by the following September. We vowed never again to stray very far from the materials themselves.

By our second summer, we had learned how to "embed" all of our PD in the exemplary materials themselves. We tried to maintain a focus on both content and pedagogy. Our professional developers worked in teams with one person, usually a public school practitioner, paying particular attention to the pedagogical possibilities and the other, typically a university faculty member, looking for opportunities within the context of the lessons to ponder the mathematics more deeply. For our teacher participants, however, the units themselves were surely the most salient aspect of the week of training.

Cranking It Up a Quantum

This summer, for our seasoned veterans, we decided to take it to the next level. Although we had seen a blossoming of content knowledge in particular domains, and teaching techniques like cooperative group work were by now familiar topics, the project leadership was still concerned that the fundamentals of the instructional model our LSC was hoping to champion were not making significant inroads. As one of our two instructors for this summer's "Level III" institute - I'll call him Jesse - noted, "We really felt the need to make the pedagogy and assessment pieces very explicit, which broke from the implicit focus of previous training." This might be accomplished, Jesse thought, by "spending less time in the units and more time in analyzing the various parts of the lessons, the mathematical content, how and when to assess understanding of said content, and just what that understanding may look like." Where past professional development featured what might have seemed like a survey of important units, the individual lesson now became the primary unit of analysis. Jesse and his co-presenter, Sal, "modeled lessons and shared lesson plans and lesson 'studies' to stir the discussions around some of the differences from traditional lesson planning and design. The teachers prepared and taught lessons based on the Connect, Launch, Investigate, Summarize model and designed evaluation formats for analyzing their performance through the lens of an evaluator."

As suggested by Jesse's description, an important product to emerge from the Level III training was a rubric of professional practice. Each group worked on their own rubric and different elements factored more or less importantly into each rubric developed. There was no attempt to merge these into a master rubric since the process seemed at least as important as the product. An example of one such rubric completed at this summer's institute appears in the table below.

	LEVEL OF PERFORMANCE			
ELEMENT	**NOT TRYING**	**EMERGING/ GROWING**	**PROFICIENT**	**MASTER**
QUESTIONING STRATEGIES	Tells, does not use questions as a teaching tool.	Uses questions with expected responses, working to become better at questioning.	Uses open-ended questions effectively, turns questions back to the group, builds on questions as a teaching tool.	Anticipates questions and plans a number of strategies to draw out student potential.
PREREQUISITE KNOWLEDGE	Knows curriculum for only current grade level.	Broadening knowledge of curriculum.	Makes connection between current and previous curriculum.	Understands curriculum for current and all previous years.
CONNECTION	No connections made.	Limited ability to connect, transitions are obvious.	Bridges concepts, transitions are less obvious.	Connections are seamless, transitions are effortless.

The development of these rubrics was a recursive process, finished only after teachers had planned, presented, and then critiqued a lesson from a *Mathematics in Context* unit. These first lessons were, for the most part, mechanical and not particularly well-thought out. Startled, the teachers regrouped and, with support (and more modelling) from Jesse and Sal, took a first step at developing a professional practices rubric. Based upon the work on these rubrics, a second lesson was planned and presented. The results were gratifying to all. Jesse and Sal felt that their decision to focus on the elements of an effective lesson was vindicated and the teacher participants described this as one of the best professional development institutes they had ever been a part of. The proof, however, is in the practice.

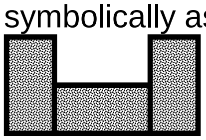
The Reality "On the Ground"

When offered the chance to write a case for this year's Lessons Learned Conference, I jumped at the opportunity. I was eager to see whether or not the effects of the Level III professional development were enduring. Had convictions cooled since August? Would I find that theory had been put into practice or would I be faced with dispiriting glimpses of high hopes dashed on the ground of daily practice? After failing to identify a cadre of teachers from our Level III training who were all teaching the same unit in the first weeks of November, I decided that the lessons of the summer were only lessons learned if they transcended particular units of study. Despite some concern on the part of the conference organizers, I decided that I would look for a "residue" from the summer PD across grades and units and, ultimately, in some rather unlikely places. In particular, I was seeking evidence that our emphasis on the instructional model, the launch-investigate-summarize lesson cycle, was finding root in actual practice.

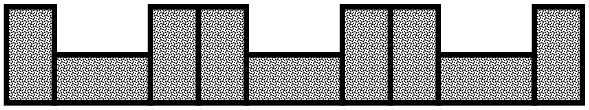
I visited the classrooms of three teachers, all relatively new to the profession, each teaching in a high poverty school and district, and all participants in our Level III training. All of these teachers welcomed me into their classroom and all were anxious to talk about what I had seen and heard. Their stories are different but the common threads are heartening and the differences worth pondering.

Jenni (a pseudonym), used to teach sixth grade. This year she was *the* eighth grade mathematics teacher in her urban middle school, a school which is home to what is often reputed to be one of the most challenging student populations in Delaware. She had used the *Mathematics in Context* materials for two years in grade six and this, she felt, eased the transition somewhat. I arrived early one Tuesday morning so that we might have a chance to discuss her plans for the lesson I was about to observe. First we talked about her students. She had taught many of these same children in the sixth grade. She had worked hard to develop a community in which the students were comfortable talking with her and with each other about the mathematics. She had achieved that with this class but was concerned about her fifth period class: "By the end of November, you hope that the class has gelled, but I'm still working on fifth period. I'm afraid they'll lose whatever gains we've made over the holidays. But this class, third period, this is a class with a good personality!" She did have special concerns about particular students, e.g. one fourteen year old had a baby and often stayed home to care for it. But when these kids were in school, Jenni was prepared to help them focus on learning mathematics. "You try to get them to care," she said, "you let them know you care what they're doing."

Next we talked about the day's lesson. According to Jenni, this was "a very critical moment" in the *MiC* algebra unit, *Building Formulas*. This was the lesson in which factoring was first introduced. We agreed that it was a seminal concept, a gatekeeper to success in a more formal algebra course. As the name of the unit suggests, building situations were used to introduce algebraic representations. Section B., *Basic Patterns*, exploited the context of construction with bricks to introduce a representation for rows of bricks involving Standing, S, and Lying, L, bricks. For example, the length of the following pattern, made up of two Standing and one Lying brick, might be represented symbolically as 2S + L.



This basic pattern might then be repeated to produce a longer string.



This new row could be represented as either three basic groups of two Standing and 1 Lying, i.e. as 3(2S + L) or, without reference to the basic pattern, as 6S + 3L.

Since she had talked about "distributing" the day before and used the metaphor of distributing papers to each of her students, Jenni had been prepared to introduce this day's lesson by talking about un-doing the distributing. But, the more we talked, the less certain she became that this would be an effective metaphor in reverse. By the end of our half-hour long pre-lesson conference, Jenni was convinced that a better approach to introducing factoring might be to challenge her students to identify the "basic pattern" in a longer string and then determine how many times that basic pattern was repeated. As the first students entered the room, Jenni apparently made up her mind to try something different this period.

Seated at the overhead projector, Jenni wrote "15S + 10L" and asked, "How can I figure out what the basic pattern is in this case?" Rather immediately a diminutive girl in the front row to Jenni's right named Ellen answered "Five . . . it fits into five . . . three times. For 10, it will be 2." Caught somewhat off guard by both the promptness and content of Ellen's response, Jenni recovered and asked, "So . . . the basic pattern is repeated how many times?" and then drew 15 Standing and 10 Lying bricks on the overhead and, indicating a basic pattern in the drawing, said, "I'll try to clarify Ellen's thinking . . . for every three Standing, there are two Lying bricks. . . . Pretty cool. I like that Ellen!" And then, looking quite pleased and shifting her gaze from Ellen to the rest of the class, "Ellen stole my thunder! She just explained my whole lesson!"

But this was just the beginning of an extended discussion that was to attract interest rather more widely across the class. Hoping that this first success was not an anomaly, Jenni said, "I have a row in mind with a basic pattern that will repeat a certain number of times." After a sufficiently dramatic pause, she added, "What I will tell you is 6S + 3L. . . . What will my basic pattern be?

Kim: LSS
Jenni: And how many times will that repeat?
Kim: Three times.
Jenni: What will go outside the parenthesis? What will go inside?
Tom: One L and 2 S.
Ellen: Another way would be . . . 2S + L.
Lamar: Maybe SLS. . . maybe SSL.
Jenni: Here's another example. My row has 12L + 8S [writes expression on overhead].

Jerome: 6L + 4S . . . twice.
Jenni: What did you do?
Jerome: Distribute the 2.
Jenni: Is there a more basic pattern?
Ellen: Four on the outside! Then 3L + 2S.
Jerome: That's great!
Dawn: All she did was take that in half!

This lesson "launch" lasted from 9:46 until 10:03. At its conclusion, Jenni instructed the class to work with a partner if they so desired on the next five examples in the book. As this next phase of the lesson began, Jerome turned to his partner, Dawn, and exclaimed with ample feeling, "This is fun!"

In a subsequent debriefing with Jenni, she said that she was disappointed that she had not managed a very good wrap-up for the day's lesson. But, as she noted, there was a lot of good mathematics going on and she did not want to interrupt it. Although she was thrilled that her students responded so enthusiastically and successfully to the prompt of "find my basic pattern," she still had some misgivings that she had not shown them how to "pull out" the common factor. Jenni acknowledged that her struggle has been this year, initiated by conversations during the summer institute, to follow her students' lead more effectively, to "let them take me where they're going." "Do you know what?" she asked rather incredulously, "Some of those same students came to class the very next day with basic pattern puzzles they wanted me to solve!" Perhaps Jenni has given her students more room than she realizes and has convinced them, at least for the moment, to care about mathematics.

The Best Laid Plans

The next class I observed was a seventh grade class in a middle school just two miles down the road from Jenni's school. This school too was known around the district and perhaps the state as a particularly challenging venue. *Mathematics in Context* has been adopted district-wide and the teachers in this school are working together to develop a successful implementation. The teacher, I'll call her Sarah, was planning to teach a lesson from the grade 6/7 statistics unit *Dealing with Data*. The particular lesson, *Soda*, involved estimating the mean from a distribution, in this case of the number of cans of soda sixth-graders drink every day.

Sarah had very carefully planned her lesson from beginning to end. It began with a Problem of the Day which clearly anticipated the lesson itself: Estimate, then calculate the mean of a small data set. Students who completed this task within the allotted time received a stamp on their paper and extra credit toward their mathematics grade.

Next, Sarah took a survey of the class with the question, "How many sodas do you drink per day?" After most of the class volunteered their estimates, which ranged from 0 to 8 cans per day, and a discursive commentary apropos the health implications of drinking an excessive amount of soda, Sarah asked how they might display these data. "Could we make a scatterplot?" she wondered out loud. After concluding that that would not work for this data set - Sarah did most of the concluding - she instructed the class to work on problems 9. and 10. from the student book. These problems involved constructing histograms with contrasting sets of soda data. When Sarah asked the class if they understood the task, one enterprising male student, obviously quite pleased with his answer said, "Draw a histogram, aka a bar graph!"

The nearly 30 students in Sarah's class were arrayed in inward-facing rows of four students each. These demi-rows faced the central axis of the classroom. The student at the front of each of these rows was the "materials person" and was instructed to get graph paper and scissors for everyone in their row. As students began work, Sarah circulated in and out of the rows to monitor and clarify but carefully avoided overly-direct answer-giving. In response to the question, "Teacher, what do they mean by 'typical'?" she reflected the question to the whole class, "Who knows what typical means?" After several students responded "average," Sarah suggested an example she had used before, "A typical Thanksgiving dinner consists of turkey." She later told me that she had come up with this example because she did not want to prejudice the jury by equating typical with average or mean.

Moments later nearly 80% of the students were attempting the assigned problem, but a good many of these students had their hands raised high waiting for more assistance from the teacher. Their difficulties seemed to stem, by and large, from their confusion about how to structure the requisite histogram on the given sheet of graph paper. This was non-trivial in that both axes involved numerals. The horizontal axis represented the categories of "number of cans of soda" while the vertical axis was a record of the frequency in each category. Sarah asked a series of structuring questions such as "Kalina had a good question, do you have to count the zero?" or "Do you have your axes labelled?" and "Now what's the range of your sodas?" Still, many hands remained raised.

Finally, Sarah called for her students' attention and said, "Everyone's having the same problem. . .This is the hardest part about graphing, how to set it up. . . . We're dealing with two things, students and sodas," and then, through further questioning and, ultimately, some direct demonstration, Sarah indicated an appropriate structure for the histogram.

Several students did reach the *denouement* of the problem, the fact that the balance point of the histogram is also the mean of the data set. For many students, however, Sarah's warning bell that signaled two minutes until cleanup, came too soon. At 8:42 after all of the scissors had been collected and stowed and with barely four minutes left in the period, Sarah began her wrapup of the day's lesson: "Okay, let's talk about what we figured out." She continued, "What was the mean?" Given the response "2.5," she asked, "What does that mean?" to which one student responded "Drink half of it today!" The class ended somewhat abruptly with the following exchange:

Sarah: What happens when you try to balance it?
Trish: Right in the middle.
Sarah: What number is that? Is that on purpose or just a fluke?
Tom: On purpose.
Sarah: So we can try to think of the mean as a balance point. . . . Okay guys, have a nice day.

In a debriefing several periods later, Sarah said that she was disappointed that they had not been able to complete the subsequent problem involving a non-symmetrical histogram which would have given more oomph to the idea of mean as a balance point. "I did the wrapup," she said, "but it didn't really work since we did not have the second example to work with." Asked about the difficulty that her class was having in setting up the histogram in the first place, she agreed that this was frustrating but said that she was reluctant to simply give them a template or show them how to do it. Sarah summed it with her conviction that "the learning is in the struggle and mastery only comes when the struggle is successful."

Voices from the Classroom

I'd seen a masterful if seat-of-the-pants launch in an eighth grade algebra unit and a well-structured if ultimately frustrating investigation-centered seventh grade statistics lesson. Jenni and Sarah were teachers who were becoming ever more thoughtful about their implementation of the *Mathematics in Context* curriculum. By their own report, good days alternated with bad days, but there were more good days now and their confidence was growing. My final foray was to be into the classroom of a sixth grade teacher who had come to teaching middle grades mathematics by way of an elementary certification. Denise was not at all sure that she was going to be good at this, and still needed considerable reassurance that she was doing a creditable job.

The lesson I managed to observe was from the unit *Fraction Times*. On this particular day, students were asked to examine the results of a survey in a section called "What Piece of the Pie?" Denise began the lesson by instructing her students to turn to page 23: "Who has been reading the newspaper in Sustained Silent Reading? Do you remember what a survey is?" Two responses followed quickly one after the other: "You ask people questions. Then you tally up," and, from a second female student, "Then they make pie charts."

Denise asked another student to read the introduction to the section. The rest of the class was attentive and absolutely quiet. Denise reviewed the important features from the introduction and asked a few questions to check for understanding: "What is data? How many people responded to the survey? What do they mean by category?" Satisfied that her students had all absorbed the critical information, she instructed them to begin work on the first problem and even suggested a strategy for organizing the results on their papers. "Are we allowed to talk?" asked one student." "Yes, I'll give you seven minutes," responded the teacher.

While the students huddled above their papers, Denise kept up a running coaching commentary: "I want to see fractions for each of these. . . . I want to see a fraction on your paper; I'm coming over in one minute. . . . If you have a fraction on your paper, see if you can think of another fraction for the same number. . . . It says 'approximately,' could you do that if you want to?"

True to her word, eight minutes later, at 9:15, Denise said to her charges, "Let's regroup." What followed was a rapid-fire discussion about significant mathematics involving many of the children in the room. I will try to capture some of the excitement with the fragment of transcript that follows.

Lamar: 105/1,205 liked school.
Denise: Did anyone say it differently?
Jasmine: One-twelfth.
Denise: How did you get that?
Jasmine: One hundred and five - the closest you can get is 100 and 12 times 100 is twelve hundred.
Laura: The 100 goes in the 1,200 twelve times.
William: One hundred and five . . . since "approximately" you can say that's 100. And 1,205 is close to 1,200.
Denise: What had that? (A dozen hands go up.)
Denise: Mike, what did you get?
Mike: One-tenth.
Denise: Tell us what you were thinking.
Archie: He really lowered the number!

This back-and-forth between teacher and student, student and teacher, and even student and student continued apace for another ten minutes! When asked what kind of graph they might make to display the results of the survey, students variously suggested a circle graph, a fraction bar, a histogram and even a ratio table. After the students worked for several minutes on these graphs, Denise indicated that they should be completed for homework and directed her students to move on to the final problem of the day.

Responding to my feedback about her questioning skills, Denise wrote the following email the very next day. "I am glad that you were able to come in. I am glad that you said that you liked my questioning skills. This summer we focused a lot on questioning and I really decided to make an effort to question more this year. Many kids have the knowledge or are right there but they just need help expressing it. I try to get them to do that. . . . I also am really trying to let the students figure things out for themselves and I try to give them the time that they need but also keep up a productive pace. I feel that it is always important to get back to the whole class discussion so that I can guide them."

Denise's reflection is certainly a vindication of the goals of our summer institute. I think the same might be said for Jenni's rethinking of the mathematical content and Sarah's careful attention to the various components of her lesson. Each one of these teachers remarked on the value of the intensive interaction with peers. Again, from Denise: "At training you hear from other teachers about what they do in their classrooms and you take that all in and try to improve yourself."

How can we improve our summer institutes? Perhaps an even more explicit focus on the components of the instructional model would make sense for next year. Clearly the introduction of more actual classroom data whether from videotapes or even classroom vignettes of the sort constructed for this case would up the ante substantially. Put another way, it is imperative that we find ways to help teachers bring their own "voices from the classroom" into our professional development activities more vividly. Reflective practice can only be as good as the mirror.